PB 151389

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Technical Note No. 30

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AERODYNAMIC PHENOMENA IN STELLAR ATMOSPHERES

- A BIBLIOGRAPHY -

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AERODYNAMIC PHENOMENA IN STELLAR ATMOSPHERES

A BIBLIOGRAPHY

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edited by

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FOREWORD

This is an attempt to provide a working bibliography for particular use in preparation for the Fourth Symposium on Cosmical Gas Dynamics: Aerodynamic Phenomena in Stellar Atmospheres. Aerodynamicists participating in previous symposia in this series have often expressed the desire to have something available in the way of background preparation or literature prior to the actual symposium. By the time the Third Symposium came around, there was something covering the field of the first three symposia, which had been devoted to the Interstellar Medium, viz: the proceedings of the first two symposia. With the shift of subject for this Fourth Symposium, the need arises anew, and this bibliography is a partial attempt to meet it. As a second attempt, the Organizing Committee for the Symposium hopes to have distributed several months prior to the Symposium preliminary drafts of introductory, summary presentations of various aspects of the general subject of aerodynamic motions occurring in stellar atmospheres. Particularly, we hope in this way to give the participating aerodynamicists and physicists some idea of the basis upon which astronomers think they have defined the existence and properties of fields of motions occurring in stellar atmospheres. Since the characteristics of some of these fields of motion differ non-trivially from those with which aerodynamicists and physicists are accustomed to deal in terrestrial experience, we hope that some thought may be given their physical consistency, and implication toward a broader structure of aerodynamics. From the standpoint of the astronomer, we hope that the bibliography and summaries may spur some re-examination of the conceptual basis underlying these astronomical results.

Essentially all the astronomical information comes as the end product of rather elaborate spectroscopic analyses. Up to a few years ago, the details of such analyses might be considered alien, hence repelling, to most aerodynamicists. The rapid growth of plasma physics as an important aspect of aerodynamics has, however, changed the outlook considerably. So also has the necessity to examine the "fusion pots" carefully, to see just what temperatures, densities, and compositions actually exist. Thus, that gaseous configuration of which the stellar atmosphere has long been the prototype is no longer so alien, nor is the methodology by which astronomers have studied it. A complaint voiced at the last symposium in the series, that caution must be exercised in considering a symposium on aerodynamic motions in stellar atmospheres lest the discussion become bogged in questions of spectroscopic analysis instead of true aerodynamic problems, simply focuses attention on the realization that the real problems may be as much analysis of observations as theory of velocity fields. Questions of radiative transfer, source-functions, and departures of occupation numbers from those holding under conditions of Local Thermodynamic Equilibrium may enter heavily in specifying the spectral function of stellar-atmospheric turbulence, radiative cooling of a progressive wave in the stellar atmosphere, and local radiative flux gradient to determine the energy balance in the atmosphere.

The above considerations must all be balanced in delineating the scope of the bibliographical material to be covered. A decision was reached to include only material giving specific information on an inference or a theory of aerodynamic motions in the stellar atmosphere. Work on aerodynamic motions in the broadest sense having no direct mention of stellar atmospheres, or stellar atmospheric analysis having no direct mention of aerodynamic motions, were both excluded. It may be that such a bibliography as this should be supplemented, particularly in the two directions of aerodynamical work on concepts of obvious interest to the astronomer but with no particular consideration of his problem, and investigations of departures from local thermodynamic equilibrium induced by non-radiative mechanical energy sources but with no direct consideration of the aerodynamic details. Also, one might include a section on the atomic cross-sections needed to explore the coupling of macroscopic and microscopic degrees of freedom. However, to ensure that at least the aspects covered here were included, and in a short enough time to be of use in preparation for this Fourth Symposium, we have adopted the restricted viewpoint stated.

Even in these restricted aspects, the bibliography falls short of its intended aim in three aspects, for which the editor must accept full responsibility. First, in establishing the collaborative efforts on a geographical-coverage basis - which was done in terms of papers appearing in journals printed within a given area rather than authors residing in a given area - some journals and areas were inadvertently omitted. Second, the contributions from all areas were not submitted in time for inclusion, or submitted only incompletely. Again, the editorial rationalization was a firm resolve to get a bibliography out in time for effective use, with the hope that it may be supplemented and amended at the Symposium or in its Proceedings. An attempt was made to remedy omissions when material was available to the editor; this will appear as out-of-order material. Finally, there has been a certain amount of editing, condensing, addition and omission of material supplied by those collaborating in an attempt to accord with the above-stated objectives.

Boulder, 15 September 1959 Richard N. Thomas

On Gravitational Displacement of Solar Lines; St. John, C.E.; M.N., 84, 93, 1923.

Comparison of pressure-sensitive lines with others shows pressure effects to be negligible. For Fe lines between λ3800 and λ6300, residuals from the relativity shift in λ (Sun - vacuum arc) range from +0.004 A for intensity 12 to -0.003 A for intensity 3, attributed to vertical currents and differential Rayleigh scattering. Red shift increases at the limb, inconsistent with downward currents for the strong lines but explicable by scattering.

The Equilibrium of the Calcium Chromosphere. I; Milne, E.A.; M.N., 85, 111, 1924.

Assuming steady state of a 2-level atom with continuum from below, equations of monochromatic transfer and hydrostatics including selective radiation pressure give distribution of density and excitation with height. In "fully supported" case (pressure gradient tends to zero at great heights), residual intensity is independent of star temperature and line width. Slow density gradient observed suggests that the solar chromosphere is fully supported. Theory predicts 10^{14} Ca^+ ions/cm^2 in the chromosphere, giving pressure only 10^{-6} dyne cm^{-2} at base. Chromosphere tends to collapse and re-form. Contrary to Jeans' conclusion (1923), this mechanism cannot support a detached shell in a steady state.

Pressure and Circulation in the Reversing Layer of the Sun's Atmosphere; St. John, C.E., and Babcock, H.D.; Ap.J. 60, 32, 1924.

A summary of height-variation of motion in the "reversing layer." At very low levels, a predominant upward movement of matter accompanied by horizontal motions; at high levels the motion is generally downward, with horizontal motions taking place in a sense opposite to that at the lowest levels; this is "a permanent east wind, decreasing in velocity with approach to the photosphere." A kinetic equilibrium is thus envisaged.

The Equilibrium of the Calcium Chromosphere. II; Milne, E.A.; M.N., 86, 8, 1925.

Account is taken of the statistical weights of the 4 ^2S and 4 ^2P levels, of the duplicity of the ^2P level, and of the metastable ^2D levels, giving from support theory a mean lifetime 1.8×10^{-8} sec in the ^2P state and predicting that emission in the infra-red Ca II ^2D - ^2P lines accompanies emission in H and K, with about 10 times the intensity. The residual intensity in the infra-red lines in absorption is predicted to be 0.4.

On the Possibility of the Emission of High-speed Atoms from the Sun and Stars; Milne, E.A.; M.N., 86, 459, 1926.

Outward-moving atoms are subjected to increased radiation pressure from the violet wing of the absorption line and thus "climb out," reaching a limiting velocity. For chromospheric Ca^+ ions this is 1600 km/sec, varying little from star to star and corresponding to nova shells. "Auroral" particles may be similarly ejected from disturbed areas, the mean free path in the upper atmosphere being sufficient. Ionized clouds will have a positive head and negative tail.

The equilibrium of the Calcium Chromosphere. III; Milne, E.A.; M.N., 86, 578, 1926.

Random velocities are taken into account. When small, these lead to deceleration owing to the Doppler effect on photon momentum, but when large they make the atom climb out. Small random radial velocities set up a Maxwell distribution with kinetic temperature 1/2 the effective temperature, while tangential velocities have temperature equal to the effective temperature. Sudden local temperature changes cause accelerations which can explain prominences, uniform motion being restored when temperature drops to normal or when radiation is screened by extra chromospheric material. Solar wave-length shift may result from asymmetrical velocity distribution rather than convection currents.

On the Chromospheric Currents Above a Sunspot; Pike, S.R.; M.N., 87, 56, 1926.

Low temperature requires an increase in residual line intensity over the spot to about 0.8; resulting low pressure of Ca^+ and other atoms leads to inward diffusion, explaining the reversed Evershed effect above 1500 km. The support of hydrogen is attributed to unknown sources of absorption, e.g., metastability of the 2s state.

The Equilibrium of the Calcium Chromosphere; Taylor, P.A.; M.N., 87, 605, 1927.

Milne's theory is modified to include curvature and gravity variation. Density tends to a small constant at infinity, but here the assumptions may break down owing to ionization of Ca^+. New solutions are obtained for the fully and partially supported cases.

The Light Intensity of the Calcium Chromosphere; Taylor, P.A.; M.N., 87, 616, 1927.

Numerical calculation of H and K intensities at the limb suggests not quite full support, 10^{-4} of the weight being supported by pressure gradient.

Viscosity in Stars; Rosseland, S.; M.N., 89, 49, 1928.

Ordinary viscosity is greatly increased above the value for laminar flow by turbulence, owing to the high characteristic length. Eddies are visible in granulation and eruptive prominences. Hence Jeans' theory of rotational braking by the angular momentum of radiation is rejected in favour of Eddington's circulating convection currents. Assuming eddy viscosity to exceed laminar by 10^6, it is shown that this smooths out shearing velocities in the Sun in about 10^8 years. Hence Eddington's circulating currents must continuously maintain the observed differential rotation.

Pressure in the Calcium Chromosphere and Reversing Layer; Milne, E.A.; M.N., 88, 188, 1928.

Unsöld (1927) concluded from Saha's formula that top chromosphere has pressure 0.2 dyne/cm^2, 10^6 times larger than Milne found. But equilibrium equations do not apply and combined gas and radiation pressure cannot support 0.2 dyne cm^{-2} at 10^4 km. When Ca^+ dissociates to Ca^{++}, Ca^{++} falls down and is replaced by another Ca^+.

A Note on Dr P.A. Taylor's Paper "The Equilibrium of the Calcium Chromosphere"; McCrea, W.H.; M.N., 88, 729, 1928.

Taylor's treatment is criticized: (a) Schuster-Schwarzschild approximation fails for curved layers; (b) isothermal approximation contradicts the condition of no back-radiation at infinity, modified to overcome these objections and solved numerically for the fully supported case, which seems to fit observation and implies temperature dimishing outwards.

Particles of High Velocity in the Chromosphere; Gurney, R.W.; M.N., 88, 377, 1928.

Lower chromosphere must be subjected to a rain of falling Ca^{++}, He, H^+ with high kinetic energies. These must either bounce, giving lines with Doppler width 1 A, or be collisionally excited, explaining qualitatively the high excitation observed.

A Spectroscopic Determination of the Pressure in the Calcium Chromosphere; Unsöld, A.; Ap.J. 69, 73, 1929.

One section treats the dynamics and stability of the chromosphere. An empirical investigation concludes that the average velocity of Ca^+ atoms exceeds the local thermal velocity; a theoretical discussion on why turbulent motion must exist in the chromosphere.

The Mechanics of the Chromosphere; McCrea, W.H.; M.N., 89, 718, 1929.

Neither radiation pressure nor electric forces explain "lift" of hydrogen. Turbulence--suggested by Rosseland's arguments and by line widths--offers an explanation by raising the effective kinetic temperature; Unsold's value of 18 km/sec fits for neutral gas; ionized gas needs 28 km/sec (still plausible). Elements with greatest velocity rise highest, explaining why gradient decreases with height. Heavy elements all have one gradient, removing an old difficulty, especially as Balmer line intensities suggest low temperature. Descent of turbulent gas gives St. John's red shift and is balanced by rising prominences; these supply both matter and turbulence, little of which is converted into heat.

On the Radial Limitation of the Sun's Magnetic Field; Cowling, T.G.; M.N., 90, 140, 1929.

Ross Gunn's and Chapman's theories of "diamagnetism" due to spiral motions of ions in the solar magnetic field are shown to lead to inconsistencies which are removed by the introduction of more general mechanical equations from which it follows that the drift currents are completely masked by the effect of the pressure gradient.

The Wave-length of Hϵ and the Displacements of the Hydrogen Lines in the Sun; Evershed, J.; M.N., 90, 762, 1930.

Red shifts of H lines, after subtracting relativity shift, decrease from +0.009 A for Hα to -0.006 A for Hϵ. This is interpreted in terms of a descending motion of 0.4 km/sec at the top of the chromosphere changing through zero to an ascending motion at the level of Hϵ.

Contours of the Chromospheric H and K Lines; Unsöld, A.; Obs., 53, 148, 1930.

Woltjer's drift theory of the calcium chromosphere leads to a violet shift of H_3 and K_3, contrary to observation. Also Hϵ and D_3 have the same width as Ca^+ lines, but without central depression.

Contours of the Chromospheric H and K Lines, Woltjer, J., Jr.; Obs., 53, 211, 1930.

Answer to Unsöld: no shift of H_3 and K_3 is implied; only asymmetry, confirmed by observation. Absence of depression in other lines is explained by the small tangential optical depth.

On Periodic Changes of the Solar Corona; Bergstrand, Ö.; Arkiv Mat., Astr., Fys. 22 A, No 1, 1930.

Convection in the Solar Atmosphere. I.; Unsöld, A.; Z.f.Ap. 1, 138, 1930.

It is shown that in the solar atmosphere a layer must exist in which convection is effective. In this layer, the thermodynamically unstable granulation and the sun spots originate. In an appendix of the paper the possibility that a star becomes a nova is discussed, if these instabilities occur in deeper layers of the star.

The Spectroheliosope and Its Work II; Hale, G.E.; Ap.J. 71, 73, 1930.

Descriptions of motions inferred from spectrohelioscopic observations of hydrogen flocculi near active sun spot regions.

On the Alteration in Form of the Solar Corona over the 11-year Cycle; Bernheimer, W.E.; Arkiv Mat., Astr., Fys. 22A, No 25, 1931.

Photometry of Hβ in the Chromospheric Spectrum; Keenan, P.C.; Ap.J. 75, 277, 1932.

Photometry of the Hβ chromospheric line indicates that the "mean velocity of turbulence" is roughly 15 km/sec, in agreement with Unsöld's measures for calcium and helium.

The Excitation of Helium in the Chromosphere; Keenan, P.C.; Ap.J. 76, 139, 1932.

Turbulent motions may be responsible for the excitation of neutral helium in the chromosphere. Observation of the He II 4686 line may provide a means for determining the solar turbulent motions.

The Shift Towards the Red of the Calcium, Aluminum and Iron Lines in the Solar Spectrum; Evershed, J.; M.N., 91, 260, 1931.

The behavior of some lines, but by no means all, is consistent with relativity plus vertical currents.

Pressures at the Base of the Chromosphere: a Critical Study of Milne's Theories; Menzel, D.H.; M.N., 91, 628, 1931.

Quantitative study shows that Milne's idea of LTE in reversing layer and monochromatic equilibrium in the chromosphere is not supported by calculation of Ca partial pressure at base of fully supported chromosphere (5×10^{-10} dyne/cm^2). Partially supported chromosphere might work if N_H/N_{Ca} exceeds 10^7, but the layer considered by Milne, if it exists at all, should be identified with the upper chromosphere.

Convection in the Solar Atmosphere, II; Unsöld, A.; Z.f.A. 2, 209, 1931.

The observed values of the temperature differences between the sun spots and their hotter surroundings are in accordance with the calculated maximum values for these differences. This is due to the fact that the eddies which form the sun spots originate mainly in the outer boundary layer of the convection zone where convection is thermodynamically stable.

Diamagnetism and Drift Currents in the Solar Atmosphere; Cowling, T.G.; M.N., 92, 407, 1932.

Gunn's hypothesis of diamagnetism due to spiralling electrons is again criticized from the point of view of diffusion theory, recovering the results obtained in M.N., 90, 140.

The Solar Chromosphere; Chandrasekhar, S.; M.N., 94, 14, 1933.

Turbulent support theory lacks theoretical basis and is rejected in favour of Milne's theory, but including variations in line radiation flux due to solar activity. Assume flux varies periodically by factor 2 in one coordinate over the surface. Periodic orbits are computed and height of chromosphere shown to be of same order as wave-length (assumed to be 20,000 km) and typical velocities are around 17 km/sec. Aperiodic solutions lead to ejection at moderate velocities of 30 km/sec (tornado prominences). Height distribution is roughly exponential and mass above 1 cm^2 corresponds to scale height $\lambda/5$, removing Menzel's pressure difficulty.

Relative Distribution and Abundance of Elements in the Lower Chromosphere; Mitchell, S.A., and Williams, E.T.R.; Ap.J. 77, 1, 1933.

Mention is made of turbulence being responsible for mixing of the elements and support of the chromosphere.

On the Rotation Velocity of the Different Layers of the Sun; Perepelkin, E.J.; Z.f.Ap. 6, 121, 1933.

Observations of the rotation velocity of the solar equator as derived from different Fraunhofer and chromospheric lines are given.

On the Theory of the Chromosphere and the Corona; Rosseland, S.; University Observatory, Oslo, Publication No 5 (Avhandlinger utgitt av det Norske Videnskaps-akademi i Oslo, I. Mat.-Naturv. Kl. 1933, No 1, 1933.

The paper contains a discussion of movements in the Solar atmosphere, taking into account electromagnetic forces.

The Solar Limb Effect; Hunter, A.; M.N., 94, 594, 1934.

Observed variation of line shift across the solar disk is not linear in cos θ and thus fails to fit radial-current hypothesis.

A Problem in Kinetic Theory Arising out of a Theory of the Chromosphere; Rosenberg, R.L.; Z.f.Ap. 8, 147 (1934).

The law of resistance when an atmosphere of neutral atoms is supported by the upward drift of positive ions is calculated in kinetic theory, and the result is used to discuss the validity of an assumption by Rosseland in his theory of the chromosphere.

The Solar Chromosphere. II; Chandrasekhar, S.; M.N., 94, 726, 1934.

Paper I is generalized to include limb-darkening and 2-dimensional intensity waves. Neglect of line absorption by chromospheric Ca^+ is justified under conditions actually prevailing. Atoms other than Ca (e.g., H) would be in a less steady state; extension of the theory to these, though possible, is not attempted.

Theories of the Solar Chromosphere; McCrea, W.H.; M.N., 95, 80, 1934.

Chandresekhar's theory is shown to be macroscopically equivalent to that of turbulent support, but provides it with a more fundamental physical basis. However, it still has the difficulties of explaining the hydrogen chromosphere and of predicting a constant residual intensity in H and K. Rosseland's suggestion of photospheric turbulence may be the clue to a more satisfactory general theory.

On the Periodic Change in Form of the Solar Corona; Bergstrand, Ö.; Arkiv Mat., Astr., Fys. 25 A, No 4, 1934.

The Solar Limb Effect; McCrea, W.H., and Mitra, K.K.; Obs., 57, 379, 1934.

Referring to Hunter (M.N., 94, 594); owing to $\underline{v}$ = const., radial streaming velocity should increase from the centre of the disk to the limb. Correction for this greatly improves the fit to the cos θ law.

On the Radial Limitation of the Sun's Magnetic Field; Ferraro, V.C.A.; M.N., 95, 280, 1935.

Taking ionization into account, Chapman's conclusion that limitation by eastward "dynamo" electric currents is less important than that by drift currents must be reversed. Estimated scale height for exponential field decay comes to 990 km. Observed scale height of 186 km requires meridional velocity 0.045 km/sec at latitude 45°, too small to be observed.

On the Apparent and the Real Forms of the Solar Corona; Bergstrand, Ö.; Uppsala Meddelanden No 62 (Reprinted from MONTHLY NOTICES OF THE R.A.S., 1935, March), 1935.

Solar Granulation; Plaskett, H.H.; M.N., 96, 402, 1936.
Granulation is considered as arising in Unsöld's hydrogen convective zone and granules are likely to be Benard cells. Empirical temperature distribution derived from limb-darkening confirms existence of extra heating due to rising elements for $\tau \leq 1$.

The Solar Limb Effect; Mitra, K.K.; Obs., 59, 160, 1936.
Results of McCrea and Mitra (Obs., 57, 379) are confirmed by a more detailed model of scattering in a moving atmosphere.

The Determination of the Mean Life of the Granulation; tenBruggencate, P., and Grotrian, W.; Z.f.Ap. 12, 323, 1936.
The mean life time of the solar granules which may be interpreted as the time needed by the turbulent elements to travel one mixing length is derived. The value is 3.2 minutes.

On the Rotational Law of the Photospheric Layers; Emden, R.; Z.f.Ap. 12, 233, 1936.
The explanation of the equatorial acceleration of the sun, given in different papers by Dedebant, Giao, Schereschwensky and Weterlé, is critically investigated. It is shown that this law of rotation of the solar atmosphere is by no means explained in these above mentioned papers.

The Non-uniform Rotation of the Sun and Its Magnetic Field; Ferraro, V.C.A.; M.N., 97, 458, 1937.
In this case, in addition to Cowling's polarization, currents flow in meridional planes unless angular velocity is constant over any surface traced out by a complete rotation of a magnetic line of force. This condition must be nearly fulfilled, with the consequence that the radial limitation of the field is unlikely to be as rapid as generally supposed in view of the latitude variation of angular velocity.

The Cores of Certain Fraunhofer Lines; Redman, R.O.; M.N., 97, 552, 1937.
Non-zero central intensities of 5 lines of Fe I and Sr II and of Hγ are established by measurement and attributed to local velocity inhomogeneities of the order of 1 km/sec.

Applications of Line Integral Theorems to the Hydrodynamics of Terrestrial and Cosmic Vortices; Bjerknes, V.; Astrophysica Norvegica II, No 6, 1937.
The paper gives a kinematical model of the outer part of the Sun which is capable of explaining the main characteristics of the sunspot cycles of 11 and 22 years and of the Sunspots themselves.

Dimensions of the Solar Granules; Keenan, P.C.; Ap.J. 88, 360, 1938.
An estimate of diameters of solar granules from the best available photographic plates, ranging from 710 km to 2100 km, with the mean at 1100 km. Histograms of the frequency function. The granule centers have an average spacing of about 1500 km. Their total number on the surface of the sun at any time is roughly 2,600,000.

Motion Pictures of Small Chromospheric Flocculi; McMath, R.R.; M.N., 99, 559, 1939.
These were first obtained on August 13, 1938, in Hα using a spectroheliograph with the second slit 0.5 A from the line centre and show turbulent oscillatory motions in the lower chromosphere. The motions show up more clearly on the violet side of the line centre than on the red side.

Measures of the Relative Shifts of the Line 5250.218 and Neighboring Lines in Mount Wilson Solar Magnetic Field Spectra; Evershed, J.; M.N., 99, 438, 1939.
This line has a large g-factor, but shows no extra splitting on some of Hale's 1913 plates; the splitting on these must therefore be due to local Doppler effects.

The Broadening of Fraunhofer Lines by Turbulence; Bruggencate, P.t.; Z.f.Ap. 18, 316, 1939.
The influence of a turbulent velocity on the width of Fraunhofer lines in the solar spectrum is discussed.

The Nature of Solar Hydrogen Vortices; Richardson, R.S.; Ap.J. 93, 24, 1941.
A study of spectroheliograms in Hα to test theories of the origin of vortices near sun spots.

Convection in the Outer Layers of the Sun; Woolley, R.v.d.R.; M.N., 101, 52, 1941.
A sufficient degree of convection to account for the discrepancies between Milne's theory of limb darkening in integrated light and Abbot's observations would require turbulent motions of the order of 10 to 100 km/sec, which would blur the Fraunhofer lines.

On the Solar Corona; Alfvén, H.; Arkiv Mat., Astr., Fys. 27 A, No 25, 1941.
The solar corona is supposed to be composed of high energy particles whose motions are governed, among other things, by magnetic fields. The supply of high energy particles to the corona (heating of the corona) may be due to the prominences or prominence-like action of the chromosphere. The total energy necessary to maintain the very high temperature of the corona is small ($\approx 10^{-5}$ of the energy radiated by the sun) because the radiation losses of the extremely thin corona are negligible.

Spectrographic Observations at the Total Solar Eclipse of 1940 Oct 1. II, Concerning the Flash Spectrum and Atomic Velocities in the Chromosphere; Redman, R.O.; M.N., 102, 140, 1942.

(a) There is no detectable shift between emission and absorption lines near the limb. (b) Line profiles suggest kinetic temperature 30,000° with turbulence $\leq$1 km/sec.

Some Studies of the Motions of Hydrogen Flocculi by Doppler Displacements of the Hα Line; Ellison, M.A.; M.N., 102, 11, 1942.

Distance integrals of radial-velocity curves agree with observed heights of corresponding limb prominences. Initial upward accelerations equalling or exceeding gravity are observed. Frequency maximum between 30 and 40 km/sec confirms Newton's result.

Investigation of the Solar Granulation; Bruggencate, P.t., and Müller, H.; Z.f.AP.21, 198, 1942.

Sizes and intensity fluctuations of the granules are derived from a series of photographs.

On the Nature of Sunspot Faculae; Bruggencate, P.t.; Z.f.AP,21, 162, 1942.

It is indicated that the small groups of faculae are long lived, stable photospheric granules.

Recent Solar Observations in Hydrogen and Helium Light; Dodson, H.W., and Dijke, S.E.A.v.; Ap.J. 95, 325, 1942.

Observations of chromospheric eruptions in Hα light show that "when Hα is most intense, a sudden symmetrical broadening (occurs). ... Its interpretation as a Doppler effect would indicate very great and sudden motion of material in both radial and tangential directions.

Note on the Ionization in the Hydrogen Convection Zone; Schwarzschild, M.; M.N., 102, 152, 1942.

Collisional ionization is rapid enough to bring about ionization equilibrium in at least the major part of the hydrogen convection zone.

Characteristic Radial Motions of Hα Absorption Markings Seen with Bright Eruptions on the Sun's Disc; Newton, H.W.; M.N., 102, 2, 1942.

Main features are: high initial outward velocities followed by sudden drop with constant downward acceleration less than gravity; velocity-frequency distribution shows excess of inward over outward velocities; both curves peak near 34 km/sec. Compare prominence observations showing descending matter to be much brighter than ascending.

Line-Width Measures and the Observation of a Red Shift in the Eruptive Hα Line; Ellison, M.A.; M.N., 103, 3, 1943.

Red shift of $\leq$ 0.3 A shown by H_α in flares is attributed to absorption on the violet side by expelled particles. There is no definite evidence for horizontal motions.

Note on Convection in the Sun; Woolley, R.v.d.R.; M.N., 103, 191, 1943.
Assuming constant velocity of 2 to 3 km/sec for rising elements, condition of energy transport leads to nearly radiative temperature gradient, granule size of 1" to 2", and mean life of about 200 sec. Agreement with observation supports Unsöld's estimate of 500 km for the depth of the convection zone.

Spectrographic Observations at the Total Solar Eclipse of 1940 October 1. III: The Spectrum of the Extreme Limb of the Sun; Redman, R.O.; M.N., 103, 173, 1943.
Behavior of Fraunhofer lines at the extreme limb ($\mu = 0.05$) is attributed to roughening by granulation with mean wave-length 7,000 km and amplitude 350 km.

Conditions in the Hydrogen Convection Zone; Eddington, A.S.; M.N., 102, 154, 1942.
Accepting Schwarzschild's result, a 2-stream model is derived in which convection carries appreciable energy and the gradient is nearly adiabatic. As before (though for another reason), temperature inhomogeneities lead to excess ultra-violet radiation and the convection zone is very extensive, both in the Sun and in a red giant. Thus Eddington's theory of cepheids is still tenable.

Line Intensities and the Solar Curve of Growth; Wright, K.O.; Ap.J. 99, 249, 1944.
A redetermination of the solar curve of growth using up-to-that-date data. "The curve corresponds to a turbulent velocity of 0.9 km/sec ..."

New Measures of the Sodium D_1 Line in the Solar Spectrum; Evershed, J.; M.N., 105, 200, 1945.
Red shift is subject to sudden changes. Mean value is 20 per cent above the Einstein effect at the center of the disk and 35 per cent greater at the limb, as with Fe and Ca lines between $\lambda\lambda$ 3930 and 3970. East-west shift confirms that angular velocity increases with height.

On the Zonal Structure of the Solar Surface; Tuominen, S.; Obs., 66, 160, 1945.
The streaming of sunspots suggests that "the Sun shows not only 'trade wind zones' and 'zones of the prevailing westerly winds', but also regular meridional currents within these zones."

Some Observations of the H and K Lines in the Solar Spectrum during a Magnetic Storm; Brück, H.A., and Rutllant, F.; M.N., 106, 130, 1946.
Profiles of H and K on 1946 Feb 7 showed slight violet depression, possibly due to particles expelled at 750 km/sec.

On Differential Rotation and Turbulence in the Sun; Tuominen, J.; Obs., 66, 340, 1946.

Mean lifetime of eddies = (mixing length)/(eddy velocity) = (space derivative of current velocity)$^{-1}$ = about 3 x 10^6 sec. From meridional drift velocity, kinematic viscosity = (mixing length) x (eddy velocity) = 10^{13}. Hence mixing length = 4^o and eddy viscosity = 0.14^o/day on solar surface, corresponding to accidental latitude motion of spots. Granulation lifetime is much smaller, so that granules do not represent turbulence from large-scale currents.

The Significance of Chromospheric Turbulence and the U-V Radiation Excess of the Sun; Biermann, L.; Naturwissenschaften 53, 118, 1946.

The transport of energy by shock waves originating in the layer between the hydrogen convection zone and the photosphere is discussed. These shock waves may be the heating mechanism for the chromosphere where they dissipate a part of their energy and thus increase the mean gas temperature.

Researches on Solar Physics: (II. On the cause of the deviations from thermal equilibrium in the outer layers of the sun). (Contribution to the theory of facules and corona.); Kiepenheuer, K.O.; Ann. Astrophys. 9, 57, 1946.

A study of the propagation of perturbations of the general magnetic field of the sun by sunspots in the solar atmosphere (photosphere, chromosphere, corona ...).

Granulation, Magneto-hydrodynamic Waves, and the Heating of the Solar Corona; Alfvén, H.; M.N., 107, 211, 1947.

Turbulence shown in granulation will excite magneto-hydro-dynamic waves propagated at 0.5 km/sec if general field is 30 gauss. Granulation with kinetic energy $10^{3.5\pm0.5}$ erg cm^{-3} gives wave with amplitude H'= about 250 gauss; H' and v vary as $\rho^{-1/4}$, so that v would be about 300 km/sec in the corona in the absence of damping. Energy propagated upwards is $10^{8.5\pm0.5}$ erg cm^{-2} sec^{-1} or $10^{-2\pm0.5}$ of total solar energy, enough for coronal radiation. Energy is dissipated by Joule heating and at the granule frequency of 10^{-2} sec^{-1}, damping is mainly at the base of the corona where $N_i=10^8$, $T=10^6$. Coronal density gradient may well be "hydrostatic" at 10^6 degrees.

Solar Hydrodynamics; Krat, W.A.; Bull. Poulkovo Obs., 16, No 139, 59-85, 1947.

1. Structure of the Solar Atmosphere. 2. Rotation of the Fluid Compressible Star. 3. Transfer of Energy and Momentum in Rotating Star. It is shown, that barotropic rotation is impossible in stellar atmospheres.

The Solar Curve of Growth for Lines of V. I; King, R.B., and Wright, K.O.; Ap.J. 106, 224, 1947.

Inference on turbulence from a curve of growth analysis; an increase of turbulence with increasing excitation potential is found.

A Working Hypothesis of Solar Flares; Evans, D.S.; Obs., 67, 218, 1947.
Flare is regarded as due to a "tornado" of hot material brought up to the surface from deep convective layers and various features are explained in this way.

On the Structure of the Solar Corona and Chromosphere; Bondi, H., Hoyle, F, and Lyttleton, R.A.; M.N., 107, 184, 1947.
Accreted material hitting the Sun with excape velocity has enough energy to explain coronal temperatures. Particles are checked by proton-proton collisions and set up a convective atmosphere in which currents carry accretion energy downwards from the corona to the chromosphere, mass balance being maintained by cooler rising currents. Steady-state solution gives a plausible model while transient states with local condensations followed by radiative cooling give moving or quiescent prominences according as the amount of cooled material is small or large.

On the Turbulent State of Solar Chromosphere; Severny, A.B.; CRAS USSR, 58, 1617, 1947.

Theory of the Solar Atmosphere, 1; Krat, W.A.; Bull. Poulkovo Obs., 18 No 139, 1-30, 1947.
Investigation of movements and flows in solar atmosphere and corona.

Solar Flare Occurrence and Development Phase of Sunspots; Newton, H.W.; Obs., 68, 29, 1948.
Giovanelli's association of flares with initial growth of spots is incorrect.

Chromospheric Flares; Giovanelli, R.G.; M.N., 108, 163, 1948.
Above a critical electric field near 10^5 emu, electric current is no longer limited by elastic collisions and conductivity rises sharply. At the neutral point, the electric field may exceed critical during the initial rapid growth of a spot group, leading to a current sheet in which excitation by electron collisions produces a flare if the sheet is seen tangentially. A larger flare may result from the volume current through a spot, and a complex group may lead to a flare roughly following the lines of force. Assuming each excitation to level 3 to lead to an Hα and a Lyman α quantum, energy predicted is of the right order.

Chromospheric Flares; Ellison, M.A.; Obs., 68, 31, 1948.
Distinction is emphasized between flares and surges. Lack of evidence for upward and rotatory motion favours Giovanelli's ideas rather than D.S. Evans'.

On the Source of Chromospheric Turbulence and the UV-excess in the Solar Radiation; Biermann, L.; Z.f.Ap., 25, 161, 1948.
Reasons are given for the hypothesis that the turbulence in the solar atmosphere (as well as other properties of this layer) can be

explained by shock waves originating from the hydrogen convection zone.

Quantitative Spectral Analysis of the Sun's Atmosphere; Unsöld, A.; Z.f.Ap., 24, 306, 1948.

A discussion of the possibilities of micro- and macro-turbulence in the solar photosphere is given.

On Noise Arising from the Solar Granulation; Schwarzchild, M.; Ap.J., 107, 1, 1948.

It is proposed that acoustical noise produced by solar granules is responsible for maintaining the high temperature of the corona. Assumed granule characteristics: mean size (1000 km.), mean velocity (1 km/sec), mean lifetime (200 sec.). The total kinetic energy flux represented by the granules is found to be 10^{30} ergs/sec.

Superthermic Phenomena in Stellar Atmospheres. I. Spicules and the Solar Chromosphere; Thomas, R.N.; Ap.J., 108, 130, 1948.

Identification of the chromospheric spicules with a system of superthermic jets, and a kinematic analysis of the spicule system. Examination of two alternatives for the source of spicules: local irregularities in the photospheric pressure field and sub-chromospheric gas-streams; the latter is preferred. Energy transferred by elastic collisions between atoms diffusing out of the jet and chromospheric atoms.

Superthermic Phenomena in Stellar Atmospheres. II. Departure from Thermodynamic Equilibrium in an Idealized Chromosphere; Thomas, R.N.; Ap.J., 108, 142, 1948.

Further examination of the concept of a chromosphere arising as a result of a mechanical energy input. The spectroscopic state is computed, assuming a steady-state departing from local thermodynamic equilibrium. The net energy supply needed to maintain a steady-state hydrogen chromosphere with a kinetic temperature of 35,000° is found to be about that which can be provided by the spicule system.

Interferometric Measurements of Solar Wave-lengths and an Investigation of the Einstein Gravitational Displacement; Adam, M.G.; M.N., 108, 446, 1948.

For lines near 6300, central wave-lengths are red-shifted by 0.005 A, suddenly increasing to +0.013 A within 0.1 R of the limb. Residual blue-shift varies across the disk in good agreement with radial currents obeying the continuity equation, but the differential velocity required has the implausibly high value of 1 km/sec, requiring total turbulent velocities of about 20 km/sec.

Some Recent Researches in Solar Physics; Hoyle, F.; Cambridge University Press, 1949.

Contains a summary of the author's views on gas-dynamical motions in solar atmosphere.

Theory of the Solar Atmosphere, 2; Krat, W.A.; Bull. Poulkovo Obs., 18, No 142, 1-29, 1949.

Investigation of movements and flows in solar atmosphere and corona.

A Note on Heat Transfer in the Upper Chromosphere and Corona; Giovanelli, R.G.; M.N., 109, 372, 1949.

Conduction along lines of force of general magnetic field, together with radiation, is adequate to transfer heat in the corona, but not in the upper chromosphere, in which convection is necessary, in agreement with observed turbulent motions. The change-over region has a steep temperature gradient and is identified with the top of the chromosphere.

The Structure of the Solar Corona. Ch. 3. The Motions in the Solar Corona; Bugoslavskaja, E.Ja.; Puol. Sternberg In., 12, 1949.

A comprehensive study of the forms of motion found in the solar corona.

The Sun's General Magnetic Field; Sweet, P.A.; M.N., 109, 507, 1949.

Cowling's (1933) theorem on dynamo action of convection currents is extended to the case where a small magnetic field is produced in the currents themselves. General magnification could occur only if the Hall currents were large enough and hence not in the Sun. Ferraro's (1937) work is extended to include the Hall effect, confirming that a steady general field is incompatible with observed differential rotation. Transverse conductivity must be treated cautiously because of body force due to resulting magnetic field.

Characteristic Properties of Chromospheric Flares; Ellison, M.A.; M.N., 109, 3, 1949.

High-velocity absorption filaments--identified with McMath's limb surges--are ejected from over 50 per cent of Class 2 and 3 flares near maximum brightness. Emission lines lack overall Doppler shift, but have asymmetric profiles.

On the Solar Electric Field Engendered by the Rotation of the Sun in Its Magnetic Field; Ferraro, V.C.A.; M.N., 109, 462, 1949.

Ferraro's (1937) isorotation law must apply to the corona and perhaps beyond. The resulting surface and space charges and the magnetic field due to their motion round the axis are negligible, contrary to conclusions of L. Davis.

Center Limb Variations of Fraunhofer Line Breadths and Intensities; Allen, C.W.; M.N., 109, 343, 1949.

Breadths of 20 faint blue and violet lines increase towards the limb, suggesting anisotropic macro-turbulence with vertical component 1.7 km/sec and horizontal component 2.8 km/sec, independent of latitude. Height-variation hypothesis fits much less well. Faint lines have constant central depth but increase in equivalent width at the limb.

The Heating of the Solar Chromosphere by Shock Waves and Related Problems; Schatzman, E.; Proc. Sym. on the Motion of Gaseous Masses of Cosmical Dimensions, Paris, 93, 1949.

Study of the energy carried by a shock wave and the fraction of this energy dissipated into heat (using the Brinley and Kirkwood theory). Problems which can be solved thusly: heating of the solar corona and chromosphere; existence of big velocities in the red giants atmosphere; material ejection in the novae.

The Heating of the Solar Corona; Schatzman, E.; C.R. Acad. Sci. France, 228, 738-39, 1949.

Study of the transformation of the acoustic waves coming from the unstable zone of the solar atmosphere into shock waves in the external layers. Estimation of the mean quadratic velocity of agitation of the model T(r), ρ(r) of the mechanical energy flux.

The Heating of the Solar Corona and Chromosphere; Schatzman, E.; Ann. Astrophys., 12, 203, 1949.

Study of the radiative and mechanical energy transfer in the solar corona and chromosphere. Theoretical model chromosphere-corona: $Te = 1.24 \cdot 10^6$ at $R = 1.056$, the high conductivity of the coronal electron gas allowing an almost isothermal corona.

On the Lateral Displacement of the Photospheric Granules; Macris, C.; C.R., 229, 112, 1949.

A study of Lyot's movies seems to prove that there is no lateral shift of the granules.

Investigation of a Dynamical Theory of the Solar Atmosphere; Schmeidler, F.; Z.f. Naturforschung 5a, 297, 1950.

An attempt to interpret the non rigid rotation of the sun by the combined action of 3 forces: the Coriolis force, the turbulent friction of the gas, and an outer force directed from the poles towards the equator the physical nature of which is not discussed.

On the Propagation of Shock Waves in the Solar Atmosphere; Schirmer, H.; Z.f.Ap. 27, 132, 1950.

The propagation of shock waves in the solar atmosphere is treated in hydrodynamical and thermodynamical respect. The paper is based on an hypothesis of Biermann's, that the turbulence of the chromosphere is caused by shock waves originating in the hydrogen convection zone.

On the Expulsion of Corpuscular Streams by Solar Flares; Kahn, F.D.; M.N., 110, 477, 1950.

Contrary to suggestions by Kiepenheuer, Hoyle and Kahn, it is shown that momentum transferred by radiation pressure in either Lyman α, H and K, H α or the Lyman continuum to auroral particles is insufficient to expel them from the Sun.

On the Turbulent Velocities of Solar Granules; Richardson, R.S., and Schwarzchild, M.; Ap.J., 111, 351, 1950.

From measures of a high dispersion solar spectrum (0.532 A/mm) the turbulence spectrum of photospheric granulation is derived. The random turbulent velocity is found to be 0.37 km/sec; the turbulence spectrum of the solar photosphere has its maximum at a scale corresponding to element diameters of 150 km. The brightness contrast of solar granulation is discussed.

Superthermic Phenomena in Stellar Atmospheres. VI. Comment on Regions of Emission Fluctuation in the Solar Atmosphere; Thomas, R.N.; Ap.J., 112, 343, 1950.

Extension of the Prandtl theory of a supersonic jet to include a gravitational field, interpretation of chromospheric "active regions" as such a jet.

Interpretation of the Measurements of Radial Velocities in the Solar Granulation; Jager, C.d., and Pecker, J-C.; C.R., 232, 1645, 1951.

In some faint lines partially formed in the turbulent elements, the Doppler width is due not only to the radial velocities of granules but to a mean between this velocity and the very faint radial velocity existing in the radiative non-turbulent zone. The true speeds of the granules are underestimated by a factor which can be as large as 4; the error on the energy of granules can be between 5 and 15.

Equivalent Widths of Solar Lines and Microturbulence; Pecker, J.C., and Jager, C.d.; C.R., 232, 1813, 1951.

Evaluation of the error made in calculating the microturbulent velocity from the equivalent widths assuming independence of this velocity with height: Δv may increase by a factor of 25 and ΔE by a factor of 80 to 500.

Remarks on the Evershed Effect; Michard, R.; Ann. Astrophys., 14, 101, 1951.

Study of the variation of the Evershed effect with position on the solar limb ($v=v_0(1-0.8 \sin\theta)$), the magnetic field (v_0 increase with H) and the sunspot surface (v_0 increase with S and seems to get a saturation).

The Solar Curve of Growth for Lines of Cr I; Sandage, A.R., and Hill, A.J.; Ap.J., 113, 525, 1951.

Eclipse Observations of the Structure of the Chromosphere; Mohler, O.C.; M.N., 111, 630, 1951.

Spicules are counted on some of Marriott's 1930 eclipse plates. Uniformly distributed over the limb with 3 per degree, they fell of sharply 7" above the limb in spite of adequate resolution. The numbers agree well with numbers of granules.

Turbulence and Temperature of the Solar Chromosphere; Unsöld, A.; Z.f. Naturforschung, 7a, 121, 1952.

The evidence of turbulence in the solar atmosphere with velocities ranging from 2 km/sec in the photosphere to about 15 km/sec in the chromosphere is given; the temperature of this layer is about 3800° K. With Mach numbers larger than 1, the formation of threadlike prominences starts which may be a plasma-physical phenomenon of general astrophysical interest.

Motions in the Sun at the Photospheric Level. II, The Evershed Effect in Sunspot Mt Wilson No 9987; Kinman, T.D.; M.N., 112, 425, 1952.

Penumbral motion in this large regular spot has cylindrical symmetry. Outward radial horizontal velocity of 1 km/sec at umbra edge increases to 2 km/sec in middle penumbra and vanishes well outside the spot. Vertical and tangential motions are below observational error. Energy exchange considerations show that equilibrium could exist between heating and acceleration of penumbral material and radiation absorbed by it.

Studies of the Cinematographic Movies of the Solar Chromosphere on the Sun Limb; Dizer, M.; C.R., 235, 1016, 1952.

On Lyot's polarizing filter movies, study of spicules on the solar limb: velocity (20 km/sec) and apparent height (10") increasing in active regions.

The Limb Flare of May 8, 1951; Dodson, H.W., and McMath, R.R.; Ap.J., 115, 78, 1952.

A description of a brilliant, fast-moving flare. The vertical speed of 700 km/sec was accompanied by large horizontal velocities. During the ascent, Hα was 8-10 Angstroms wide.

Preliminary Analysis of the Turbulence Spectrum of the Solar Photosphere at Long Wavelengths; Frenkiel, F.N., and Schwarzchild, M.; Ap.J., 116, 422, 1952.

Measurement of Doppler shifts of solar granules leads to a standard deviation of the random turbulent velocity which is smaller than that expected for the solar photosphere. There is suggested a secondary maximum in the turbulence spectrum at a wavelength of 15,000 km. Possible driving mechanisms for these large eddies are discussed.

Thermal Radio Emission from the Sun and the Source of Coronal Heating; Piddington, J.H., and Davies, R.D.; M.N., 113, 582, 1953.

Statistical analysis of radio data suggests that extra-hot spots in the corona survive their parent sunspots by a month and thus contribute nearly all the radio noise at certain frequencies. It is concluded that the corona was replenished every 4 days or so during 1947-51 by gases from sunspots.

Study of the Photospheric Granulation; Macris, C.; Ann. Astrophys., 16, 19, 1953.

Determination of the size (1".3 - 1".5), and of the lifetime of granules. The bright plages seen in sunspot penumbra exist more than half an hour.

Motions in the Sun at the Photospheric Level. III, The Evershed Effect in Sunspots of Different Sizes; Kinman, T.D.; M.N., 113, 613, 1953.

Observations show (1) maximum radial velocity increases linearly with umbra radius, (2) time to reach maximum velocity is about 1.3×10^4 sec in all cases. This suggests that the total heat absorbed per gram in its flow is constant.

A New Theory of Solar Granulation; Schatzman, E.; Bull. Ac. Roy. Belg., Cl. Sc., 5e série, 39, 960-970, 1953.

A model for the solar atmosphere extending down into the convection zone of hydrogen is built and used to study the propagation of sound waves. Assuming an excess of the source function on the acoustical wave front, the author finds that the horizontal extent of the optical intensity perturbation corresponding to a given wave should be about 4 times the depth of origin of the wave. Identifying these optical perturbations with granules, then responsible compression waves should originate in the upper part of the hydrogen convection zone.

Ejection of Hydrogen and Ionized Calcium Atoms with High Velocity at the Time of Solar Flares; Dodson, H.W., Hedeman, E.R., and Chamberlain, J.; Ap.J., 117, 66, 1953.

High velocity ejection of hydrogen and calcium at the time of onset of five flares are described. The apparent trajectories are nearly linear and cut the solar limb in directions that deviate from the radial by as much as 30°.

A Family of Solutions of the Magneto-Hydrostatic Problem in a Conducting Atmosphere in a Gravitational Field; Dungey, J.W.; M.N., 113, 180, 1953.

The static equilibrium of quiescent prominences strongly suggests a magnetic field, electromagnetic forces balancing the resultant of pressure gradient and gravity. The static equation for an isothermal ionized atmosphere is derived and a family of 2-dimensional solutions obtained representing lines of force in static equilibrium. A model is obtained resembling a filament and its associated coronal arches.

Theories of Solar Phenomena Depending on Sunspot Fields Moving in the Chromosphere and Corona; Piddington, J.H.; M.N., 113, 188, 1953.

Giovanelli's and Hoyle's flare theory and corresponding theories of prominences, cosmic rays and sunspot radio noise turn out to be untenable when mechanical reactions between the magnetic fields and the conducting gas are considered.

Motions in the Sun at the Photospheric Level. IV, The Equatorial Rotation and Possible Velocity Fields in the Photosphere; Hart, A.B.; M.N., 114, 17, 1954.

Measurements at numerous points show a real dispersion with range 0.3 km/sec and wave-length of order 75,000 km.

Motions in the Sun at the Photospheric Level. V, Velocities of Granules and of Other Localized Regions; Plaskett, H.H.; M.N., 114, 251, 1954.

Three Oxford spectra are measured for granulation and two of them give -0.28 for the velocity-brightness correlation coefficient while the third gives 0. Assuming the top of the granulation to be at $\tau = 1$, velocity of ascent ≥ 0.75 km/sec. The small or zero correlation suggests an additional oscillatory velocity field with amplitude 0.5 km/sec and wave-length 5".

Radial Velocities of Spicules and the Width of Chromospheric Lines; Michard, R.; Obs., 74, 209, 1954.

A study of the lines Hα, Hβ, D_3 and of the infra red triplet of CaII between 300 and 6500 kms from the solar limb. For 50 percent of the spicules, the radial velocity is bigger than 8 km/sec, with a quadratic mean velocity of 13.7 km/sec.

The Significance of Center Limb Variation of Fraunhofer Lines; Böhm, K.H.; Z.f.Ap., 35, 179, 1954.

The center-limb-variation of the absorption lines of different elements can only be explained by assuming local temperature inhomogeneities, caused by the turbulence of the photosphere (granulation). In high layers of the atmosphere, considerable deviations from local thermodynamical equilibrium must exist which influence the center-limb-variation. If these two effects are taken into account, the observations of all the iron lines can be explained by theory, while a slight discrepancy remains for the D lines of sodium.

On the Interpretation of the Contours of Strong Fraunhofer Lines; Miyamoto, S.; Z.f.Ap., 35, 145, 1954.

Doppler widths of strong lines indicate a turbulence of 4 km/sec in the upper photosphere, increasing from the weaker turbulence comparable with the thermal motions of metallic elements at the lower photosphere.

Photoelectric Observations of the Profile of Hα in the Sun's Spectrum; Price, A.K.; Ap.J. 120, 233, 1954.

Photoelectric scans of the solar Hα line show that it is asymmetric the core lying -0.037 A from its expect position. The author asserts that such a profile might arise in an atmosphere with a velocity gradient.

Temperature and Turbulence in the Chromosphere; Redman, R.O., and Suemoto, Z.; M.N., 114, 524, 1954.

He I and metal line widths on 1952 eclipse spectrograms, taking self-absorption into account by an empirical method, lead to a roughly linear increase in turbulent velocity with height, from 2.5 km/sec at the limb to 16 km/sec at 2600 km. From the hydrogen lines, the kinetic temperature is between 6,000° and 10,000°.

On a New Theory of the Solar Granulation. II. Propagation in an Isothermal Atmosphere; Schatzman, E.; Bull. Ac. Roy. Belg., Cl. Sc., 40, 139-142, 1954.

This paper contains a short discussion of the propagation of a pulse (either plane or spherical) in an isothermal atmosphere and its characteristics are related very briefly to the heating of the solar corona and the solar granulation.

Comment on the Solar Granulation; Thomas, R.N.; Bull. Ac. Roy. Belg., Cl. Sc., 40, 621-624, 1954.

The author presents a series of arguments against the interpretation of the solar granulation in terms of turbulence or cellular convection although the latter might be present but on a much larger scale. He favours an interpretation in terms of acoustical waves.

Electromagnetic Field Equations for a Moving Medium with Hall Conductivity; Piddington, J.H.; M.N., 114, 638, 1954.

Field equations are set up with tensor conductivity, e.g., for ionized gas in a strong magnetic field, and applied to hydromagnetic waves in the corona. In agreement with Cowling, it is shown that the high Hall conductivity, neglected by Alfven (1947), prevents Joule heating and ensures that lines of force are frozen in. It is the Hall conductivity that determines the rate of energy dissipation.

Correlation Analysis of Turbulent Velocities and Brightness of Photospheric Granulation; Stuart, F.E., and Rush, J.H.; Ap.J., 120, 245, 1954.

A correlation analysis of the Richardson and Schwarzchild (Ap.J., 1950) solar granulation data giving a turbulence spectrum centered on an average cell size of 2300 km with a random velocity of 0.17 km/sec. Analysis of other material indicates brightness fluctuations with a mean wavelngth of 14,000 km. The suggested granular structure consists of three superimposed orders: small (unresolved) 200 km cells, the 2,300 km cells found here, and cells about 15,000 km in diameter.

The Solar Photospheric Gradient; Henriksen, S.W.; Ap.J., 120, 521, 1954.

The density gradient of the solar photosphere is derived from 1945 eclipse observations. The results "support the hypothesis of a solar photosphere in hydrostatic equilibrium near the boundary with no considerable amount of turbulence present."

On Magnetohydrodynamic Effects near the Solar Surface; Severny, A.B.; Publ. Crimean AO, 11, 129, 1954.

An Investigation of the Development of Chromospheric Flares; Severny, A.B., and Shaposhnicova, E.Ph.; Publ. Crimean AO, 12, 3, 1954; AJ USSR, 31, No 2, 124-130, 1954.

Effect of Magnetic Fields on Generation of Noise by Isotropic Turbulence; Kulsrud, R.M.; Ap.J., 121, 461, 1955.

The effects of two types of magnetic fields are discussed: (1) turbulent magnetic fields and (2) constant magnetic fields. Expressions found for the rate of noise generated; and the results applied to the problem of heating the chromosphere and corona.

On the Ejection of Matter from Chromospheric Flares; Mustel, E.R.; Publ. Crimean AO, 15, 95, 1955.

The importance of Lyα radiative pressure is discussed.

Doppler Shifts in Solar Granules; McMath, R.R., Mohler, O.C., and Pierce, A.K.; Ap.J., 122, 566, 1955.

A description of the observed distortion of Fraunhofer lines due to Doppler shifts.

The Excitation Temperature of Faint and Strong Lines; Regemorter, H.V.; C.R., 240, 2053, 1955.

The excitation temperature is for the faint lines a mean of the temperatures in the outer layers of the photosphere, but for the middle and strong lines this excitation temperature depends on the line intensities. It is consequently impossible to draw only one curve of growth by the sliding of parts corresponding to different values of X. This result is in agreement with King and Wright measurements.

New Morphological Results on the Solar Photospheric Granulation; Rösch, J.; C.R., 240, 1630, 1955.

Dimension, distances, and grouping of granules. There seems to exist an elongation of the granules parallel to the solar limb, and an alignment in sets of 5 or 6.

On Solar Granulation; Thiessen, G.; Z.f.Ap., 35, 237, 1955.

Recent observations of the solar granulations indicate the real existence of the 1" - 2" granulation. The Doppler shifts between the granules and their darker surroundings lead to a turbulence velocity of 1.85 km/sec, if one takes into account the effect of scattered light. These values are compared with the values derived earlier by Schwarzschild and Richardson, and the effect of scattered light is discussed.

The Center-limb Variation of Weak to Intermediate Strength Fraunhofer Lines on the Solar Surface; Elste, G.; Z.f.Ap., 37, 184, 1955.

In an investigation of the center-limb-variation of intensities and contours of several Fraunhofer lines, the possibility of an anisotropical macro-turbulence as well as a micro-turbulence depending on the depth of the atmospheric layer is discussed.

Investigation of Turbulence in the Solar Atmosphere; Uberoi, M.S.; Ap.J., 121, 400, 1955.

The correlation spectrum of solar granules velocities is analysed, and a temperature-velocity correlation is also discussed. An analysis of the correlation of brightness fluctuations in granular observations leading to a brightness fluctuation spectrum. Comment on temperature-velocity correlation.

Additional Data for Turbulence Spectrum of Solar Photosphere at Long Wave Lengths; Frenkiel, F.N., and Schwarzschild, M.; Ap.J., 121, 216, 1955.

An analysis of intensity measurements. A comparison of these results to the turbulence spectrum of the vertical granulation velocities.

Variation of the Photospheric Granules Number with the Solar Activity; Macris, C., and Elias, D.; Ann. Astrophys., 18, 143, 1955.

Using Jansen (1880--1915), Lyot (1943) and Keenan (1943) observations, deduction of a relation between the number of granules and the Wolf number.

Spectrophotometry of the Chromospheric Intense Emission Lines--II. The Hα Line in the Spicules; Michard, R.; Ann. Astrophys., 19, 1-8, 1956.

Study of the Hα emission line between h = 4000 kms and h = 9000 kms above the solar limb. Maximum brightness in the center of Hα, half-width; profile of the line. The Doppler widths give a distinction of velocities, with a mean quadratic velocity of 19.5 km/sec--a kinetic temperature $T \simeq 10^4$.

Motions in the Sun at the Photospheric Level. VI, Large Scale Motions in the Equatorial Region; Hart, A.B.; M.N., 116, 38, 1956.

After removing rotation and limb effect, the velocities show a residual dispersion of 0.16 km/sec, which must be real. The average extent of a fluctuation is 2.6×10^4 km, and they persist for over an hour.

An Examination of the Observational Evidence for the Accretion Theory of the Solar Corona; Blackwell, D.E., and Dewhirst, D.W.; M.N., 116, 637, 1956.

Accretion theory requires a change in electron density gradient in the collision region, disappearance of the chromosphere in regions of low coronal density, enhancement at the poles due to the magnetic field, insensitivity to the solar cycle, a constant symmetry axis to great distances, an $r^{-3/2}$ density law, and coronal turbulent motions of 280 km/sec. All these are contrary to observation, even when possible modifications to the theory are considered.

Solar Atmospheric Heating and Flares; Piddington, J.H.; Obs., 76, 21, 1956.

Previous mechanisms proposed have grave difficulties, but friction between plasma ions oscillating in a hydromagnetic wave and neutral particles is much more promising. E.g., granulation may propagate 10^7 erg cm^{-2} sec^{-1}, $10^{2.5\pm0.5}$ times what is needed for the "quiet" corona. Probably 10 per cent of this is transmitted and then dissipated in the half-ionized region. Under disturbed conditions, a similar mechanism may explain bright flocculi and flares occurring at the top of the chromosphere.

The Radiation Field in the Transition Layer Between Chromosphere and Corona; Oster, L.; Z.f.Ap. 40, 28, 1956.

The empirical models for the layer between the chromosphere and the corona are given, both of which are in hydrodynamic equilibrium. Initial data are taken from the model chromosphere as calculated by E. Böhm-Vitense, and electron densities and temperatures of the corona given by Van de Hulst are used.

"Three -stream-model" of the Solar Atmosphere and Asymmetry of the Lines of the Infrared Oxygen Triplet; Voigt, H.H.; Z.f.Ap., 40, 157, 1956.

The asymmetry of the infrared oxygen triplet λ7772/74/75 A can be explained by taking into account the inhomogeneities of the temperature (granulation) in the photosphere by means of a three stream model proposed by K.H. Böhm. In addition to this model it is supposed that these inhomogeneities diminish with the height in the photosphere. Center-limb-variations of the halfwidths yield a micro-turbulence increasing to about 3 km/sec in the higher levels.

High Speed Photography of the Photosphere and the Sunspots; Rösch, J.; C.R., 243, 478, 1956.

Discussion of the reality of granule strings (5 or 6 elements) and of the apparent elongation of granules parallel to the solar limb. Existence in sunspots of bright granules smaller and with more contrast than the photospheric ones. The dimension of photospheric granules is almost always 1".5 or less.

Some Characteristics of a Chromospheric Model; Athay, R.G., and Thomas, R.N.; Ap.J., 123, 309, 1956.

Includes a discussion of the characteristics of the mechanical energy supply required to sustain the chromosphere; comments on the behavior and state of spicules and of acoustic waves traversing chromosphere.

A Model Atmosphere for the Solar Limb Based on Continuum Observations; Pagel, B.E.J.; M.N., 116, 608, 1956.

The limb emission gradient is accounted for by temperature rising with height and negligible "lift" from turbulence, in agreement with observations at the 1952 eclipse.

Granulation of the Solar Surface; Klüber, H.v.; Obs., 76, 68, 1956.
With high resolution, Doppler granulation is visually conspicuous almost every day. Strong lines, especially Hα, show "spikes," with widths ranging from several seconds to under 1" and lasting for some minutes. Spikes are usually symmetrical, but sometimes show on one side of Hα out to over 1.5 A. In strong lines, local shifts are up to 1 km/sec and cause "snake effect" when the image is trailed.

Fine Structure in Solar Spectra; Severyny, A.B.; Obs., 76, 241, 1956.
Bright "moustaches" often extend to 15 A from strong lines, especially on the violet side, and are sometimes accompanied by continuous emission probably from relativistic electrons. "Moustaches" imply ejection velocities of 1000 km/sec and are accompanied by a deuterium line at λ6561. These and other flare effects are attributed to an explosive shock wave with particle ejection from small unstable regions.

Solar Atmospheric Heating by Hydromagnetic Waves; Piddington, J.H.; M.N., 116, 314, 1956.
Hydromagnetic waves can cause strong heating through dissipation by collisions between ions and neutral atoms. The propagation of such waves from granules is discussed and 10^5 erg cm^{-2} sec^{-1} are estimated to be absorbed in the transition zone between slight and full ionization, enough for the quiet corona. Transient effects, e.g., flares and cosmic rays, may arise by a similar mechanism.

Motions in the Sun at the Photospheric Level. VI, Vertical Distribution of the Equatorial Velocity Field; Hart, A.B.; M.N., 116, 489, 1956.
Comparison of the D lines with weak Ni and Ti lines suggests that the velocity amplitude diminishes from 0.16 km/sec at τ = 0.4 to 0.12 km/sec at τ = 0.3.

Investigation of Granulation in Solar Atmosphere; Krat, W.A., and Goldberg, H.M.; Bull. Poulkovo Obs., 20, No 155, 17-29, 1956.
Movement of granulae has the appearance of magnetohydrodynamics waves.

The Width of the Infrared Helium Line in the Solar Spectrum; Mohler, O.C., and Goldberg, L.; Ap.J., 124, 13, 1956.
The broadening of the He I λ10830 line is found to arise in random motions; a value of ξ = 15 km/sec is derived, though it is not clear what part of this, if any, is due to mass motion.

Preliminary Results with a Vacuum Solar Spectrograph; McMath, R.R., Mohler, O.C., Pierce, A.K., and Goldberg, L.; Ap.J., 124, 1, 1956.
A discussion of first results from the McMath-Hulbert vacuum solar spectrograph including conclusions on kinematic features of the

atmosphere inferred from these data. A statistical study of Doppler shifts in two lines suggests an increase in turbulence towards the solar limb.

On a Type of Inhomogeneous Magneto-hydrodynamical Waves; Nardini, R.; Boll. U.M.I., s. III, XI, No.3, 350-358, 1956.

Treatment of an incompressible, perfectly conducting fluid under assumed spherical symmetry. A solution exists for waves propagating along the axis of a pre-existing static magnetic field, with transverse components of velocity and magnetic field proportional to each other. The author terms these waves "vortical" and suggests that they can replace the Alfven-Walen magnetohydrodynamical vortices which, in the Alfven-Walen theory, travel from the solar interior to solar surface and appear as sunspots.

Temperature Variation and Turbulence in the Low Chromosphere; de Jager, C.; B.A.N., 13, 275, 1957.

Turbulent velocities are discussed in connection with a two component model of the chromosphere. The observed solar limb intensity profile is explained by an empirical temperature and turbulence function.

The Interpretation of Hydrogen Spectroheliograms; de Jager, C; B.A.N., 13,133, 1957.

Discussion of velocity fields in two connections (1) observed velocities of fine mottled areas on spectroheliograms and (2) broadening of H . The broadening is interpreted as a large-scale increase in the microturbulent velocity component of spicules.

The Velocity Distribution in a Turbulent Medium and the Profiles of Spectral Lines Radiated by Knots of Quiescent Prominences; Dubov, E.E.; Publ. Crimean AO., 17, 199, 1957.

On the Movement of the Electromagnetic Field in the Solar Atmosphere; Kolpakov, P.E.; AJ USSR, 28, No. 6, 443-449,1957.

Some Results of Investigations of Nonstationary Processes on the Sun; Severny, A.B.; AJ USSR, 34, No.5, 684, 1957.

The Number of Spicules in the Middle Chromosphere; Athay, R.G.; Ap.J., 129, 164, 1959.

An analysis for the distribution of spicules in the middle and upper solar chromosphere.

An Investigation of Motions in the Chromosphere and Flocculi from the Doppler Shift of the K 2and K 3Lines of Ca^+; Khochlova, V.L.; Publ. Crimean AO., 77, 177, 1957.

Evidence of Closed Flux Loops in the Solar Atmosphere; Billings, D.E.; A.S.P., 69, 162, 1957.

Observations of small loop prominences suggest that they might be associated with the interaction of turbulence and magnetic fields in the solar atmosphere.

Interferometric Study of Faint Fraunhofer Lines; Suemoto, Z.; M.N., 117, 2, 1957.

Profiles of red metallic lines at various points of the disk are used with Vitense's Model II to derive profiles of the line absorption coefficients, which are found to be broadest for the weakest lines and to increase towards the limb. This suggests anisotropic turbulence increasing with depth and leads to a circulation picture with vertical upward granule motion changing to horizontal at $\tau = 0.4$ and finally becoming downward motion back to the convection layer.

Anisotropy of Solar Convection; Unno, W.; Ap.J., 126, 259, 1957.

An interpretation of an observed anisotropy in solar photospheric turbulence in terms of the properties of convective flow associated with the atmospheric convection zone. The horizontal convective velocity is found to exceed the vertical for eddies with horizontal diameters exceeding one (vertical) scale height.

The Numbers and Motions of Solar Spicules; Athay, R.G., and Thomas, R.N.; Ap.J., 125, 804, 1957.

Spicule motions are interpreted in terms of two models (1) constant velocity and (2) gravitational deceleration. The statistics favor, but not uniquely, the gravitational model. The total number of spicules is also estimated.

The Flare and Prominence of 4 June 1956; Comper, W., and Kern, R.; Z.f.Ap., 43, 20, 1957.

The motion of the ascending prominence which accompanies the flare is investigated and velocities of 8 knots are deduced. The dependence of height with time confirms the 1st law of motion found by Pettit.

Studies of the Spicules in Projection on the Solar Dis ; Macris, C.J.; Rend dell. Acad. Naz dei Lincei, VIII, XXI, No 6, 1957; Ann. Astrophys., 20, 179-84, 1957.

A study of spicules in projection on the solar disc from spectroheliograms. Distribution of lifetime, mean diameter of 54 spicules. Relation between these two quantities. Comparison with the results obtained on the solar limb.

Spectrophotometry of the Chromospheric Intense Emission Lines. II. The Line HeI 5876; Michard, R.; Ann. Astrophys., 20, 1-9, 1957.

On chromospheric spectra taken with the Arcetri Solar tower, measurements of the central intensity of the profile and total intensity of D_3 in terms of heights from the solar limb. No spicular structure of D_3 lines is seen (below 500 km or less). Comparison of the results with Athay and Roberts, and with the empirical model of Athay and Menzel.

Photoelectric Observations of Solar-Line Profiles; Rogerson, J.B., Jr.; Ap.J., 125, 275, 1957.

Turbulent velocity from line profiles found to be constant with depth 1.4 km/sec.

The Profiles of Chromospheric H_α and D_3; Clube, S.V.M.; M.N., 118, 18, 1958.

Profiles corrected for H_α self-absorption suggest $N_2 = 10^4$ cm^{-3} and turbulent velocity = 16 km/sec at 1500 km.

The Appearance of Flares in Neutral Points of the Solar Magnetic Field and the Pinch-effect; Publ. Crimean AO., 20, 22, 1958; AJ USSR, 35, No 3, 335, 1958.

The White-light-flare of 23 March 1958; Waldmeier, M.; Z.f.Ap., 46, 92, 1958.

The development of a white flare near the eastern limb of the sun is described in detail.

The Dynamic Constitution of the Outer Layer of the Sun. I. Rotation, Meridional Currents, Acitivity; Wasiutynski, J.; Ann. Astrophys., 21, No 3, 118-136, 1958.

Rotational instability can arise if an outer layer of rotation determined by the Jeans effect is accelerated by an inner layer of rotation determined by magnetic fields and gravitational instability. This gives an explanation of the equatorial acceleration of the sun, of the meridional drift of sunspots, and of their variation with the solar cycle.

Study of Solar Turbulence Based on Profiles of Weak Fraunhofer Lines; Waddell, J.H., III; Ap.J., 127, 284, 1958.

Observation of profiles of weak lines of neutral Fe, Ti and V with the 50-foot vacuum spectrograph to study turbulence in the solar atmosphere. The center-limb variation in profiles leads to a photospheric model with anisotropic turbulence which is non-depth-dependent.

Hydromagnetic Waves in a Horizontally Stratified Atmosphere; Ferraro, V.C., and Plumpton, C.; Ap.J., 127, 459, 1958.

The propagation of hydromagnetic waves in an isothermal horizontally stratified atmosphere with a uniform, vertical magnetic field is studied. It is shown that a complex type of wave, represented by a coupling between sonic and Alfven waves, may arise through excitation by photospheric turbulence. If these waves have a period of the order of a granule lifetime, they behave effectively as acoustic waves in the upper chromosphere. Spicules may be material that is thrust up along magnetic lines of force when the period of the granules approaches the critical period of the atmosphere.

Polar Rays of the Solar Corona; Saito, K.; Publ. Astr. Soc. Japan, 10, 49-78, 1958.

The polar rays of the solar corona are investigated from observations in 1952, 1954 and 1955 eclipses. They are found to be distributed on the sun's surface in a ring-like zone 10^o wide and about 10^o--15^o distant from the pole. Departure of the curvature of the polar rays from dipole field is greatest at the corona minimum and becomes less either before or after the epoch. Abundance, life time and width are also discussed. Photometry is carried out for eight conspicuous rays and the electron densities in the rays are calculated, giving the value 5.4 times the surrounding space in the corona. Static equilibrium theory of the ray is confirmed. Relationship between the polar rays and polar faculae are thoroughly discussed. Epoch of appearance and distribution curves of both phenomena are in agreement with each other, suggesting the same origin of both objects.

Solar and Interplanetary Magnetic Field. II. Polar Rays and the Central Magnetic Field; Shimooda, H.; Publ. Astr. Soc. Japan, 10, 107-119, 1958.

An analytical expression for the polar ray and equipotential surface were obtained under the assumption that the corona remains in the hydrostatic equilibrium under the interaction of the coronal matter with the general magnetic field of the sun. They are compared with observations and found that the solar magnetic field is different from dipole and from magnet.

Some Problems of Subphotospheric Stratification, Investigation of the Convective Zone; Rubashev, B.M.; Bull. Poulkovo Obs., 21, No 162, 39-62, 1958.

Interferometric Measurements of Wave-lengths. V, The Radial Current Interpretation of Solar Red Shifts; Adam, M.G.; M.N., 118, 106, 1958.

Schröter's assumption of high-contrast 0".4 granules can explain magnitudes and centre-limb variation of shifts with reasonable streaming motion of 2 or 3 km/sec, but does not explain the variation with line strength or wave-length.

On the Size of Convective Elements in Layers with Variable Temperature Gradient; Böhm, K.H.; Z.f.Ap., 46, 245, 1958.

The structure of the solar hydrogen convection zone is described, and the influence of a non-adiabatic temperature on the "mixing length" is discussed. Numerical results concerning the convection instability of a polytropic atmosphere are communicated in an appendix of the paper.

Motions in the Solar Flare of August 31, 1956; Gopasuk, S.I.; Publ. Crimean AO., 19, 100, 1958.

A Spectrophotometric Investigation of the H and K Lines of Ca^+ in the Chromosphere and Solar Faculae; Khochlova, V.L.; AJ USSR, 36, No 1, 54-64, 1959.

The Flare of September 18, 1957; Jefferies, J.T., Smith, E.V.P., and Smith, H.J.; Ap.J., 129, 146, 1959.

An analysis of the Balmer line wings in the flare in terms of broadening by a non-Maxwellian velocity distribution of macroscopic or microscopic elements.

The Center-Limb Variation of the Intensities of Selected Solar Lines; Mitchell, W.E., Jr.; Ap.J., 129, 93, 1959.

An analysis of the observed vs. predicted center-limb variation in the equivalent widths of certain Frauhofer lines in terms of the influence of macro- and microscopic velocity fields. It is suggested that the microturbulence has a depth dependence, and that large scale motions are more pronounced on the limb.

On Line Formation in a Moving Atmosphere; Kulikowski, J.; Postepy Astronomii, 1959, in press.

Calculation of profiles and equivalent widths in a moving atmosphere, approximating the atmosphere with a finite number of layers following the Milne-Eddington approximation. Case of pure absorption (OI λ7772), and of diffusion and absorption in the case of the sun.

The Propagation of Hydromagnetic Waves of Finite Amplitude in a Horizontally Stratified Atmosphere; Plumpton, C.; Ap.J., 129, 1959.

A study of the vertical propagation of a train of transverse harmonic hydromagnetic waves of finite amplitude in the presence of a uniform vertical magnetic field. It is shown that the vertical material motion is negligible so long as the particle velocity is small compared with the local sonic velocity. Approximate solutions of the field equations are derived, and the results are discussed in relation to the propagation of waves in the solar atmosphere.

Hα Line in the Chromosphere; Michard, R.; Ann. Astrophys., 1959, in press.

Studies of the variation with height of the profiles for spicular and interspecular regions. Determination from some profiles of the source-function, the optical depth, the abundance of spicules above 1000 kms. The spicules are identified as the hot component of the low chromosphere.

Observations of the Solar Photosphere. I. Techniques of the Photographic Observations (23 cm lens); Rösch, J.; Ann. Astrophys., 1959, in press.

Description and first results.

Observations on the Solar Photosphere. II. Numeration and Photometry of Granules in the Region 5900-6000 A; Rösch, J.; Ann. Astrophys., 1959, in press.

Evaluation of the number of granules. ($3.5.10^6$), of the mean distance between the center of two granules (2".0) and of the mean quadratic variation in brightness (3.5 percent). From a mean profile of granules and porules, determination of the brilliancy excess of the granules on the background (23 percent).

Note on the Excitation of Ionized Helium in the Solar Chromosphere; Namba, O.; Publ. Astr. Soc. Japan, 11, 50-53, 1959.

The helium ions carried from the corona by invisible hot streams are ascribed to the source of the high excitation of the HeII spectrum in the low-temperature chromosphere. Significance of the far ultraviolet radiation carried by the hot stream is suggested.

Turbulent Motion in the Solar Atmosphere. I. Doppler Widths of Photospheric Lines; Unno, W.; Ap.J., 129, 375, 1959.

A comparative analysis of pairs of lines from the same multiplet to obtain the Doppler width of the absorption coefficient for the line. The derived turbulent velocities decrease with height in the photosphere.

Turbulent Motion in the Solar Atmosphere. II. Turbulent Velocities in the Lower Chromosphere; Unno, W.; Ap.J., 129, 388, 1959.

The methodology of Paper I. Turbulent velocities increase with height in the chromosphere.

The Resistance Experienced by the Outward Moving Chromospheric Ca^+ Ions and Its Effect on Density; Woltjer, F., Jr.; B.A.N., 6, 91, 1931.

A kinetic theory treatment of the drag on Ca^+ ions; chromospheric density is calculated by balancing this drag against the excess of radiation pressure over gravity.

On the Diffusion of Monochromatic Radiation Through a Medium Consisting of Plan-Parallel Layers in Relative Motion; Woltjer, F., Jr.; B.A.N., 7, 217, 1934.

Layers of Ca^+ atoms moving outward give rise to transparency in excess of that obtained for matter at rest.

On the Polar Rays of the Corona; Hulst, H.C.v.d.; B.A.N., 11, 150, 1950.

Includes a theoretical discussion of the polar rays. Observational data contradict the hypothesis that the corona is a collection of fast ejected streams. A detailed discussion shows that magnetic acceleration does not change the equilibrium equations.

Observations and Computations About Center-limb Variations of Fraunhofer Lines; Houtgast, J.; B.A.N., 11, 475, 1952.

From the computation of line profile no reason is found to introduce horizontal currents or anisotropic turbulence as had been done previously.

SUNSPOTS

Radiation Through a Moving Medium; Rosseland, S.; Ap.J., 63, 342, 1926.
Application of the equation of radiative transfer in a moving medium to the case of sun-spots. The photosphere is assumed in radiative equilibrium; and the spot regions, characterized by local stationary convection currents. The result is that the vertical thickness of sun-spots cannot be less than fifty kilometers.

On the Calculation of the Relative Temperatures and Pressures Existing at the Base of Sunspots; Petrie, R.M.; M.N., 90, 480, 1930.
Equilibrium of sunspots is treated on the basis of Russell's theory of cooling by adiabatic expansion, but taking into account a particular opacity law and pressure differences between spot and photosphere at a given level. Spot on equator is found to have a vertical rotation with a speed of about 1 km/sec.

Preliminary Note on the Structure of Sunspots; Milne, E.A.; M.N., 90, 487, 1930.
Petrie's results are slightly modified by taking radiation into account.

The Magnetic Field of Sunspots; Cowling, T.G.; M.N., 94, 39 1933.
Larmor's analogy with a self-exciting dynamo is criticized. Theorem is proved that an axially symmetric magnetic field cannot be self-maintained, because currents flowing near a limiting point are too small to maintain the field near the point, so that lines of force contract and disappear. The spot field may, however, arise as a disturbance in a solar general magnetic field.

The Structure of Sunspots; Cowling, T.G.; M.N., 96, 15, 1935.
Circulation with adiabatic cooling usually postulated cannot continue unless the temperature gradient is super-adiabatic. Model atmosphere is computed which suggests that this is so and resulting currents can extend upwards into the radiative region, but this requires downward motion of the gas, contrary to observation.

The Systematic Motion of Sunspots in Latitude; Tuominen, J.; Z.f.Ap., 21, 96, 1941.
A statistical investigation is given to the drift of sunspots towards the solar equator or poles. A correlation of this drift to circulations in the interior of the sun is discussed.

On Sunspots and the Solar Cycle; Alfvén, H.; Arkiv Mat., Astr., Fys., 29 A, No 12, 1942.
Sunspots are supposed to owe their existense to magnetohydrodynamic waves in the sun.

On the Theory of Sunspots; Walen, C.; Arkiv Mat., Astr., Fys., 31 B, No 3, 1944.

Sunspots are supposed to owe their existence to magnetohydrodynamic waves in the sun.

Magneto-hydrodynamic Waves and Sunspots; Alfven, H.; M.N., 105, 3, 1945.

Spot field is believed to originate as disturbance of local magnetic field by convection near the solar centre and to be transmitted to the surface by newly introduced magneto-hydrodynamic waves along lines of force of the general field. Disturbance reaches the surface at a high latitude and proceeds towards the equator. Spots cool owing to decrease in density resulting from magnetic pressure. Comparison of theoretical and observational latitude-drift curves suggests a polar field between 10 and 40 gauss and replacement of the external dipole field by a homogeneous field within a region less than 1/3 of the solar radius from the centre.

Sunspots and Magneto-hydrodynamic Waves. II; Alfven, H.; M.N., 105, 382, 1945.

Whirl rings propagate outwards forming bipolar spots. The rings may be nearly circular and normally in a plane parallel to the general field and normal to a meridian plane. Propagation of magneto-hydrodynamic waves causes convection in the solar regions normally regarded as radiative.

The Growth and Decay of the Sunspot Magnetic Field; Cowling, T.G.; M.N., 106, 218, 1946.

Life histories of spots lasting 30 and 55 days show that the field --if due to darkening--must be established in under 1 day. Theory indicates a decay time of 300 years. Therefore the field must have a more permanent existence.

On Movements and Origin of Sunspots; Tuominen, J.; Obs., 66, 387, 1946.

Differential rotation causes a cyclone at intermediate latitudes, elongated along the direction of rotation, and this picture fits the initial movement of the leader and follower of a pair. Velocity discontinuity on low-latitude edge causes a small anti-cyclone, complicating the movement.

Alfven's Theory of Sunspots; Cowling, T.G.; M.N., 106, 446, 1946.

By balancing adiabatic cooling against heat input through radiation, bearing in mind that lines of force are "frozen in", Cowling shows that the theory needs the base of the spot to be 10^4 km below the surface (deep enough for radiation to blur the visible outlines) and the field to be 5×10^4 gauss. Also the Evershed effect needs extra assumptions. Alfven's and Walen's assumptions on the origin and propagation of disturbances from the centre and on the 11-year cycle are criticized and found to conflict with observation.

Magneto-Hydrodynamic Waves and Sunspots. III; Alfvén, H.; Arkiv Mat., Astr., Fys., 34 A, No 23, 1947.

Note on the Circular Vortex Theory of Sunspots; Woltjer, F., Jr.; B.A.N., 7, 164, 1934.

Two interacting circular vortices do not represent a particular solution of the hydrodynamic equations.

Identification of Sunspots; Alfvén, H.; Tellus, 5, 423, 1953.

According to the magneto-hydrodynamic theory of sunspots there should be a correlation between the spots on one hemisphere during a certain cycle and spots on the opposite hemisphere during the following cycle. This has been statistically confirmed by several writers. In the present paper it is pointed out that individual Sunspots may be reproduced at the opposite hemisphere during the following cycle. Theoretically this is a consequence of the circumstances that hydrodynamic disturbances in the sun propagate in both directions along the magnetic lines of force.

The Latitude Drift on Sunspot Groups; Tuominen, J.; Z.f.Ap., 37, 145, 1955.

An analysis of the dependence of the latitude drift of sunspots on phase in the solar cycle.

The Formation of Sunspots from the Solar Toroidal Field; Parker, E.N.; Ap.J., 121, 491, 1955.

It is shown that a horizontal magnetic flux tube in an electrically conducting atmosphere is buoyant and will tend to rise. Sunspots are identified with a flux tube that rises to intersect the photosphere. Other sunspot phenomena are also accounted for.

On Mean Latitudinal Movements of Sunspots; Tuominen, J.; Reprint from the Radio Astronomy Station, University of Helsinki, No 1, 1955.

An analysis of the motions of sunspots in latitude indicates that (1) between about -16° and $+16^{\circ}$ heliographic latitude the spots are drifting towards the equator, while beyond these parallels they are moving towards the poles, and that (2) this larger system of meridional "vortices" seems to be superimposed by another system which divides the sun into zones about 10° wide from South to North. The paper is a continuation to similar studies by the same author, the first of them published in Zeitschrift für Astrophysik in the year 1941.

On the Theory of Sunspots; Alfvén, H.; Tellus, 8, 274, 1956.

It seems unlikely that sunspots are produced by the nonuniform rotation of the sun. The nuclear energy released in the solar core is their most probable energy source. The heat is converted into mechanical and electromagnetic (magneto-hydrodynamic) energy in a convection region. The latitude dependence seems to indicate that this region is deep inside the sun. The magnetic field makes the solar matter anisotropic to magneto-hydrodynamic waves. A decisive check of the hypothesis of a generation of sunspots in the core is that sunspots in the northern hemisphere show a special type of correlation with spots on the southern hemisphere.

The Magnetic Fields of Sunspots and the Evershed Effect; Jensen, E.; The Institute of Theoretical Astrophysica, Blindern, Norway, Reprint No 23 (Reprinted from I.A.U. Symposium No 6), 1958.

The observational data on the magnetic fields and the physical parameters in Sunspots indicate in a qualitative way how the magnetic lines of force run relative to the isobaric surfaces. If matter is confined to move only along the lines of force it is shown that for sufficient tilt between these lines and the isobars, matter will be accelerated outward along the lines of force. The flow corresponding to this forced convection works as a cooling cap for the core of the spot. It is indicated how a stationary state may be reached with the outward velocity adapted to the temperature difference between the spot and the photosphere.

Excitation Temperatures and Turbulent Velocities in Sunspots; Howard, R.; Ap.J., 127, 108, 1958.

Turbulence velocities are derived for individual sunspots by curve of growth methods and by analysis of line profiles. The role of magnetic intensification is taken into account. Assuming that the photospheric turbulent velocity is 1.7 km/sec, the curves of growth for sunspots yield turbulence of about 2.5 to 2.9 km/sec, while line profiles indicate a sunspot turbulence centered at 3.7 km/sec.

PROMINENCES

Observations of the Total Solar Eclipse of September 10, 1923, by the Sproul Observatory; Miller, J.A., and Marriott, R.W.; Ap.J., 61, 73, 1925.

Descriptions of prominence motions are included in the discussion.

On Selective Radiation Pressure and the Accelerated Motion of Ca^+ Vapor in Eruptive Prominences; Sur, R.K.; Ap.J., 63, 111, 1926.

An attempt to explain the accelerated motions of eruptive prominences. The development of a bright Ca^+ facula below the prominence is responsible for a selective radiation pressure on the Ca^+ of the prominence.

The Motion of Gases in the Sun's Atmosphere; Pike, S.R.; M.N., 88, 3, 1927.

At 6,000 km, pressure is only 10^{-3} dyne/cm^2 and collisions very rare, so that atomic motion is controlled by radiation, equilibrium being upset by local temperature fluctuations and random velocities. Resulting forces are calculated and horizontal accelerations shown to occur. Thus a prominence ejected vertically also tends to dissipate horizontally in agreement with observation, discounting Pettit's conclusion of sudden changes in velocity. Sunspots cause downward and horizontal acceleration. Theory explains most but not all observations of prominence motion.

Note on the Separation of Gases in Prominences; Pike, S.R.; M.N., 88, 635, 1928.

New data on atomic constants enable separation of elements to be predicted, e.g., Sr^+, Fe, Ti, with narrow lines, should be higher up than H and Ca^+ with broad lines.

Repulsive Forces in Solar Prominences; Bobrovnikoff, N.T.; Ap.J., 74, 157, 1931.

Repulsive forces are calculated from the observed motion of 21 prominences. The forces for both Ca^+ and H are found to increase with distance from the surface.

Characteristic Features of Solar Prominences; Petit, E.; Ap.J., 76, 9, 1932.

A thorough study of solar prominences. The question of uniform prominence motion modified by abrupt increases of velocity is carefully discussed. It is concluded that this is indeed a general principle in prominence motions.

Heights of the Eruptive Solar Prominence of Sep. 21, 1932; Keenan, P.C., and Rudnick, P.; Ap.J., 80, 157, 1934.

Observation of an eruptive prominence. "There is some indication of uniform motion with sudden accelerations ... but the evidence is not decisive."

A Study of the Solar Prominence of July 18, 1933, Rudnick, P.; Ap.J. 80, 377, 1934.

The history of an active prominence, together with velocities. Motion mainly parallel to solar surface.

The Relations between the Chromosphere and the Prominences; Chandrasekhar, S.; Obs., 57, 65, 1934.

Refer to M.N., 94, 14. A density distribution consistent with continuity equation derived assuming velocity to be a unique function of position has various solutions. One with positive density between two trajectories only has periodic solutions representing floating filaments, solutions with both trajectories going to infinity representing "tornado" prominences, and solutions with one trajectory periodic and the other going to infinity representing "exploding tornado" prominences.

The Distribution of Centers of Attraction for Prominences; Keenan, P.C.; Ap.J., 82, 369, 1935.

Measurements of the heliographic latitudes of centers of influence for prominences showed that the centers were largely confined to the sunspot zones and closely correlated with individual spots. The mass velocity was measured for a number of streamers.

Gas Motions in Prominences, Wolf-Rayet Stars and Novae; McCrea, W.H.; M.N., 95, 509, 1935.

Observation suggests that different elements "stream" with about the same velocity. Motion of one gas through another is examined and it is found that chromospheric density is just sufficient for elements to "drag one another. Similar conclusion is tentatively applied to WR stars and novae.

Observations of Radial Motions of Prominences; Keenan, P.C.; Ap.J., 83, 55, 1936.

A summary of the kinds of prominence motions observed in the interval 1930 to 1935 at Yerkes. The prominences fall into three groups (i) spot-type prominences--jets lasting a short time; (ii) portions of active prominences which suddenly brighten and develop high speeds; (iii) streamers to centers of attraction, characterized by persistent motions.

The Motions of Prominences of the Eruptive and Sun-Spot Types; Pettit, E.; Ap.J., 84, 319, 1936.

A collection of empirical rules which appear to govern the motions of solar prominences. The "first law for eruptive prominences": uniform motion which increases abruptly at intervals; the "second law": the new velocity is a small multiple of the old velocity.

Prominences of the Active and Sunspot Types Compared; McMath, R.R., and Tettit, E.; Ap.J., 85, 279, 1937.

Description and measurements of motions are included for the following phenomena (1) activity within a sunspot group (ejection of bright flucculi), (2) sun-spot prominences, (3) surges, (4) quasi-eruptions, and (5) active prominences.

Ascending Prominences; Waldmeier, M.; Z.f.Ap., 15, 298, 1938.
Observations of some ascending prominences are given and the motions in the prominences are discussed.

On the Dynamics of Solar Prominences; Kiepenheuer, K.O.; Z.f.Ap., 15, 53, 1938.
The effect of different forces acting on the solar prominences is investigated.

Prominence Studies; McMath, R.R., and Pettit, E.; Ap.J., 88, 244, 1938.
Further elucidation of the empirical laws of prominence motions.

On the Motion of Solar Prominences and Streamers; Hulme, H.R.; M.N., 99, 634, 1939.
Doubt is cast on the evidence for Pettit's two laws of prominence motion.

Some Hydrodynamical Experiments in Connection with Prominences; Zanstra, H.; M.N., 99, 499, 1939.
Liquid of low viscosity spreading out into a basin from a hole in the base breaks up into several streamers; these result from instability due to inward acceleration of the outward moving liquid and theory is given agreeing well with experimental results. Similar ideas are applied to prominences occurring when there is a general downward rush of gas; streamers may originate as a thin central sheet in a collapsing ridge in a medium of roughly the same density, with luminosity due to mechanical excitation by compression.

Motion of Ascending Prominences; Waldmeier, M.; Z.f.Ap., 18, 241, 1939.
The motion of an ascending prominence is discussed and examples are given.

Studies on the Motion of Solar Prominences; Pan Puh, M.; Annales de l'Observatorie de Paris, Meudon, VIII, No 4, 1939.
Studying prominence movies, the author shows that E. Pettit's two laws are incorrect.

The Motions of Eruptive Prominences; Giovanelli, R.G.; Ap.J., 91, 83, 1940.
A theory for the motions of eruptive prominences; the constant vertical motions are due to the pressure of Lα quanta emitted from hydrogen flocculi below the prominence. When the prominence material, moving along a magnetic field, encounters a field of the proper sign, it is deflected towards the vertical with an increased velocity.

Solar Eruptions; Giovanelli, R.G.; Ap.J., 91, 334, 1940.
A generalization of the laws of prominence motion from spectroheliosopic observations. It is concluded that the eruptions giving rise to eruptive prominences are at no great height above the chromosphere, and are confined to the regions in which normal bright hydrogen occurs.

Tentative Theory of Solar Prominences; Alfvén, H.; Arkiv Mat., Astr., Fys., 27 A, No 20, 1940.
An interpretation of solar prominences. Sunspots are supposed to be associated with strong magnetic fields to rotate as a vortex. Similarly as in a unipolar inductor, this produces differences of electrical potential between different points of the solar surface. This leads to discharges in the tenuous atmosphere above the solar surface. The electrical particles follow the magnetic lines of force.

Chromospheric Eruptions; Waldmeier, M.; Z.f.Ap., 20, 46, 1941.
A description of the evolution and brightness of chromospheric eruptions. Values for the intensity and equivalent width of the Hα line as well as matter densities of the eruption.

Motion in Solar Prominences, I; Waldmeier, M.; Z.f.Ap., 21, 130, 1942.
A new law for the motions in prominences is derived from a series of photographs of a prominence on December 28, 1940.

Motion in Solar Prominences, II; Waldmeier, M.; Z.f.Ap., 21, 286, 1942.
Motions in ascending prominences are derived from a series of photographs of two prominences of April 18, 1941, and August 18, 1941.

The Properties of Solar Prominences as Related to Type; Pettit, E.; Ap.J., 98, 6, 1943.
Types of prominences are discussed according to (1) association with sunspots, (2) origin, (3) motion, and (4) structure.

Sunspot Prominences--Some Comparisons between Limb and Disk Appearances; Ellison, M.A.; M.N., 104, 22, 1944.
Type IIIa: Inflowing filaments, projected length around 60,000 km, descend along curved paths to boundary of penumbra with final velocity around 50 km/sec. Type IIIb: Arches leave one spot at about 30 km/sec and enter another spot of the same group at about 40 km/sec. Type IIIc: Large flanking prominences stay quiescent for many days and are then disrupted, rising suddenly and partially descending again in streamers.

Electromagnetic Forces in Solar Prominences; Evans, D.S.; M.N., 106, 300, 1946.
Prominences are considered as resulting from motion of ions in a magnetic field, streamers resembling orbits in a mass spectrograph. Mutual repulsion causes acceleration, and resulting velocity curves for the non-overtaking and overtaking cases correspond to various trajectories of knots observed by McMath et al. With hydrogen mainly neutral,

electrostatic field large enough to keep metallic ions and electrons together exerts net upthrust on protons and highly charged heavier ions, which recombine at greater heights and fall back, accounting for support of prominences and the corona · Electromagnetic forces predominate even at considerable distances from sunspots.

Solar Prominences; Bruce, C.E.R.; Obs., 66, 263, 1946.
Prominences are explained as electric discharges and the evidence for this is briefly reviewed.

Researches on Solar Physics: (III. Contribution to the Studies of Prominences and Remarks on the Magnetic Field of the Sun); Kiepenheuer, K.O.; Ann. Astrophys., 9, 57, 1946.
Study of the motion of ionized and conducting gaseous masses in an inhomogeneous magnetic field variable with the time. Application to the study of prominences; regularization of the prominence velocities by radiative pressure and magnetic forces. Evaluation of the radiation intensity necessary to sustain a prominence.

Magnetic and Electric Phenomena in the Sun's Atmosphere Associated with Sunspots; Giovanelli, R.G.; M.N., 107, 338, 1947.
Field of uniformly growing spot may be rapidly propagated owing to the decrease in conductivity perpendicular to the field, but the current density is consequently low. An additional general magnetic field leads to a current sheet near a neutral point and a volume current through the spot. These currents may be the sources of flares and 1-m. radio bursts.

The Interactive Prominence of September-October, 1947; Pettit, E.; A.S.P. Pub., 59, 332, 1947.
Description of motion.

A General Study of a Prominence Field; Dodson, H.W.; M.N., 108, 383, 1948.
Nine moving knots in the prominence of 1947 Sept 16 traversed similar paths from a region high above a spot area to a point on the disk. Velocities increased from 0 to over 100 km/sec with maximum acceleration g/3 and velocities seem to be given as a common function of distance or time from the starting points, suggesting action of a common force field.

The Eruptive Prominence of June 3-4, 1949; Pettit, E.; A.S.P. Pub., 61, 186, 1949.
Description of motion.

A Study of the Eruptive Prominence of 1948 Sept 27; Dodson, H.W.; M.N., 110, 199, 1950.
Radial velocities of gases in this prominence are shown to agree with cross-motions shown by spectroheliograms. This supports the hypothesis of moving material.

The Eruptive Prominence of August 7, 1950; Dodson, J.W., and Donselman, R.W.; Ap.J., 113, 519, 1951.
Detailed discussion of the motion of the prominence.

The Eruptive Prominence of August 7, 1950; Pettit, E.; A.S.P. Pub., 63 26, 1951.
Description of motion.

The Eruptive Prominence of December 23, 1950; Pettit, E.; A.S.P. Pub., 63, 84, 1951.
Description of motion.

The Motions of Eruptive Prominences; Pettit, E.; A.S.P. Pub., 237, 1951.
Time velocity plots of a number of prominences.

The Eruptive Prominence of January 17, 1951; Pettit, E.; A.S.P. Pub., 63, 87, 1951.
Description of motion.

The Nature of Solar Prominences; Kiepenheuer, K.O.; A.S.P. Pub., 63, 161, 1951.
General features of prominences are discussed in an attempt to answer the question of their origin.

A Solar Flare and Associated Dark Flocculi of May 19, 1951; Dodson, H.W.; Ap.J., 115, 320, 1952.
An active dark flucculus is interpreted as a surge-type prominence seen in projection on the solar side.

Sunspot Prominences and the Yellow Coronal Line; Roberts, W.O.; Ap.J., 115, 488, 1952.
There appears to be a close association between the coronal Ca XV emission at λ 5694 and fast-moving prominences of the "sunspot" type.

The Main Types of the Motions in Solar Prominences; Severny, A.B.; CRAS USSR, 82, 25, 1952.

On the Magnetohydrodynamic Motions in the Solar Prominences; Severny, A.B.; CRAS USSR, 91, 1051, 1953.

An Investigation of Motions and Emission of Solar Prominences; Severny, A.B., and Khochlova, V.L.; Publ. Crimean AO, 10, 9, 1953.
The classification of prominences according to types of main motions: eruptive, electromagnetic and chaotic. Variations of brightness are connected with variations of velocities.

Eruptive Prominence Associated with Limb Flare of May 8, 1951; Bartlett, T.J.; Witte, B., and Roberts, W.O.; Ap.J., 117, 292, 1953.
Measures of several knots in the prominence showed that forces large compared with solar gravitation were present.

Magneto-Hydrodynamic Shock Waves; Helfer, H.L.; Ap.J., 117, 177, 1953.
A detailed treatment of shock waves in a compressible fluid using the de Hoffman-Teller shock wave equations for an infinitely conducting medium with applications to two cases: (1) interstellar clouds and (2) prominence motions. It is shown for (2) that in a perfect gas at the temperature and density of the chromosphere and inner corona, a shock wave will produce a velocity discontinuity in agreement with some observations. $H \sim 0.1$ gauss suffices to describe the prominence motion.

A Study of the Motions of Solar Prominences; Larmore, L.; Ap.J., 118, 436, 1953.
A study of the motion of four prominences concludes that Pettit's laws of prominence motion are not obeyed; no sudden velocity increases were found. A brief consideration of the motion of prominence material under the influence of electrostatic and electromagnetic forces leads to a suggestion involving two magnetic dipoles for the formation of eruptive prominences.

Active Region Prominences and the Yellow Coronal Line; Dolder, F.P., Roberts, W.O., and Billings, D.E.; Ap.J., 120, 112, 1954.
The relation of the $\lambda 5694$ coronal line to prominence activity is examined; it is found that very characteristic types of moving prominences--surge-type, doward streaming knots, focussed streamers--are closely associated with the yellow emission. Quiescent prominences appear to be negatively associated.

On Turbulence in the Quiescent Prominences; Dubov, E.E.; Publ. Crimean AO, 12, 46, 1954.

The Prominence of July 25, 1951; Rothschild, K., Pecker, J.-C., and Roberts, W.O.; Ap.J., 121, 224, 1955.
The motions of 49 knots in the prominence were measured. For 17 of them a definite variation of acceleration vectors has been found. They could not be represented by a coherent field of force. Gravity seems to play no role.

An Extra-Solar Prominence Trajectory; Pettit, E.; A.S.P. Pub., 67, 256, 1955.
Description of motion.

On the Possible Existence of Low Temperature Prominences; Öhman, Y.; Arkiv för Astronomi, 2, No 1, 1955.
The possibility of an adiabatic cooling is considered when jets of gases are leaving the solar surface.

Anisotropic Turbulence and Dissipation of Energy in Quiescent Prominences; Dubov, E.E.; Publ. Crimean AO, 15, 121, 1955.

On the Possibility of Expansion and Shock Flow in Prominences; Ericsson, U.; Arkiv för Astronomi, 2, No 1, 1956.

A suggestion of Öhman has been studied more in detail. The expansion of the gas cooled to a temperature 1700° K penetrates into the gas of 6000° K. In this way a shock wave is produced.

Motions of Prominences; Correll, M., Hazen, M., and Bahug, J.; Ap.J., 124, 597, 1956.

Trajectories of prominence material frequently display patterns which suggest motions along lines of force around a magnetic dipole. The authors try to fit a dipole field to actual observations.

On Some Solar Disturbances on 18 August and 24 September 1956; Rosseland, S., and Tandberg-Hanssen, E.; Astrophysica Norvegica, 5, No 11, 1957.

Study of an eruption prominence and its association with a small flare.

Sudden Disappearance of a Prominence on the Solar Limb; Olivieri, G.; L'Astronomie, 70, 120, 1956.

Study of the "flight" of the February 9, 1956 prominence (velocities bigger than 150 km/sec.).

An Investigation of Bright and Dark Surges Observed on the Sun; Lodén, K.; Arkiv för Astronomi, 2, No 14, 1957.

Spectroscopic measurements of radial velocities of dark surges give high values, sometimes over 500 km/s. Such high velocities make visual observations difficult because of the great Doppler shifts. In a few cases it was possible to follow visually a dark surge across the disk and over the limb where it appeared as an eruptive prominence. In these cases the ejected material shows a larger and more irregular structure than do the common surges.

Flare-Connected Prominences; Warwick, J.W.; Ap.J., 125, 811, 1957.

A combination of Lyman-α observations with ionospheric data during solar flares gives the conclusion that Lyman-α radiation pressure may contribute appreciably to forces that cause the sun to eject certain flare-associated prominences. The curvature of the trajectories followed by the material in these high-velocity prominences suggests that rather strong magnetic fields may exist in coronal regions.

A Theory of Solar Filaments; Kippenhahn, R., and Schlüter, A.; Z.f.Ap., 43, 36, 1957.

A theory of the stationary support of solar filaments by the magnetic field of Babcock's field patches is proposed. The theoretically derived structure and density of the filaments is found in satisfactory agreement with observations. Some remarks are made concerning the theory of sudden disappearances, and this theory is compared with that of corpuscular emission proposed earlier.

The Eruptive Prominence of May 18, 1956; Cragg, T.A.; A.S.P., 69, 268, 1957.
Description of motion.

On the Interpretation of Prominence Spectra:I Balmer Series Line Widths; Jeffries, J.T., and Orrall, F.Q.; Ap.J., 127, 714, 1958.
The source function for Hα in prominences is probably a function of depth. If this is so then the common method of deriving turbulence velocities may lead to erroneous results.

The Eruptive Prominence of 16 December 1956; Comper, W.; Z.f.Ap., 45, 83, 1958.
Spectrograms in $H_{\alpha 1}$ of an eruptive prominence were taken, and an ascending velocity of 2 knots in this prominence was found to be 263 km/sec.

Motions in Solar Prominences, I; Waldmeier, M.; Z.f.Ap., 44, 213, 1958.
The motions of a quasi-eruptive prominence in the polar region have been investigated. Velocities and accelerations are given. The latter are due to the sun's gravitational force and to an unknown.

Motions in Solar Prominences, II; Izsàk, I.; Z.f.Ap., 45, 91, 1958.
The motions of 23 knots in the prominence of July 18, 1956 have been studied.

Motions in Solar Prominences, III; Izsàk, I.; Z.f.Ap., 46, 203, 1958.
The motions of an eruptive prominence of July 13, 1950 are examined in detail.

On Absorption Effects in Prominences Possibly Connected with a Magnetic Cooling Mechanism Proposed by L. Marshall; Öhman, Y.; Ap.J., 108 No 1, 1958.

Physical Conditions in Limb Flares and Active Prominences. I. The Loop Prominences of November 12 and 22, 1956; Tandberg-Hansen, E., and Zirin, H.; Ap.J., 129, 408, 1959.
Included in the analysis of the spectra is mention of turbulent velocities and some details of the observed motions.

STELLAR ATMOSPHERES: NON-VARIABLE

Convection Currents in Stellar Atmospheres; St. John, C.E., and Adams, W.S.; Ap.J., 60, 43, 1924.

An investigation of relative motion at different atmospheric levels of atmosphere in eight giants. Levels assigned by comparison of excitation level of lines with Mitchell's work on solar chromosphere.

An Astrophysical Determination of the Average Life of an Excited Calcium Atom; Milne, E.A.; M.N., 84, 354, 1924.

Assuming the calcium chromosphere to be supported in a steady state by selective radiation pressure, mean life of excited Ca^+ ion is 0.6×10^{-8} sec, which is reasonable. Equilibrium corresponds to a particular central residual intensity and tends to be unstable. Theory may explain He in the metastable $2\ ^3S$ state, but hydrogen is more difficult.

The Emission of Hydrogen and Helium from a Star by Radiation Pressure and Its Effect in the Ultra-violet Continuous Spectrum; Johnson, M.C.; M.N., 85, 813, 1925.

Planetary nebula is taken as a Milne-type chromosphere above a stellar surface at 40,000°. Abundant ultra-violet makes He^+ and heavier ions rise highest; H experiences no appreciable lift owing to high ionization, nor do electrons. High velocities attained by electrons photo-ejected at great heights under subsequent free fall may account for the Balmer continuum.

On the Origin of Bright Lines in Stellar Spectra; Rosseland, S.; Ap.J., 63, 218, 1926.

A discussion of four possible mechanisms for the production of emission lines in stellar spectra. It is suggested, particularly for late-type spectra, that departures from hydrostatic equilibrium might produce "violent and local variations in temperature" that would give rise to emission lines.

The K-Term, Relativity Displacements and Convection Currents in B-Type Stars; Albrecht, S.; Ap.J., 63, 277, 1926.

An analysis of factors contributing to the K-term for B stars. It is found that systematic errors may contribute to the K-term; also, the relativistic gravity shift is evaluated. When these effects are removed, there remains a value of +1.2 km/sec, which may be explained in terms of predominating downward convection in B-type atmospheres, though there is a "fair possibility that (such currents) may be negligible."

The Velocities of Ions under Radiation Pressure in a Stellar Atmosphere, and Their Effect in the Ultra-violet Continuous Spectrum; Johnson, M.C.; M.N., 86, 300, 1926.

Electrons and ions separate under gravity and radiation pressure, but space charge keeps equilibrium that may break down for He, Ca, Si, C, N, O if star temperature exceeds 25,000°. Ions of these may then be shot out together with electrons, which produce continuous emission through partial captures by protons.

Selective Radiation Pressure and the Structure of a Stellar Atmosphere; Milne, E.A.; M.N., 87, 697, 1927.

Selective radiation pressure is unimportant in interiors owing to isotropy of the radiation field. Transition to the boundary is discussed, distinguishing layer R_2 in LTE (photosphere and lower reversing layer) and R_1 with coherent scattering (upper reversing layer and chromosphere) forming line cores.

The Theoretical Contours of Absorption Lines. I; Pannekoek, A.; M.N., 91, 139, 1930.

Turbulence alone cannot account for the finite central intensities of strong lines without introducing excessive broadening of the line core.

On the Stability of the Outer Layers of a Star; Thüring, B.; Z.f.Ap., 2, 70, 1931.

The influence of an ionization of the matter in the outer layers of a gaseous star on the specific heat can cause an instability of these layers. A special assumption about the energy generation in the interior and deviations from an ideal gas can remove these instabilities.

Axial Rotation as a Major Factor in Stellar Spectroscopy; Struve, O.; Obs., 54, 80, 1931.

Evidence from eclipsing binaries suggests that rotation, not convection, causes dish-shaped profiles in early-type stars. Rotation is especially associated with Be stars; equatorial velocity of 250 km/sec leads to rotational instability. Lack of rotation may account for narrow lines of supergiants, either as a real effect or because rotation simulates earlier spectral type.

The Spectrum of Alpha Canis Minoris; Albrecht, S.; Ap.J., 80, 86, 1934.

High-dispersion spectra give no evidence for any level effect, in terms of velocity, in this dF5 atmosphere.

The Intensities of Stellar Absorption Lines; Struve, O., and Elvey, C.T.; Ap.J., 79, 409, 1934.

The classic paper introducing the concept of "turbulence" in stellar spectra to explain the large equivalent widths observed in spectra of several supergiants.

Radiation Pressure in an Expanding Nebula; Zanstra, H.; M.N., 95, 84, 1934.

Radiation pressure of Lyman α is cut down by (1/3) $(w/v_L)^2$ in case of accelerated expansion with velocity proportional to optical depth (w = random velocity parameter; v_L = velocity range), compared with the value found by Ambarzumian; this explains the low expansion velocities observed.

Systematic Displacements of Lines in the Spectra of Certain Bright Stars; Adams, W.S., and MacCormack, E.; Ap.J., 81, 119, 1935.

Radial convection currents in stellar atmospheres, with upward motion at low levels and downward motion at high levels, is used to explain displacements of some lines.

Recent Changes in the Spectrum of γ Cassiopeiae; McLaughlin, D.B.; Ap.J., 84, 235, 1936.

Remarkable changes in the spectrum of this Be star appear to indicate that material is being added to the outer shell "by the process of outward streaming of atoms."

On the Theory of Rotating Gas Masses; Krat, W.; Z.f.Ap., 12, 192, 1936.

The differential equations which describe a rotating gaseous mass are discussed. It is pointed out that in the atmosphere of close binaries tidal pulsations should occur.

Dynamics of Radiation Pressure for a Diffuse Nebula; Zanstra, H.; M.N., 97, 37, 1936.

Lyman α radiation pressure is found for general distribution of velocity as a function of optical depth and resulting dynamics is compared with observations of the Orion Nebula giving rough agreement with the observed line width of 25 km/sec.

Surface Gravity in Supergiant Stars; Pannekoek, A.; B.A.N., 8, 175, 1937.

An analysis of the low effective gravity in supergiants in terms of a radiation pressure varying with atmospheric depth, leading to streaming motions in the atmosphere.

Quantitative Analysis of the B Star τ Scorpii; Unsold, A.; Z.f.Ap., 21, 22, 1941.

The analysis of the atmosphere of this star indicates among other results, that no considerable turbulence seems to exist.

On the Curve of Growth of the Chromospheric Absorption in the Spectrum of ζ Aurigae; Wellmann, P.; Z.f.Ap., 20, 303, 1941.

The interpretation of the curve of growth of the chromospheric absorption in the eclipsing binary system ζ Aurigae indicates a rather pronounced turbulence in the atmosphere of this star.

Ionization Equilibrium in a Convective Region; Eddington, A.S.; M.N., 101, 177, 1941.

For currents rising through the convection zone at a few km/sec, Saha's equation breaks down owing to the time taken for recombination. This may lead to (a) excess ultra-violet radiation and (b) a greatly increased extent of the convection zone.

On the Existence of Electromagnetic-Hydrodynamic Waves; Alfvén, H.; Arkiv Mat., Astr., Fys., 29 B, No 2, 1942.

On the Type of Convection in the Zone of Instability; Biermann, L.; Z.f.Ap., 22, 65, 1942.

The characteristic number which determines the type of convection in a thermally unstable matter is given.

On Convection is Stellar Atmospheres; Rudkjöbing, M.; Z.f.Ap., 21, 254, 1942.

The convection in the atmosphere of the sun, a yellow giant star and a star of spectral type A 5 is estimated. Only in the A star the convection zone seems to reach into the atmosphere, while it remains in the deeper layers in the other two types of stars.

On the Effect of a Vertical Magnetic Field in a Conducting Atmosphere; Alfvén, H.; Arkiv Mat., Astr., Fys., 29 A, No 11, 1942.

A static equilibrium in a vertical magnetic field is possible only if the temperature in the field is lower than in the environment. But radiation will tend to smooth out the temperature differences in every horizontal layer. This must give rise to convection currents. In the centre of the field the currents flow upwards, thus cooling the gas adiabatically.

The Spectrum of α Carinae; Greenstein, J.L.; Ap.J., 95, 161, 1942.

A detailed study of the spectrum of this supergiant F0 star apparently confirms a general relation between increased turbulence and luminosity.

The Spectrum of BD $+11^{\circ}4673$ During the Years 1937-1941; Merrill, P.W.; Ap.J., 95, 386, 1942.

It is hypothesized that the peculiar spectrum is due to continuous accelerated ejection of material from the star's surface with a stratification of atoms producing a particular spectral line.

The Composite Spectrum of ζ Tauri; Hynek, J.A., and Struve, O.; Ap.J., 96, 425, 1942.

The secondary disturbance in the velocity curve is supposed due to prominence activity on the side of this star which faces its invisible companion.

Tables of Model Stellar Atmospheres; Strömgren, B.; Det Kgl. Danske Videnskabernes Selskab, Mat.-Fys. Meddelelser XXI, 3, 1944.

The paper is, for a small part, concerned with the convectional instability in a stellar atmosphere.

Rapid Changes in the Spectrum of HD 218393; Struve, O.; Ap.J., 99, 75, 1944.

The author presents arguments in favor of "exceptionally powerful prominence activity" which is enhanced by the rapid rotation of this shell star.

"Physical Characteristics of the Atmospheres of Supergiants of Classes cB5 to cA3" by G. A. Shajn; Struve, O.; Ap.J., 100, 88, 1944.

This is a critical review of Abastumani Observatory's Bulletin No. 7. Shajn has found a g_{eff} of the order of unity for early supergiant stars; if indeed the atmospheres of these stars are supported by radiation pressure, then there may be a tendency towards expansion. It appears that the early supergiants do have a negative K-term, and there may be evidence for a change of K with spectral type, in the sense of less negative K for later types.

"Gaseous Rings in Close Binary Systems" by Struve, O.; Obs., 66, 208, 1946.

One in four of deep-eclipse systems show ring effects, and more do so for long periods. Excellent correlation exists between period and spectral type. Ring size is roughly that of the large cool component. Variable, double bright lines show complex motions.

"An Interesting Phenomenon in Stellar Spectroscopy" by Struve, O.; Ap.J., 104, 138, 1946.

Turbulent velocities in the atmosphere of δ CMa are of the order of 5 km/sec from curve of growth analysis. Yet individual line contours indicate turbulence up to 30 km/sec. Emphasizes need for analysis of line profiles as well as total absorption.

Curve of Growth of γ Cygni; Sahade, J., and Cesco, C.U.; Ap.J., 104, 133, 1946.

A curve of growth for this F8Ib star yields an atmospheric turbulent velocity of 7.5 km/sec.

A Comparative Study of the Spectra of α Bootis and 70 Ophiuchi A; Dijke, S.E.A.v.; Ap.J., 104, 27, 1946.

Curve of growth analysis indicates that the turbulent velocity in the atmosphere of Arcturus is 3.25 km/sec.

Some Radial Velocity and Line-Intensity Measures in the Spectrum of β Canis Majoris; Underhill, A.B.; Ap.J., 104, 388, 1946.

Curves of growth show that the wide OII and He I lines are not due to microturbulence; macroturbulence is suspected as causing the widening.

Studies in Hydrodynamics and Structure of Stars and Planets; Wasiutyński, J.; Astrophysica Norvegica, IV, 1946.

The paper comprises a large volume of nearly 500 pages. It contains the following chapters: 1. Turbulence in Stars; 2. Large-Scale Currents in Stars, Historical Survey and Generalities; 3. The Hydrodynamics of Solar Activity and Stellar Variability; 4. Convection Currents of the Bénard-Rayleigh and Allied Types, especially in the Outer Layers of the Sun; 5. Orogenic Currents in Planets; 6. Currents in Planetary Atmospheres and Stellar Evelopes; 7. Gravitational Instability in Stars; 8. Stellar Structure and Evolution. At the end of the volume there is a bibliography of 14 pages.

On the Temperature Distribution in a Stellar Atmosphere with a Convectively Unstable Zone; Rudkjøbing, M.; Publ. Københavns Observatorium, No 143 (Reprinted from Annales d'Astrophysique, 9, 1-2), 1946.

The temperature gradient in the convective layer of the solar atmosphere is calculated on the basis of 1. convective equilibrium and 2. radiative equilibrium. The influence of their difference upon the net flux of radiation in the upper stable layer is investigated. It is found that the temperature gradient has to be raised in the latter layer in order to make the flux constant. This leads to a ratio of effective temperature to surface temperature, which differs from the standard relation holding for an atmosphere in radiative equilibrium throughout. Further it raises the upper boundary of the convective layer to a higher level.

The Pressure of Radiation in Stellar Atmosphere; Pickelner, S.B.; AJ USSR, 24, No 1, 3-14, 1947.

On the Nonstationary Stellar Atmospheres; Severny, A.B.; AJ USSR, 34, No 6, 344-358, 1947.

On the Atmospheres of B-Stars; Rudkjøbing, M.; Publ. Københavns Observatorium, No 145, 1947.

A part of the paper is concerned with the stability against convection of a model atmosphere.

The Systematic Shift of Spectral Lines of O Ceti; Shajn, P.Ph.; Publ. Crimean AO, 1, Part I, 116, 1947.

Absorption Lines Formed in a Moving Atmosphere; Underhill, A.B.; Ap.J., 106, 128, 1947.

A calculation of line profiles produced in a uniformly expanding atmosphere. As the velocity of expansion increases, the lines become shallower and broader, and asymetric wings develop to the red. Rotation, expansion, and turbulence are shown to produce a change in the equivalent width of the line.

The Structure of the Atmosphere of the K-Type Component of Zeta Aurigae; Wilson, O.C.; Ap.J., 107, 126, 1948.

Turbulence in the K5 atmosphere increases with height--there is a linear relation between height and $\Delta\lambda_D$. Derivation of densities as a function of height shows that the density gradient for the K5 atmosphere is smaller than the theoretical gradient by a factor of twenty. Turbulent support of the atmosphere is invoked, but the observed gradient is still too flat by a factor of ten.

Spectrophotometry of the F Stars and of Tau Ursae Majoris I; Greenstein, J.L.; Ap.J., 107, 151, 1948.

Turbulent velocities tend to increase as one passes from normal and sub-giant stars to supergiants. Systematically, $g_{eff} < g$. The turbulent velocity for the peculiar F star τ UMa is very large for a dwarf: 4 km/sec. The ratio g_{eff}/g is quite small.

The Intensities and Profiles of Lines in Some B-Type Stars; Underhill, A.B.; Ap.J., 107, 349, 1948.

The author finds a $\Delta\lambda_D$ of 37 ± 2 km/ sec for 0^2 CMa and 27 ± 2 km/sec for ϵ CMa. "These values, if interpreted as turbulent velocities, are considerably larger ..." than those found previously.

The Differential Systematic Shift of Spectral Lines of White Supergiants; Shajn, G.A.; Publ. Crimean AO, 4, 23, 1949.

The hydrogen lines of α Cyg, β Ori, 67 Oph show a small positive shift in comparison with the lines of ionized metals (2-4 km/sec).

Turbulence--A Physical Theory of Astrophysical Interest; Chandrasekhar, S.; Ap.J., 109, 329, 1949.

Conceptual summary of developments in spectral theory of turbulence and a survey of various astrophysical problems in which turbulence may play a role, mainly in cosmogony with a passing reference to the importance of turbulence in solar granulation.

On the Effect of Radiation Pressure in the Atmospheres of Early-Type Stars; Underhill, A.B.; M.N., 109, 562, 1949.

Radiation pressure becomes appreciable when effective temperature exceeds 2×10^4. Unsöld's entropy method is extended to find the adiabatic gradient in the presence of radiation, which turns out to be lower than otherwise. Finally, surface layers are blown off by radiation pressure if $g < 3700$.

Analysis of the Metallic-Line Stars. II; Greenstein, J.L.; Ap.J., 109, 121, 1949.

One section is devoted to a discussion of turbulence in the atmospheres of these stars.

The Turbulent Velocities in the Red Giant Atmospheres; Schatzman, E.; C.R., 238, 814, 1949.

Investigation of the transformation of acoustic waves into shock waves, attempting to explain the differences between velocities deduced from the curves of growth and those deduced from the line-profiles. Numerical calculations with $\gamma = 0.3$, $F_{mech}/F_{tot} = 1/25$. (Conservation of the mechanic energy flux, equation of hydrostatic equilibrium.

Curves of Growth and Line Contours; Unsöld, A., and Struve, O.; Ap.J., 110, 455, 1949.

An interpretation of curve of growth data for δ Canis Majoris assuming large scale turbulent velocities. Turbulent velocities are greater for ionized atoms and for atoms of low excitation potential than for neutral atoms and atoms of high excitation potential. The ionized and low excitation potential atoms are most likely to be found in the upper layers, where the velocities will be greater because of the low pressure.

A Thermodynamic Consideration in Relation to Acoustic Energy in Stellar Models; Gold, T.; M.N., 109, 115, 1949.

Thermal generation of free acoustic energy at T_1 requires net outflow of heat $T_2/(T_1 - T_2)$ times as great, so that acoustic waves can never be the main means of energy transfer.

Turbulence in Stellar Atmospheres; Schatzman, E.; Ciel et Terre, 66, 222, 1950.

A summary of how an absorption line is formed in a stellar atmosphere and several examples on how to produce turbulent motions in the laboratory. Then an application to stellar atmospheres of the results obtained from experiences in laboratories. This paper summarizes the chief ideas concerning turbulence in stellar atmosphers.

On Turbulence in the Atmospheres of the Sun and the Stars; Huang, S.-S.; Ap.J., 112, 418, 1950.

"... the observed data on turbulence in stellar atmospheres can be understood, at least qualitatively, in terms of the hierarchy of eddies as introduced by Kolmogoroff." The effects of macroturbulence and microturbulence on absorption lines are analyzed and the application to observational evidence of turbulence discussed. The turbulent spectrum of the solar atmosphere is considered, and the Richardson-Schwarzchild spectrum is revised. The spectrum has its maximum at a scale size corresponding to granule diameters of 100 km.

Model of a Turbulent Stellar Atmosphere; Baroin, M., and Schatzman, E.; C.R., 231, 757-758, 1950.

For a star like η Aquilae, calculations of an atmospheric model with large turbulent velocities caused by the propagation of shock waves of large amplitude (turbulent pressure and dissipation of the acoustic mechanical flux are taken into account). Results fitting with the interpretation of δ Canis Majoris spectrum by Struve and Unsöld.

Spectra of White Dwarfs; Schatzman, E.; Det. Kgl. Danske Videnskabernes Selskab, Mat.-Fys. Meddelelser, 25, 7, 1950.

For a small part the paper is concerned with the convective layer in the atmosphere of a white dwarf.

Adjustments within Shells and Asymmetric Ejecta from Z And, ζ Aur, β Lyrae, γ Cas and ρ Cas; Johnson, M.; M.N., 110, 84, 1950.

"Stratification" in peculiar spectra may be due to (a) excitation variations, (b) separation of elements, or (c) lack of spherical symmetry. From equations of McCrea (1935), viscosity prevents (b) for densities above 10^8 cm^{-3} except in case of actual eruptions with differential radiation pressure found following Gerasimovic (1934). From work of Grotrian (1937), (a) may exist for long periods owing to time of readjustment to steady state after sudden changes in stellar radiation, but (b) may occur under "nebular" conditions.

On the Doppler Broadening of Absorption Lines by Turbulence and by Multiple Interstellar Clouds; Huang, S.-S.; Ap.J., 112, 399, 1950.

A study of the influence of turbulence on an absorption line. Line profiles and curves of growth are calculated for two distributions of turbulent velocities: A Gaussian distribution and a delta-function distribution; the profiles are greatly different for the two cases while the curves of growth are quite similar.

Turbulence and the Curve of Growth; Wrubel, M.H.; Ap.J., 112, 424, 1950.

A weighting function is developed for a continuous-energy spectrum of turbulence; this weighting function expresses the contribution which eddies of various sizes make to a curve of growth. In order to explain the large differences between turbulent velocities inferred from line profiles and curves of growth for supergiant spectra, a turbulence spectrum with considerable energy in the very large eddies is required.

The Condition for Turbulence in Rotating Stars; Cowling, T.G.; Ap.J., 114, 272, 1951.

Stability against convection for small displacements is analyzed for both uniformly and non-uniformly rotating stars. For axial symmetric displacements a stabilizing condition is found, while for non-symmetric displacements the stabilizing effect is less or vanishing.

On the Variation of Turbulent Velocities in Stellar and Solar Atmospheres; Huang, S.-S.; Ap.J., 114, 287, 1951.

A demonstration that the turbulent velocity varies with the excitation potential of the lower level of the line used to observe the motion, and that the turbulent velocity is greater for ionized atoms than for neutral atoms, assuming the turbulent velocity in the "reversing layer" to increase exponentially with height. The calculated curves of turbulent velocity versus ionization potential are compared to curve of growth data for the sun and selected stars; also center to limb variation in inferred turbulent velocity is discussed.

Displaced Calcium Lines in the Spectrum of HD 190073; Merrill, P.W.; Ap.J., 113, 55, 1951.

A study of displaced components of Ca^+ H and K; the displacements lie in three groups--0, 150-200, and 300-400 km/sec. with little temporal variation. The persistent displacement results from atoms transported from the photosphere through circumstellar zones in which the lines are formed.

Shell Stars; Merril, P.W.; A.S.P. Pub., 63, 113, 1951.

Atoms are not expelled at high velocities, but drift outward from the photosphere slowly. Brief mention of the nature of the forces which might have caused the movement.

Displaced Helium Lines in the Spectrum of BD +11°4673; Merrill, P.W.; Ap.J., 114, 338, 1951.

Measures of the displacement of components of HeI 3888 suggest discrete outward motions possibly related to the rapid motions of eruptive prominences.

The Interpretation of Change in Spectra of γ Cas; Gorbatsky, V.G.; AJ USSR, 28, No.6, 450-465, 1951.

The Curve of Line-Width Correlation and Doppler Velocities in Stellar Atmospheres; Huang, S.-S., and Struve, O.; Ap.J., 116, 410, 1952.

A method of studying turbulence in stellar atmospheres is developed; it depends on a relation between equivalent widths and half-widths of absorption lines. The spectrum of turbulence derived is discrete, assigning unique velocities to the small and large eddies. Application is made to δCMa.

Compression Waves in an Atmosphere in Radiative Equilibrium; Dumezil-Curien, P.; C.R., 235, 1369-70, 1952.

The variation with height of the acoustic radiation pressure due to compressive waves produces an effective gravity bigger than the true gravity in a large portion of the atmosphere. Estimations of this effect for a red giant in radiative equilibrium.

Quantitative Analysis of the Supergiant 55 Cygni; Voigt, H.H.; Z.f.Ap., 31, 48, 1952.

Besides other information, the analysis of the atmosphere of 55 Cygnis leads to a turbulence velocity of 36 km/sec.

Thermal Velocities in the Red Giants Atmospheres; Schatzman, E.; C.R., 234, 1349, 1952.

The constant ratio existing for certain stars between the mechanical flux and the total flux is supposed to be the consequence of compression waves produced by the turbulence existing in a thick convective zone.

Intensity and Radial-Velocity Measurements on the Spectrum of Zeta Aurigae at Recent Eclipses; McKellar, A., and Petrie, R.M.; M.N., 112, 641, 1952.

Deviations of individual velocities of hydrogen and metal lines from the mean curve for the gK component suggest varying large-scale prominence activity.

Two F-Type Stars with Expanding Hydrogen Atmospheres; Merrill, P.W.; Ap.J., 115, 154, 1952.

Two spectroscopic binaries in which one component resembles a giant or supergiant F-type star. Spectra show bright hydrogen lines with greatly displaced dark hydrogen lines; these dark lines show large outward velocities which are subject to large variations. An interpretation in terms of material ejected from the surface of the F star in prominence-like activity.

Radial Velocities of 31 Cygni During Atmospheric Eclipse; McLaughlin, D.B.; Ap.J., 116, 546, 1952.

A detailed discussion of radial velocities measured near second and third contacts suggests great prominence activity at the surface of the K1 supergiant component.

The Motion of a Gas Cloud Expanding into a Vacuum; Pack, D.C.; M.N., 113, 43, 1953.

Unless certain initial conditions are satisfied, continuity breaks down and shock waves must occur. A particular example is considered and it is shown that the disconcertingly high final velocity obtained in previous solutions cannot be avoided by varying the initial inhomogeneities.

Eta Carinae. II. The Spectrum; Gaviola, E.; Ap.J., 118, 234, 1953.

Study of the spectrum suggests that the emission is produced by localized eruptions which do not disturb the star's atmosphere.

Intercomparison of Shell Spectra; Merrill, P.W., and Lowen, A.L.; Ap.J., 118, 18, 1953.

Data concerning motions in shells are summarized. Atoms which form the shell leave the photosphere very slowly; brief discussion of the accelerating force.

A Study of Line Profiles: The Spectrum of Rho Leonis; Huang, S.-S.; Ap.J., 118, 463, 1953.

Theoretical broadening functions and line profiles for various possible types of mass motion are presented. Lines of the spectra of Rho Leonis are compared to the theoretical profiles; it is not possible to differentiate between rotational broadening and broadening by vertical convection with a step function distribution of velocities.

On the Problem of the $H\alpha$ Emission in the Shell Stars; Underhill, A.B.; M.N., 113, 477, 1953.

$H\alpha$ and $H\beta$ emissions observed in certain Be stars suggest rotational broadening in equatorial bulge as suggested by Struve, but extended wings in H_{α} suggest faster, randomly oriented, tenuous streamers.

Contribution to the Physical Study of the Convective Zone; Pecker, C.; Ann.d'Astrophys., 1953.

Investigation of stellar atmospheric models having an adiabatic convective zone underlying exterior radiative zone. Discussion and demonstration of presence of two zones of instability produced by the ionization of H and HeII. Discussion of the results.

Waves of Finite Amplitude in an Infinite Homogeneous Medium; Helfer, H.L.; Ap.J., 119, 34, 1954.

Stationary, progressive and solitary waves are all permitted solutions in an infinite homogeneous medium, including gravity. Jeans' criterion represents adequately the effective scale of these disturbances, so long as they are purely adiabatic. Non-adiabatic processes may result in stable fluctuations much in excess of Jeans' critical length.

Some Results of Spectrophotometric Study of A Stars; Melnikov, O.A.; AJ USSR, 31, No 3, 249-268, 1954.

The observational data about turbulence in the atmospheres of these stars are discussed.

Origin of Narrow Absorption Lines in the Spectra of Be Stars; Gorbatsky, V.G.; AJ USSR, 31, No 5, 413-424, 1954.

Movement of the shells of γ Cas and Pleona.

Chromospheric Structure of the K-Type Component of Zeta Aurigae; Wilson, O.C., and Abt, H.A.; Ap.J. Supplement, 1, 1, 1954.

Analysis of spectrograms made during ingress and egress of the B star behind the K-type component leads the authors to conclude that the K-type chromosphere consists mostly of small, dense condensations. The relative motions of these condensations accounts for the observed turbulence. Suggestion is made that these condensations might be similar in nature to the solar spicules.

The Motion of Ionized Gas in Combined Magnetic, Electric and Mechanical Fields of Force; Piddington, J.H.; M.N., 114, 651, 1954.

Transient space-uniform electric and mechanical forces acting on anisotropically conducting medium lead to damped oscillatory motion followed by a steady state. Internal electric fields perpendicular to the magnetic field are accompanied by mechanical forces, the neglect of which vitiates many astrophysical theories. Solution given here should have numerous astrophysical applications.

On the Propagation of a Wave Through a Generalized Roche Model; Simon, R.; The Institute of Theoretical Astrophysics, Blindern, Norway, Reprint No 11 (Reprinted from Annales d'Astrophysique, 18, 92), 1955.

The paper discusses the propagation of a radial perturbation through the envelope of a generalized Roche model, the surface of the core acting as a piston. When the equations may be linearized, an explicit solution may be found for certain values of the parameters.

Angular Momentum Transport by Magnetic Fields and the Deceleration of Rotating Stars; Lüst, R., and Schlüter, A.; Z.f.Ap., 38, 190, 1955.

To explain the observed correlation between the spectral type of a star and its axial rotation, the magnetic deceleration of a rotating star is discussed. It is shown that torque-free magnetic fields can transport angular momentum. The present loss of angular momentum of the sun is estimated, as well as the loss during the lifetime of a star. The mechanism is effective enough to decelerate even fast rotating stars.

On Thermal Convection in a Polytropic Atmosphere; Skumanich, A.; Ap.J., 121, 408, 1955.

An investigation of thermally induced convection in a horizontally stratified, polytropic atmosphere with a large density variation. The speed of development of a perturbation increases with decreasing horizontal wave length of the perturbations.

Magnetohydrodynamic Waves Under the Action of the Coriolis Force. II; Lehnert, B.; Ap.J., 121, 481, 1955.

Three effects modify the properties of magnetohydrodynamic waves when the coriolis force is comparable to the electromagnetic force: (1) a plane polarized Alfvén wave is split up into two circularly polarized waves, (2) a complex disturbance will not necessarily travel along the external magnetic field and will be distorted because of anisotropic dispersion, and (3) for large amplitudes, nonlinear interactions arise between the components of the spectrum of a traveling disturbance. Applications to sunspots.

The Atmosphere of the B O-star τ Scorpii; Traving, G.; Z.f.Ap., 36, 1, 1955.

A detailed analysis of the atmosphere of the B O-star τ Scorpii seems to indicate that no turbulence is effective in the atmosphere of this star.

The Atmosphere of the A O-star α Lyrae; Hunger, K.; Z.f.Ap., 36, 42, 1955.

The curve of growth leads to a turbulence velocity of the atmosphere of roughly 3 km/sec.

The Deep Atmosphere Layers of the K Component in the System ζ Aurigae; Groth, H.G.; Z.f.Ap., 37, 261, 1955.

The curve of growth constructed with equivalent widths of 130 lines gives excitation temperatures and atomic numbers for some metals and hydrogen and a turbulence velocity of 14.5 km/sec.

Relative Abundances and Atmospheric Conditions in the Magnetic Star HD 133029; Burbidge, E.M., and Burbidge, G.R.; Ap.J., 122, 396, 1955.

Velocities measured by curve-of-growth analysis indicate hydromagnetic turbulent motions.

Study of Doppler Velocities in Stellar Atmospheres, The Spectrum of Alpha Cygni; Huang, S.-S., and Struve, O.; Ap.J., 121, 84, 1955.

New methods are advanced for the study of Doppler velocities in stellar atmospheres and applied to spectra of α Cygni, ρ Leonis, and δ Canis Majoris.

Nuclear Reactions and Element Synthesis in the Surfaces of Stars; Fowler, W.A., Burbidge, G.R., and Burbidge, E.M.; Ap.J. Supp. Ser., 2, 167, 1955.

It is suggested that regions develop in which sufficient magnetic energy is available to accelerate particles on the stellar surface so that nuclear reactions can take place there. Possibly the particles are accelerated in regions of changing magnetic field by the Swann betatron mechanism, modified to take account of the plasma and collision properties of the gas.

Hydromagnetic Waves in Ionized Gas; Piddington, J.H.; M.N., 115, 671, 1955.

Theory is given for the 3 hydromagnetic waves propagated in an anisotropically conducting gas and their physical nature is discussed.

The Correlation Curves in the Schuster-Schwarzschild Hypothesis; Regemorter, H.V.; C.R., 240, 1968, 1955.

Extension of the work of Struve and Huang, applying Pecker's formula for the intensities and the equivalent widths. Deep modifications of the values of microturbulence and macroturbulence found. Precise calculations will be done for δ Canis Majoris and for the sun using the Fe neutral lines.

Influence of Magnetic Field on Convective Instability in the Atmospheres of Stars and the Ionosphere of the Earth; Hershman, B.N., and Ginsburg, V.L.; AJ USSR, 32, No 3, 201-208, 1955.

On the Equilibrium of Magnetic Stars; Mestel, L.; M.N., 116, 324, 1956.

Ferraro (1954) showed that Cowling's (1945) decaying field fails to satisfy a certain non-linear condition derived for incompressible fluid and concluded that it would set up mass motions. However, a gas can adjust itself to a stress by temperature changes having only a very small reaction on the field through energy balance. The electron-pressure and magnetic force terms lead to a slight modification of the iso-rotation law.

The Dissipation of Magnetic Energy in an Ionized Gas; Cowling, T.G.; M.N., 116, 114, 1956.

Piddington's results for the dissipation rate are confirmed and generalized by a simpler derivation and his criticisms of the "equivalent electric force" concept rejected. In a partially ionized gas the rate of dissipation may become appreciable owing to collisions between ions and neutral atoms.

Line Broadening in the Spectra of O- and Early B-Type Stars; Slettebak, A.; Ap.J., 124, 173, 1956.

Although it is impossible to distinguish between rotation and macroturbulence as the mechanisms contributing to broadened lines in a given spectrum, a statistical discussion leads to: Large scale motions contribute to broad lines in all very early stars (O5--O8) and to the high-luminosity stars of types 09--B1; these large scale motions appear to increase with increasing temperature and luminosity, while the contribution by axial rotation decreases with increasing luminosity at a given spectral type. Large-scale motions no longer dominate in supergiants later than B1. At 05- 08 axial rotation increases, and macroturbulence decreases, with decreasing luminosity.

On the Energy Transfer in Thermally Inhomogeneous Medium at Turbulent Convection; Zhevakin, S.A.; AJ USSR, 33, No 2, 137, 1956.

A Spectrophotometric Analysis of Two Metallic-Line Stars; Miczaika, G.R., Franklin, F.A., Deutsch, A.J., and Greenstein, J.L.; Ap.J., 124, 134, 1956.

Analysis of curves of growth and line profiles for the spectra of two metallic-line A stars. Turbulent velocities of 3.8 km/sec (15 Vul) and 4.8 km/sec (8 Com) result. "It thus seems beyond doubt that turbulence is linked with metallicism."

A Possible Cause of the Ejection of Material by Late-Type Giants; Hoyle, F.; Ap.J., 124, 482, 1956.

In sub-photospheric regions, ionized hydrogen at 20,000° possesses a total energy of which only a small fraction is kinetic; the rest is contributed as ionization energy: Through some sort of perturbation, this could be converted entirely into kinetic energy of mass motion; the resulting velocity would be about 60 km/sec. This may be the cause for ejection of material as observed in α Her.

A Microphotometric Study of the Spectrum of Maia; Huang, S.-S., Struve, O.; Ap.J., 123, 231, 1956.

A microturbulent velocity of 1.5 km/sec is derived from curve of growth analysis; the widening of the spectrum lines is due to rotation and not to macroturbulence.

Complex Lines in the Spectrum of RW Cephei; Merrill, P.W., and Wilson, O.C.; Ap.J., 123, 392, 1956.

A model for the atmosphere is proposed: Absorption lines from the reversing layer are widened--probably by turbulence--to a total velocity spread of 80 km/sec. An emitting zone above the reversing layer is either stationary or has a small outward velocity, while absorption lines originating in an expanding "upper atmosphere" are narrow and are shifted to the violet by 20 km/sec. Such a three-layer model might be characteristic of M-type supergiants, and possibly of S-type stars.

Spectrophotometry of Gamma Leonis; Wehlau, W.H.; Ap.J., 123, 34, 1956.

Application of Huang and Struve's curve-of-line-width correlation to study the turbulence; the velocities derived for small eddies are 3.1 km/sec and 2.3 km/sec for the primary (KO III) and secondary (G7 III) components; pressures due to the turbulent velocities are quite inadequate to account for differences between the effective surface gravity and the values determined from the dimensions of the stars.

Investigation of a Stellar Model for a Red Giant; Dumezil-Curien, P.; Ann. Astrophys., 17, 197, 1956.

For an η Aqu-type star, investigation of a model with a convective zone in the outer layers, and in the inner regions, a zone of discontinuity in chemical composition.

Atmospheres of the B Stars. I. The Supergiant Epsilon Canis Majoris; Aller, L.H.; Ap.J., 123, 117, 1956.

Application of three formulations for the curve of growth, and derived atmospheric parameters are compared. The degree of microturbulence is different for the three theoretical curves used, being least for a Milne-Eddington formulation with pure scattering, intermediate for the Unsöld approximation and greatest for a pure absorption Milne-Eddington formulation. The greatest difference amounts to 0.4 in log v.

Spectrophotometric Analysis of the Brightest Herbig-Haro Object; Bohm, K.-H.; Ap.J., 123, 379, 1956.

It is shown that the level of ionization is due to a strong ultraviolet radiation field, and a tentative suggestion of a strong convection zone near the surface which might be responsible for an extended, ultraviolet-emitting chromosphere is advanced.

Magneto-hydrodynamical Motions with Axial Symmetry. The Case of the Small Oscillations of a Spheroidal Fluid Mass; Agostinelli, C.; Atti Acc. di Torino, 91, 263-298, 1956-57.

A study of magneto-hydrodynamical motions with an axis of symmetry assuming that the fluid mass is rotating uniformly about the axis and is subjected to a uniform magnetic field parallel to the axis. The amplitude of oscillations increase with the angular velocity; the frequency of the waves produced by the oscillations can be arbitrary, but for the velocity of propagation a set of eigenvalues exist. The first of these results can explain why sun-spots are confined in the low solar latitudes.

Asymmetric Contours of CaII K Line; Miyamoto, S.; Publ. Astr. Soc. Japan, 9, 146-169, 1957.

The double reversal of CaII H and K lines observed in the solar and late type stars is assumed due to frequency redistribution by non-coherent scattering in the atmospheres. The contours are calculated for the atmosphere in differential motion and compared with the observations. Calculations for the cases: (1) The optical thickness of the upper (falling) atmosphere at the line center is unity, and (2) the optical thickness of the upper atmosphere at the inner wing is unity. In case (1), the central K3 absorption is very much weakened compared with the static contour. The K3 contour becomes asymmetric and the violet component of K2 emission is strengthened while the red component weakened. The wave length shifts of K2 and K3 are small and complicated.

Coronal Streaming in Solar Sunspot Prominences; Marshall, L.; Ap.J., 126, 177, 1957.

An explanation of coronal condensations and streaming temperatures and pressures in looped solar prominences are such that small changes in kinetic temperature cause large changes in the density of H atoms and therefore increase the intensity of Hα light emitted. It is proposed that small changes in magnetic fields of looped prominences produce these changes by induction acceleration. A proposal that small changes in magnetic fields in looped prominences suffice to change T_e from its equilibrium value to the value at which radiative instability sets in, thus causing a change in observed form of the prominences.

H and K Emission in Late-Type Stars: Dependence of Line Width on Luminosity and Related Topics; Wilson, O.C., and Bappu, M.K.V.; Ap.J., 125, 661, 1957.

An empirical study of the widths of the Ca^+ H and K emission Cores as a function of (1) emission intensity, (2) stellar luminosity, and (3) spectral type. An interpretation assumes a thin hot layer to form the emission core; the width arises from the turbulent broadening; an asymmetry of the lines comes from an outward motion of the hot layer and an inward motion of an overlying thin absorbing layer.

The Study of Gaseous Motions in Stellar Atmospheres: A Review; Huang, S.-S.; Pub. A.S.P., 69, 65, 1957.

A review of work at Berkeley in the five preceding years on gaseous motions in stellar atmospheres with a short qualitative discussion of: (1) broadening effects of large and small eddies, (2) separations or asymmetries in spectral lines due to motions, and (3) methods of determining the magnitude of turbulent motions.

Turbulent Velocities Inferred from the H and K Emission Lines in Stellar Spectra; Goldberg, L.; Ap.J., 126, 318, 1957.

A re-interpretation of the Wilson-Bappu results (1957) in H and K emission cores, in terms of a thick atmosphere.

Some Characteristics of Shells of Be Stars; Boyarchuk, A.A.; AJ USSR, 34, No 2, 193-202, 1957.

The system is probably formed by an undermassive late A-type star which ejects matter at high velocities. The gaseous mass forms an expanding envelope around this star, and the whole system is surrounded by an extended atmosphere. There is also a gaseous stream from the secondary star.

The Outer Atmospheric Layers of the K Component in the System ζ Aurigae; Groth, H.G.; Z.f.Ap., 43, 185, 1957.

The curve of growth constructed with equivalent widths of 83 chromospheric lines gives a turbulence velocity of 22.8 km/sec and an excitation temperature of iron of 4100° K. The density and the density gradient of some neutral and ionized metals as well as of hydrogen can only be explained by an over-excitation in the chromosphere. The Balmer lines of the K-star are formed mainly in the over-excited layers of the chromosphere.

Communication 40: On the Width of Emission Lines; Schatzman, E.; VIIIe Colloque International d'Astrophysique, 1957.

The author attributed the broadening of emission lines in red giants to acoustic waves generated in the atmosphere and after some crude approximations he finds a relation between the mean quadratic velocity and the luminosity analogous to the observed relation.

Communication 18: The Chromosphere of G Type Stars; Jager, C.d.; Colloque Liege, 1957.

This work is an attempt to "translate" our knowledge of the solar chromosphere to the atmosphere of stars with a different surface gravity. The theory is checked by a comparison of the computations of the K lines inversion with the observations. It is shown that in all G type stars, the transition chromosphere-corona occurs at about the same electron density value if $\log g \sim 4.5$. The widening of the K_2 reversal increases with brightness and is due to the increasing scale height in the atmosphere.

Formation of Emission Bands in the Spectra of Extended Envelopes in the Presence of Turbulent Processes; Mustel, E.R.; VIIIe Colloque International d'Astrophysique de Liège, Mém. Soc. Roy. Sc. de Liège, ser. 4e, 20, 1957.

A discussion of possible excitation mechanisms other than recombination; in particular the excitation by collisions between turbulent elements (treated as separate clouds) of large relative velocities (100-200 km/sec.).

Diffusion of Lyman Alpha Radiation in Stellar Envelopes; Sobolev, V.V.; Colloque Liege, 1957.

The problem of diffusion of Lyman alpha radiation with complete redistribution in frequency for an arbitrary contour of the absorption coefficient and for any velocity gradient in the medium. Expressions are found for Lyman alpha intensity and radiation pressure.

Analytic Solutions for the Blast-Wave Problem with an Atmosphere of Varying Density; Rogers, M.H.; Ap.J., 125, 478, 1957.

The adiabatic motion of a gas behind an infinitely strong shock wave is examined in the case when the density of the gas ahead of the shock front varies as a power of the distance from the origin.

Inhibition of Convection by a Magnetic Field; Makita, M.; Publ. Astr. Soc. Japan, 10, 1-7, 1958.

The stability of the stellar atmosphere in the presence of a magnetic field is considered. It is assumed that initially the magnetic field is homogeneous and the atmosphere is in hydrostatic equilibrium. By the perturbation calculation, Walén's criterion is extended and applied to the solar convection zone. Supposing that the penumbra is in the state of critical stability, magnetic field strength is estimated as 200 gauss.

Doppler Motions in the Atmosphere of 8 Comae; Miczaika, G.R., and Wade, M.S.; Ap.J., 127, 143, 1958.

Turbulent velocities derived with the aid of Huang + Struve's curve of line-width correlation: ξ_S = 6.9 km/sec, ξ_L = 5.4 km/sec. "High (velocities of) turbulence seem to be definitely linked to metallicism."

Line-Broadening in High Luminosity Stars, II--Less Luminous Supergiants; Abt, H.A.; Ap.J., 127, 658, 1958.

It is impossible to distinguish between the effects of macroturbulence and of rotation in the observed broadening of spectral lines. However, since supergiants are evolved from main-sequence B stars, they have a certain amount of line broadening due to rotation. It is concluded that macroturbulence does not contribute to the lines to any appreciable extent.

Some Theoretical Aspects of H and K Emission in Late-Type Stars; Hoyle, F., and Wilson, O.C.; Ap.J., 128, 604, 1958.

An attempt to explain the Wilson-Bappu correlation of H and K emission width with absolute magnitude. If a velocity V be defined such that $1/2\rho V^2$ = mean convective energy per unit volume at a point in the sub-photospheric convection zone, it is shown that V varies from star to star in the same way as does the observed emission-line width. The subphotospheric V is perhaps just the hydromagnetic wave velocity in material in the convection zone.

On the Hydrogen Convection Zone in Stars of Different Effective Temperature and Pressure; Böhm-Vitense, E.; Z.f.Ap., 46, 108, 1958.

The variations of temperature and pressure in the hydrogen convection zone of stars with effective temperatures between 4400 and 8000° K are calculated. Maximum velocities and temperature inhomogeneities are given. In hot stars and supergiants of medium temperature, the exchange of radiation in horizontal direction prevents the formation of a convection zone.

On the Possibility of Outflow of Matter from Supergiant Stars of Late Spectral Classes; Rublev, S.B.; AJ USSR, 36, No 1, 73-78, 1959.

The Double Reversal in the Cores of the Fraunhofer H and K Lines; Goldberg, L., Mohler, O.C., and Muller, E.A.; Ap.J., 129, 119, 1959.

A comparative analysis of the profiles of the cores of Ca^+ H and K to infer the distribution of source-function and Doppler width of the absorption coefficient with depth in the atmosphere, under the assumption of a common source-function for the lines.

Shock-Waves in Stars; Kaplan, S.A., and Klimishin, I.A.; AJ USSR, 36, No 3, 1959.

VARIABLE STARS

On the Nature and Cause of Cepheid Variation; Shapley, H.; Ap.J., 40, 448, 1914.

"The main conclusion is ... that the explanation ... can ... be found in a consideration of internal or surface pulsations of isolated stellar bodies."

On the Pulsations of a Gaseous Star and the Problem of the Cepheid Variables; Eddington, A.S.; M.N., 79, 2, 1918.

Radial pulsations of a "standard" gaseous star model are analysed. Observed "orbits" and light curves are used to derive radius and temperature oscillations. Mean luminosities and spectral types give masses, radii and $(1-\beta)$, verifying $P\rho^{1/2}$ = const. Owing to high opacity, oscillation is adiabatic for all layers with $P > 10^7$ dynes cm^{-2}. Adiabatic theory is developed and solved numerically; approximately $P\rho_c^{1/2} = 0.29(3\gamma-4)^{-1/2}$, agreeing with mean of observations if $\gamma = 1.4$. Gravitational contraction would already have produced a noticeable change in period and is thus unlikely to be the energy source.

The Pulsations of a Gaseous Star and the Problem of the Cepheid Variables. II; Eddington, A.S.; M.N., 79, 177, 1919.

Thermal dissipation is found to be 10^{-3} of pulsation energy per year and 1/200 of radiation output. Since adiabatic oscillations offer no source of amplification, oscillations may be maintained by the outer layers in which the 1/4 period retardation must occur. Here temperature oscillations depend on heat received (maximum at compression) and radiated (maximum at rarefaction if temperature were constant, but it isn't), which may qualitatively produce the right result in the presence of a heat reservoir such as ionization. Inclusion of anharmonic terms leads to an overtone of the right phase to give the asymmetrical velocity curve.

Temporary Shifting Absorption in the Spectrum of Gamma Argus; Perrine, C.D.; Ap.J., 52, 39, 1920.

Absorption lines are seen to appear in this Wolf Rayet star from time to time on the violet edges of emission bands, their displacement increasing with time. These shifted absorptions indicate motions in a radially expanding shell of gas whose speed increases with time.

A Spectrographic Study of Mira Ceti; Joy, A.H.; Ap.J., 63, 281, 1926.

The classic study of a red variable star. The velocity curve resembles the light curve, as for cepheids, though here the phase is opposite, showing a maximum velocity of approach at minimum light. Individual lines in the absorption bands give the same velocities as atomic absorption lines, while the emission lines show outward motion relative to the absorption lines except at minimum light, when the difference is zero. While the magnitude at maximum light varies from cycle to cycle, the absorption line velocities at maximum do not vary. Though information for emission lines is incomplete, there is indication that larger inward velocities occur at brighter maxima.

Note on the Problem of Cepheid Variation; Bruggencate, P.t.; M.N., 86, 335, 1926.

Jeans' theory of secularly unstable rotating pear-shaped fluid explains period-luminosity law and secondary maxima, but the latter increase with increasing period; nor does Jeans explain the period-spectral type relation. These facts are qualitatively explained by suggesting that cepheids have both ordinary and secular instability, low masses breaking up equatorially and high masses by fission.

The Radiation from a Pulsating Star and from a Star in Process of Fission; Jeans, J.H.; M.N., 86, 86, 1926.

Fact that luminosity and velocity curves of cepheids are in phase supports the fission theory, but the asymmetry of the curves is still a difficulty.

Note on the Radiation from a Pulsating Star; Reesinck, J.J.M.; M.N., 86, 379, 1926.

Jeans' argument that pulsation cannot be accompanied by a phase lag in the outer layers is criticized as involving a question-begging approximation.

The Effect of Viscosity on the Oscillation of a Cepheid Variable; Persico, E.; M.N., 86, 98, 1926.

Damping by viscosity is found to be negligible.

The Exact Equations of Radiative Equilibrium; Jeans, J.H.; M.N., 86, 574, 1926.

In answer to Reesinck, the energy relevant to any phase lag is that stored in the region of the "transient" term in the solution of the transfer equation, i.e., in the region $\tau < 1$, and is thus utterly negligible.

Theory of the Outer Layers of a Pulsating Star; Eddington, A.S.; M.N., 87, 539, 1927.

Adiabatic approximation ceases to be valid well below the photosphere. Distinguish regions A (adiabatic), B (transition), C (outer). Phase is constant in C owing to low heat capacity, but may vary in B. Analysis is possible owing to validity of the approximations that relative pressure and radius amplitudes are constant through B. Detailed theory is worked out and the required phase lag does not appear. This result is independent of any detailed theory as to the origin of pulsation, provided one assumes that the Doppler shifts represent atmospheric movement, and suggests that other physical effects must be considered.

The Atmosphere of a Pulsating Star; Reesinck, J.J.M.; M.N., 87, 414, 1927.

Eddington (1918, 1919) tried to explain phase lag through heat capacity of outer layers; Jeans (1926) criticized this but took only a very thin layer into account. More detailed theory confirms Jeans' conclusion that the harmonic pulsation theory in radiative equilibrium cannot produce an appreciable phase lag.

Note on the Theory of the Outer Layers of a Pulsating Star; Reesinck, J.J.M.; M.N., 88, 502, 1928.

Discussion of differences between Reesinck's and Eddington's treatments, with results supporting Eddington's conclusions.

On the Period and Radial Velocity of RR Lyrae; Sanford, R.F.; Ap.J., 67, 319, 1928.

The velocity curve defined by the hydrogen lines has a greater amplitude and a slightly retarded phase relative to absorption lines from other chemical elements. The author supposes that these hydrogen lines originate at high levels in the star, and thus that these results indicate a growing velocity amplitude and phase retardation with height.

On the Nature of Wolf-Rayet Emission; Beals, C.S.; M.N., 90, 202, 1929.

Great widths of emission bands in WR and nova spectra are attributed to Doppler effect since $\Delta\lambda \propto \lambda$. This fact and presence of violet-shifted absorption component can be explained by theory of continuous ejection of matter and Zanstra's fluorescence mechanism. Expansion may be due to Milne's selective radiation pressure effect. Same idea is extended to P Cygni, η Carinae, etc., these being slightly cooler, but with lower surface gravity.

Behaviour of Bright Lines in the Spectra of Several Long-Period Variable Stars; Merrill, P.W., and Burwell, C.G.; Ap.J., 71, 285, 1930.

A thorough discussion of emission lines seen in the spectra of 13 stars. Velocity-curves for 11 stars are given: typically, emission line velocities are decreasing at and after maximum light, the velocity-curve reaching a flat minimum 30—80 days after that. Indications that the emission lines may arise at some subphotospheric level, the level then rising as the cycle progresses.

The Contours of Emission Bands in Novae and Wolf-Rayet Stars; Beals, C.S.; M.N., 91, 966, 1931.

Theory of uniformly expanding shell leads to flat-topped band profile with Doppler wings. Observational evidence from $H\beta$, λ4686, and λ5695 in novae and WR stars agrees with this.

On Irregular Oscillations in a δ-Cephei Variable; Bernheimer, W.E.; Lund Meddelande, ser. 2, No 61, 1931.

It is supposed that the observed secondary waves in the light curve of η Aquilae are produced by vibrations in its atmosphere.

Remarks on the Maintenance of Pulsation in Cepheids; Gerasimovic, B.P.; Z.f.Ap., 2, 85, 1931.

The influence f the distribution of the amplitudes on Eddington's pulsation theory is theoretically investigated. It is shown that the observed maximum of this curve is a support of this hypothesis, though somewhat modified.

Spectrum of the Iron Star XX Ophiuchi; Merrill, P.W.; Ap.J., 75, 133, 1932.

At the beginning and end of a 10 year period the spectrum was marked by emission lines, but in 1925 wide, displaced absorption lines appeared, suggesting as a model: the 1925 spectrum was qualitatively P Cygni or nova type, but the absorptions predominated over the emission lines. Hence a supra-photospheric shell is envisaged, rather thin compared to the stellar diameter.

Spectroscopic Observations of SX Herculis; Joy, A.H.; Ap.J., 75, 127, 1932.

In cepheids, maximum light occurs at minimum velocity, while the opposite is true for Mira Ceti and R Vir. In SX Her, which is of intermediate period and spectrum, this phase relationship is also intermediate.

The Expansion Hypothesis for Planetary Nebulae; Zanstra, H.; M.N., 93, 131, 1932.

Line doubling, spherical shape and analogy with novae suggest planetaries are expanding, not rotating. Simple hypothesis of one definite velocity for thin ejected shell implies that all radii and velocities are equally probable and is therefore abandoned. Assuming that a range of velocities exists, size of H II region is calculated, giving sharp outer boundary with radius distribution function as $r^{-3/4}$, agreeing qualitatively with observed distribution. Expansion-velocity distribution function as $v_e^{-2/3}$ again agrees with limited observations available. Luminous surface progresses with velocity $4v_e$. Mass of envelope is about 1 solar or more.

The Radiative Equilibrium of a Planetary Nebula; Ambarzumian, V.A.; M.N., 93, 50, 1932.

Since Lyman continuum is transformed into Lyman α on passage through the nebula and absorption coefficient for Lyman α is about 10^4 times that for continuum, pressure gradient increases by 10^4 as light passes through nebula. Thus radiation pressure greatly exceeding gravity will be built up.

Intensity Distribution in Emission Bands of Novae; Genard, J.; M.N., 92, 396, 1932.

Complex band profiles in Meudon nova spectra require some modification of Beal's hypothesis.

17 Leporis: A New Type of Spectrum Variable; Struve, O.; Ap.J., 76, 85, 1932.
A discussion of the change in character of spectrum and the several velocity systems implied by different sets of spectral lines; interpretation as periodic ejection of shells of matter.

P Cygni and Radial Ejection; Beals, C.S.; Obs., 57, 378, 1934.
Violet absorption complicates Chandrasekhar's occultation effect.

Non-Static Hydrogen Chromospheres and the Problem of Be Stars; Gerasimovic, B.P.; M.N., 94, 737, 1934.
Be shells and continuous ejection from P Cygni are attributed to radiation pressure, but with some help from rotation in the Be case. Radiation pressure is computed for B stars and found to exceed gravity if P_e exceeds 10^3 dynes/cm^2. Non-static version of Milne's chromosphere. The velocity field and form of emission are computed for an expanding hydrogen nebula, and P Cygni is found to have lost 2 x 10^{-3} of its mass since 1715.

The Variable Spectrum of VV Cephei; McLaughlin, D.B.; Ap.J., 79, 380, 1934.
A discussion of spectrographic observations leads to the conclusion that this supergiant M star is surrounded by an optically thin, infalling hydrogen shell. Since the Balmer lines appear to be displaced relative to one another, it appears that a velocity gradient exists in the infalling shell.

The Analysis of Nova Emission Bands; Wilson, O.C.; Ap.J., 80, 259, 1934.
"It is assumed that nova emission bands originate in spherical expanding gaseous envelopes having internal velocity gradients..." The transparent approximation is adopted. The author then developes a method of deducing the velocity gradient from the observed band shapes. Numerical values for two parameters must be estimated.

On the Hypothesis of the Radial Ejection of High Speed Atoms from the Wolf-Rayet Stars and Novae; Chandrasekhar, S.; M.N., 94, 522, 1934.
Band contours are computed for hypotheses A (continuous repulsion by force proportional to r^{-2}) and B (initial explosion), taking velocity variation into account. Contours are peaked or rounded and descend more steeply on the red side owing to occultation (unless many atoms return), especially in Case B. Observation seems to favour Case A.

The Radius-Luminosity Relation in the Cepheid Variables; Bleksley, A.E.H.; Obs., 57, 343, 1934.
Analysis of photometric data in two colours suggests that maximum temperature and luminosity almost coincide with minimum radius, contrary to what the velocity curve suggests.

Be Spectrum Variables; Gerasimovic, B.P.; Obs., 58, 115, 1935.
Rough balance between gravity and radiation pressure leads to shell

being formed until it becomes opaque in pressure-providing frequencies, then slowly dissipating and being replaced. The V/R effect is explained qualitatively in expanding, non-rotating evelope according as shell is in a detached or undetached state.

The Spectrum of Nova Herculis 5150-6550 A; Merrill, P.W.; Ap.J., 82, 3, 1935.

The absorption and emission spectrum conforms to the hypothesis of an expanding atmosphere. The atmosphere might arise from an explosive pulse which drives off matter in a condensed or quasi-liquid state from which gaseous atoms later evaporate.

On the Pulsations of the δ-Cepheid Stars; Schwarzschild, M.; Z.f.Ap., 11, 152, 1935.

In this paper the attempt is made to throw more light on some problems connected with Eddington's pulsation theory for Cepheids. The main objections that have been made are critically discussed, and the numerical results of some calculations are given.

The Spectrum of P Cygni; Struve, O.; Ap.J., 81, 66, 1935.

One of the conclusions of the study of the spectra indicates that the absolute value of velocity increases with the intensity of the line and decreases from elements of low ionization potential to those of high ionization potential, suggesting an accelerated outward motion of the shell.

Absorption Lines Due to an Expanding Star; Wilson, O.C.; Ap.J., 82, 233, 1935.

An investigation of the absorption-line profile produced by expansion or contraction of a star. Applications to giant stars and Cepheids are discussed briefly, and to Wolf-Rayet stars and novae in more detail.

On the Deceleration of Expanding Shells Around Novae; Stratton, F.J.M.; Obs., 59, 325, 1936.

Observations of Nova Herculis fail to fit Russell's (1936) hypothesis of gravitational deceleration. Resisting medium is suggested.

Note on Radiation Pressure in an Expanding Envelope; Gerasimovic, B.P.; M.N., 96, 574, 1936.

Owing to enormous absorption coefficient for Lyman α, expansion causes only a small reduction in radiation pressure in this line.

On the Spectrum of the Supernova S Andromedae; Gaposchkin, C.P.; Ap.J., 83, 245, 1936.

A re-iteration of the hypothesis that supernovae spectra consist of enormously widened emission lines.

The Spectrum of V 444 Cygni; Freddo, F.A.; Ap.J., 83, 515, 1936.

There was a remarkable pygmi,
Who arrived from V 444 Cygni.
He said, as he grope,
Through his old spectroscope,
"It's them emission lines that intrygmi!"

Ed. note: This abstract, submitted by one of those collaborating, poses the painful question of editorial responsibility vs. personal interest of the editor. The foreward-thinking, non-LTE bias of the last line of the abstract is the compelling argument for inclusion.

Note on the Spectrum of Z Centauri; Gaposchkin, C.P.; Ap.J., 83, 173, 1936.

The author suggests that the spectrum of this supernova, which was previously classified as type R, is really a bright line spectrum with very broad emission lines. These emissions suggest radial velocities of the order of 10,000 km/sec in the expanding shell.

A Study of the Spectrum of 25 Orionis; Dodson, H.W.; Ap.J., 84, 180, 1936.

A study of spectra of this Be star, taken between 1915 and 1933, indicates that it has a pulsating atmosphere. A velocity gradient may exist, its amplitude increasing downwards. A phase difference between hydrogen emission velocities and absorption velocities suggests a compressional wave traveling outward from the photosphere. The helium absorption lines show velocity variations which bear no phase relation to the hydrogen velocity curves.

Variations in the Spectrum of P Cygni; Wilson, O.C.; Ap.J., 84, 296, 1936.

High-dispersion spectra of P Cygni show that the absorption components of the hydrogen lines are double, varying in intensity and in position, though no periodicity is observed. Similar behavior for the helium lines is suspected.

On the Extension of the Theory of Adiabatic Cepheid Pulsation; Kluyver, H.A.; B.A.N., 7, 313, 1936.

The observed changes in radial velocity of RR Lyrae can be interpreted as due to approximate commensurability between 1st and 3rd characteristics.

On the Theory of Rotating Stars I; Rosseland, S.; Astrophysica Norvegica, 2, No 3, 1936.

A theory developed for the so-called generalized polytropic stars indicates that an equatorial zone of instability may be a normal thing in the stars. This leads one to consider whether the instability evidenced by the sunspot zones may not, somehow, be due to a too rapid increase of angular velocity with depth.

On the Theory of Rotating Stars II; Rosseland, S.; Astrophysica Norvegica, 2, No 5, 1937.
Continuation of the discussion of Paper I.

The Ejection of Matter by Novae; McCrea, W.H.; Z.f.Ap., 14, 208, 1937.
The possible influence of radiative pressure for the ejection of matter by novae is investigated.

The Velocities of Matter Ejected by Novae; McCrea, W.H.; Obs., 60, 277, 1937.
Lyman α radiation pressure is much greater than gravity and leads to acceleration as r^{-2} according to Milne's mechanism. Allowing for ionization, limiting velocity is 2,000 km/sec. Displaced absorption line represents accumulation of atoms at the limiting velocity, in reasonable agreement with computation. Apparent retardation could come from slower movement of atoms ejected later owing to increased ionization.

Retardation of Shells Emitted by Novae; Cowling, T.G.; Obs., 60, 167, 1937.
For magnetic retardation, field of only 10^{-6} gauss is required, 10^{-3} of that found by Minlowski (1937). Stellar surface field is consequently near 1 gauss. But there are difficulties, since retardation is greatest initially and material will spread out in the symmetry plane. Therefore resisting medium seems more reasonable; possibly, also, atoms ejected later are slower.

The Dimensions of Novae in the Pre-maximum Stage; Gerasimovic, B.P.; Obs., 60, 165, 1937.
Formation of velocity integral from Doppler shifts to get distance travelled assumes that the same atoms absorb all the time, which is probably wrong. After detachment of the shell, one can legitimately "follow the element." This difficulty also arises in cepheids.

The Contours of Absorption and Emission Bands in Nova Herculis--First Phase; Williams, E.G.; M.N., 97, 612, 1937.
P-Cygni line contours observed seem to favour continuous ejection with constant velocity rather than an expanding shell.

On Some Features of Planetary Nebulae and Novae, Hagihara, Y.; Obs., 61, 45, 1938.
Lyman α radiation makes a stationary shell unstable; the shell expands until it becomes transparent, when its expansion is consequently retarded. Rotating nebula opaque in Lyman continuum becomes a prolate spheroid. A lower limit is found for the radius of a star capable of being surrounded by a static nebula.

Convection Currents in Rotating Stars; Randers, G.; Astrophysica Norvegica, 3, No 4, 1938.
The convection currents in the stellar interior are studied. The

idealized model reaches up to the atmosphere.

The Spectrum of γ Casseiopeiae in the Photographic Region; Baldwin, R.B.; Sp.J., 87, 573, 1938.

This star is a spectrum variable, type BOne; the author discusses the spectrum changes which were taking place during 1936-37. He emphsizes the changing aspect of the doubled emission lines.

Variable Hydrogen Emission in the Spectrum of γ UMa; Cherrington, E, Jr.; Ap.J., 88, 205, 1938.

A report of qualitative observations at the Hα line.

Nova Herculis 1934: Contours and Intensities of Absorption and Emission Bands During the First 3 Months of 1935; Williams, E.G.; M.N., 99, 91, 1939.

H and Ca II profiles agree with Chandrasekhar's theory for continuous ejection with outward acceleration, the width increasing by 50 per cent during this period. There is also broad absorption from a higher level and narrow absorption from a detached expanding shell, and the emission has two maxima attributed to knots on opposite sides, but which show deceleration after minimum in contrast to the uniform movement of the knots observed directly.

Supernovae; Lundmark, K.; Lund Meddelande, ser. 1, No 155, 1939 (Reprinted from Vierteljahreschrift der Astronomischen Gesellschaft, 74, No 4, 1939).

Remarks on Loreta's Hypothesis Concerning R Coronae Borealis; O'Keefe, J.A.; Ap.J., 90, 294, 1939.

The shape of the light curve and the spectral variations at minimum are accounted for by the ejection of matter, principally carbon, which condenses at a considerable distance and forms obscuring clouds.

The Spectrum of 25 Orionis, 1933-1939; Dodson, H.W.; Ap.J., 91, 126, 1940.

The previously-reported (1936) cyclical variations of hydrogen velocities have disappeared. During this interval of quiescence (1933-1938), the emission components steadily increased in width while remaining of equal intensity. From 1938 to 1939 the emission widths diminished while the violet component became very strong.

The Relation Between Absorption Velocity and Rate of Decline for Galactic Novae; McLaughlin, D.B.; Ap.J., 91, 369, 1940.

The relations between times of decline of light and the velocities of the principal spectrum and the diffuse enhanced spectrum are discussed. It is concluded that the time of decline is inversely proportional to the square of the velocity shown by the principal spectrum. Further, the velocity of the diffuse enhanced spectrum is roughly twice that of the principal spectrum.

Spectrographic Observations of Peculiar Stars; Swings, P., and Struve, O.; Ap.J., 91, 546, 1940.

Details of spectrographic observations of peculiar stars--O-stars related to the Wolf-Rayet stars, P Cygni types, and other spectra showing forbidden emission lines.

Physical Characteristics of the Wolf-Rayet Stars; Wilson, O.C.; Ap.J., 91, 394, 1940.

There is evidence that the emission bands in Wolf-Rayet stars--at least along the nitrogen sequence--are systematically shifted to the red by an amount of the order of 1 Angstrom, suggesting either that the violet edges of the emission bands are weakened by absorption in an expanding envelope or that the red shift is relativistic in nature.

Spectroscopic Observations of Barnard's Variable in Messier 3; Joy, A.H.; Ap.J., 92, 396, 1940.

This globular cluster variable resembles W Vir in its light curve and spectral changes. Emission lines, which are seen for about $0\overset{p}{.}2$, show no certain velocity variation, having a constant velocity of approach, relative to the γ velocity, of 41 km/sec.

Contributions Toward a Physical Model of α Cassiopeiae; Baldwin, R.B.; Ap.J., 92, 82, 1940.

The model consists of an emission layer overlying the stellar photosphere, and above this, but no contiguous to it, is a shell. The emission layer and shell pulsate with the photosphere, but with a moderate phase lag; the shell has a greater amplitude of pulsation than does the emitting layer, so that at minimum radius the two have approached quite close to the photosphere.

On the Cause of Cepheid Pulsation; Eddington, A.S.; M.N., 101, 182, 1941.

Concentration of cepheids along a strip in the HR diagram could correspond to the existence of sub-photospheric hydrogen ionization zone; this zone's extra heat capacity accounts qualitatively for the phase lag, which in turn explains the low dissipation in the appropriate range of stellar structures (the primary nuclear source of pulsational energy probably exists over a much wider range of stellar models). This theory predicts a reasonable period-luminosity relation and maximum bolometric magnitude range $0\overset{m}{.}8$.

On the Radial Velocity Curve of δ Cephei; Brück, H.A., and Green, H.E.; M.N., 101, 376, 1941.

Cambridge 4-prism spectrograms do not confirm the relative velocity displacements between different groups of lines found by Michigan observers from 1-prism plates.

The Pulsation Theory of Long-Period Variables; Scott, R.M.; Ap.J., 95, 58, 1942.

A discussion based on the assumption that the emission lines originate in deeper atmospheric regions than do the absorption lines, and are therfore more closely connected with radiometric variations than are the absorption lines.

Ca II Emission in 56 Pagasi; Keenan, P.C., and Greenstein, J.L.; Ap.J., 96, 309, 1942.

A spectrogram of 17 A/mm dispersion shows strong emission components in the H and K lines, "possibly the strongest yet observed." The breadth of these emission components, 1.2 A, indicates "a considerable expansion velocity, or turbulence, in the 'chromosphere' of the star."

The Spectra of Wolf-Rayet Stars and Related Objects; Swings, P.; Ap.J., 95, 112, 1942.

Assuming that the broad emission lines are formed by particles being ejected from the surface of the star, the author computes the radii of Wolf-Rayet shells; these are found to be only supra-photospheric in nature. A table of ejection velocities for some P Cygni, Wolf-Rayet, Of stars and novae is given. Comment is made on central reversals seen in some Wolf-Rayet emission bands. These reversals may be observational evidence for outward acceleration or deceleration of specific ejected atoms.

Atmospheric Velocities in VV Cephei; Goedicke, V.; Ap.J., 95, 319, 1942

Measures of spectrograms made near third contact support the idea that the M supergiant component has no appreciable rotation about an axis at right angles to the plane of the orbit. Measures in the red, which correspond to velocities of the M star averaged over the disk, appear to show pulsation.

Absolute Dimensions of a Wolf-Rayet Star and the Expanding-Envelope Hypothesis; Wilson, O.C.; Ap.J., 95, 402, 1942.

Observations of the eclipsing system HD 193576 have allowed determination of the absolute dimensions of the WN5 component. Solution of the system allows a critical re-appraisal of the expanding-envelope hypothesis for Wolf-Rayet stars, and it is found that observational objections may be raised against it.

Spectrographic Observations of 17 Leporis; Smith, B., and Struve, O.; Ap.J., 95, 468, 1942.

Discussion of the observations between 1932-1942 leads to the following model: An outburst consists in the sudden acceleration of a part of the existing shell--the entire upper stratum being impulsively moved, while the inner layers appear to remain stationary with respect to the photosphere. In the moving layer, there is a great increase in turbulence. All chemical elements in the upper stratum appear to be affected simultaneously by the acceleration.

The Theory of Cepheid Variables and Novae; Hoyle, F, and Lyttleton, R.A.; M.N., 103, 21, 1943.

Binary system moving through stationary common atmosphere like β Lyrae (which may be expected to occur as a result of accretion) sets up oscillations with variations in surface temperature+luminosity following the period-density and period-luminosity relations. Final coalition of the components leads to ejection of matter through rotational instability, giving a nova outburst which may be repeated.

The Pulsation Theory of Cepheid Variables (George Darwin Lecture); Rosseland, S.; M.N., 103, 233, 1943.

Observationally, different groups of variables fall on parallel lines in the log P - log ρ diagram. Only short-period variables in M3 fit predicted relation for standard model with γ = 5/3. Phase retardation suggests travelling waves (Schwarzschild), probably explicable by convection zone (Eddington). Anharmonic oscillations may help solve some problems, but are not too promising.

The Spectrum of AX Monocerotis (HD 45910); Struve, O.; Ap.J., 98, 212, 1943.

Study of the spectra indicates that the sources of the expanding motions are located at a low level, possible in the photosphere.

The Spectra of the Cepheid Variables; Struve, O.; Obs., 65, 257, 1944.

Resemblance between SX Cas and α Cyg suggests extended envelope; cf., Pannekoek and Reesinck's (1925) observation of low gravity for cepheids. Ionization effects may be masked by dilution. Adams and Joy's (1927) and Payne-Gaposchkin's conclusion that spectroscopic absolute magnitude agrees with light curve leads to difficulties in view of evidence that the temperature change is predominent and their observations are attributed to dilution. Curved atmosphere may explain temperature discrepancies. New observations show Ib spectra at minimum and abnormal spectra between Ia and Ib at maximum, resembling shell spectra.

A Note on the Pulsation Theory of Cepheid Variables; Bhatnagar, P.L., and Kothari, D.S.; M.N., 104, 292, 1944.

Investigation of anharmonic pulsations confirms Rosseland's conclusion that observed amplitudes are too small to account in this way for the observed skewness in the velocity curve.

The Hydrogen Emission Lines in Spectra of Long-period Variable Stars; Shajn, G.A.; CRAS USSR, 44, No 7, 293, 1944.

Spectroscopic Observations of AX Per, RW Hya, CI Cyg and Z And; Merrill, P.W.; Ap.J., 99, 15, 1944.

Data concerning probable periodic variations in the velocities of bright lines in some combination spectra are discussed. The observations seem to indicate pulsations in an extensive atmosphere in which spectroscopic effects are stratified.

Spectroscopic Observations of 48 Librae; Merrill, P.W., and Sanford, R.F.; Ap.J., 100, 14, 1944.

The spectrum of this Be star showed remarkable fluctuations of velocity between 1935 and 1944. It appears that the amplitude of velocity fluctuations increases outwards from the photosphere.

Some Results of a Spectrophotometric Study of the Wolf-Rayet Binary HD 193576 (V 444 Cygni); Beals, C.S.; M.N., 104, 205, 1944.

Asymmetry of emission bands is attributed to tidal action in an extended envelope; displacement of He I and He II absorptions agrees with this idea. He I envelope encloses both stars; He II envelope encloses the WR component only. Asymmetry of the envelope upsets the possibility of observing O.C. Wilson's "transit time" effect.

Measurements in the Spectrum of R Hydrae; Merrill, P.W.; Ap.J., 103, 6, 1946.

Velocity curves taken on the declining branch of the light curve of this 390-day M6e variable. Stratification is suggested by a systematic displacement (+4 km/sec) of Fe lines whose E.P. is 1.6 volts relative to lines of 0.0 volts E.P. Velocity curves are different for different lines.

Spectrographic Observations of μ Cephei; McLaughlin, D.B.; Ap.J., 103, 35, 1946.

The variations of light and velocity are unpredictably irregular for this star. There is only a loose correlation between velocities and light variations, but velocity minimum may lag behind light-maximum by about one-fourth of a cycle. Bright lines are not appreciably displaced relative to the absorption spectrum.

Observations of Brightness, Color, and Radial Velocity of δ Cephei and the Pulsation Hypothesis; Werselink, A.J.; B.A.N., 10, 91, 1946.

Application of an analysis of brightness, color, and radial velocity data to test the validity of the simple pulsation hypothesis, depending upon the existence of a single-valued relation between surface brightness and color. Also an attempt to investigate the last assumption.

Moving Shells of Stars; Sobolev, V.V.; Published by Leningrad University in 1947.

This book is devoted to problem of radiative transfer and formation of spectral lines in the moving shells of stars and nebulae.

Comment on the Wolf-Rayet Atmosphere; Thomas, R.N.; Ap.J., 106, 482, 1947.

A demonstration that observed emission band profiles for V 444 Cygni are incompatible with an expanding-shell model of a Wolf-Rayet star, when the observed mass distribution in the atmosphere is used to compute the profile produced by such a model.

A Spectrophotometric Study of Maxima in the Emission Lines of Nova Herculis 1934; Aly, M.K.; M.N., 107, 316, 1947.

Red-violet intensity ratio of doubled emission lines fluctuates with nova brightness with good correlation in the case of (O I), perhaps due to successive ejections of knots of material suggested by direct photographs.

The Spectrum of Z Andromedae in 1946 and 1947; Merrill, P.W.; Ap.J., 107, 317, 1948.

"As in previous observations, various lines yield different velocities and appreciable changes occur from plate to plate." Velocity measures for hydrogen show a progression with quantum number. The velocity measures, as well as the light curve, suggest damped vibrations which start in a cycle of near 700 days.

The Retardation of Ions in Stellar Atmospheres in Connection with Wolf-Rayet Stars and the Sun; Pickelner, S.B.; Publ. Crimean AO, 3, 51, 1948.

An Investigation of the Problem of the Ejection of Matter by Novae after Maximum of Brightness; Mustel, E.R.; Publ. Crimean AO, 1, Part 2, 91, 1948.

On the Interpretation of Negative Acceleration in Atmospheres of Novae; Mustel, E.R.; AJ USSR, 25, No 1, 11-17, 1948.

The Radial Velocity of RR Lyrae; Struve, O., and Blaauw, A.; Ap.J., 108, 60, 1948.

The velocity curve is found to undergo flucturations in conformity with those of the light curve; the dates of greatest retardation and greatest advance also agree. The earliest spectral type is reached shortly before the phase of minimum radial velocity and the latest spectral type occurs shortly before maximum radial velocity.

Rapid Variations in the Spectrum of Rho Cassiopeiae; Greenstein, J.L.; Ap.J., 108, 78, 1948.

Unblended lines are quite wide, an effect which "cannot be due to rotation but may arise from turbulence or filamentary prominence-like motions." A rapid change in the radial velocity of this supergiant F8 star is interpreted as a collapse of its extended atmosphere. It is supposed that normally the atmosphere is supported by radiation pressure ("Differential expansion may be present."), and that a burst of ionizing radiation was responsible for the removal of this means of support.

Emission Lines of CaII in X Cygni; Hoof, A.v.; Ap.J., 108, 160, 1948.

Emission cores of CaII. They appear shortly before maximum light and persist until after maximum, having an apparently constant velocity of about -86 km/sec relative to the absorption lines.

On the Pulsation of the Atmosphere of Eta Aquilae; Schwarzchild, M., Schwarzchild, B., and Adams, W.S.; Ap.J., 108, 207, 1948.

Curve of growth analysis indicates microturbulent velocities of 4 km/sec in the atmosphere of η Aql, while line profiles show macroturbulent motions amounting to 12.2 km/sec. The large-scale turbulence ... is found to be the essential factor in determining the average structure of the atmosphere." The comparison of the velocity variation with the density variation throughout a cycle indicates that the character of the pulsation is composite. The sub-photospheric pulsation consists of a standing wave, while a progressive wave represents the pulsation in the corona.

The Balmer Series in the Spectrum of HD 45910; Merrill, P.W.; Ap.J., 108, 481, 1948.
The dark hydrogen lines in this peculiar Be star show large and variable negative displacements from plate to plate. Frequently the displacements increase algebraically in passing from $H\beta$ to the series limit; on most plates two components are visible; the components do not always show the same velocity-quantum number relation.

A Note on the Spectrum of 27 Canis Majoris; Struve, O., and Kao, S.-K.; Ap.J., 108, 537, 1948.
This star is surrounded by an inner reversing layer, whose radial velocity is about +40 km/sec, and an outer shell, whose radial velocity is about -43 km/sec.

Superthermic Phenomena in Stellar Atmospheres: IV, The Wolf-Rayet Atmosphere; Thomas, R.N.; Ap.J., 109, 500, 1949.
Treats two problems in the W-R atmosphere: (1) consequences of non-LTE in atmosphere resulting from dissipation of velocity fields so that $T_e > T_r$; (2) analysis of macroscopic motions required to give observed density gradient. (1) suggests outward increase in T_e; (2) gives macroscopic velocities decreasing outward.

Pressure and Temperature Cycles in the Reversing Layers of Cepheid Variables; Abbott, W.N.; M.N., 109, 108, 1949.
Radii, surface pressures and temperatures for 5 cepheids are computed as function of phase from published data on velocities and spectral types. Atomic volume is then plotted against phase to show pulsation of the reversing layer which turns out to be usually slightly ahead of star volume.

The Pulsation of Cepheids; Gurevitch, L.E., and Lebedinsky, A.I.; AJ USSR, 26, No 3, 97-103, 1949.

The Luminosity-Velocity Relation for Pulsating Stars; Milne, E.A.; M.N., 109, 517, 1949.
From the virial theorem it is shown that a homogeneous pulsating star should have luminosity and velocity variations in phase, like cepheids. High mass-concentration at centre leads to opposite phases like long-period variables. Adiabatic pulsations (not assumed in above) give zero luminosity variation.

On the Mechanism of Blowing of Novae Before the Maximum and the Masses of Novae; Mustel, E.R.; Publ. Crimean Obs., 4, 195, 1949.

An Interpretation of the Phenomena Accompanying the Transition from the Pre-maxima Spectra of Novae to the Main Spectra; Mustel, E.R.; Publ. Crimean Obs., 4, 23, 1949.

Variations in Velocity and Spectrum of Eight N-Type Long-Period Variable Stars; Sanford, R.F.; Ap.J., 111, 270, 1950.

Velocities from CN lines and from atomic absorptions are in essential agreement; absorption line velocities are therefore based upon measures of CN lines. Velocities of Hα emission are measured, but these are not sufficient to show the relation of emission velocity variation to the velocity curve for absorption lines. The mean for eight stars, averaged over their periods, is V (emission) - V (absorption) = -20.3 km/sec.

A Spectrographic Study of HD 193576; Munch, G.; Ap.J., 112, 266, 1950.

A study of the eclipsing system, whose components are an 06 star and a WN 5-6 star. The state of motion in the lower WR envelope might possibly be described in terms of a random flow of gas leaving the nucleus in all directions. Statistical fluctuations in the velocity field in the lower strata are smoothed out as the matter moves outward.

The Spectra and Orbits of AR Lacertae; Sanford, R.E.; Ap.J., 113, 299, 1951.

The measured difference in radial velocity between the Ca H and K lines in emission and in absorption is accounted for by the outward flow of the source region emitting these lines.

The Semiregular Variable Stars of the RV Tauri and Related Classes; Joy, A.H.; Ap.J., 115, 25, 1952.

There are indications that these F, G and K semiregular variables may be more luminous than long-period cepheids. The average radial velocity-range is 36 km/sec (less than that of the most luminous cepheids), though irregularities are so great that mean velocity curves cannot be drawn.

Asymmetry in the Line Profiles of Eta Aquilae; Hoof, A.v., and Deurink, R.; Ap.J., 115, 166, 1952.

The authors compute a series of theoretical line profiles for a uniformly expanding atmosphere; they then fit these asymmetric profiles by asymmetric lines observed in the spectrum of η Aql. From the parameters of the best-fitting theoretical profile the limb-darkening coefficient and expansion velocity are deduced. The RMS velocities of macroturbulence, microturbulence and totalturbulence and are given as functions of phase. A phase effect in the velocity difference shown by Fe I and Fe II is found.

Variations in the Spectrum of Sigma Scorpii; Levee, R.D.; Ap.J., 115, 402, 1952.

There is a variation in the mean velocity with a period of about 33 days, and also a variation in the line width; on some nights double lines appear at maximum or minimum radial velocity. The author attempts to fit σ Sco into the framework of Struve's theory for β CMa: a rotating star with a turbulent spot on its surface.

The Postminimum Spectrum of R Hydrae; Merrill, P.W.; Ap.J., 116, 18, 195 1952.

A study of the spectrum of R Hya on the rising branch of the light curve. The Al I lines 3944 and 3961 are asymmetric with redward wings, while the cores are displaced -0.07 A with respect to other dark lines. Measurements of bright hydrogen lines indicate an outward acceleration, since the radial velocity of these lines falls algebraically through 13 km/sec during the time they are seen. Absorption lines yield about the same velocity shortly after minimum as at maximum, though there is a drop of 8 km/sec after maximum.

The Radial Velocity of 16 Lac; Struve, O., et al.; Ap.J., 116, 81, 1952.

16 Lac is a βCMa star which demonstrates the beat phenomenon. P_1 and P_2 are very nearly 4^h 5^m, while K_1 = 4.5 km/sec, K_2 = 14.8 km/sec. On the descending branches of the short-period velocity curves, the spectrum lines become broad, while they are sharpest on the ascending branches.

HD 160641, A Hydrogen-Deficient O-Type Star; Bidelman, W.F.; Ap.J., 116, 227, 1952.

Radial velocities of He lines are discordant with those given by other, presumably unblended, lines.

Measurements in the Spectra of Four Long-Period Variable Stars of Class Me; Merrill, P.W.; Ap.J., 116, 344, 1952.

A brief discussion of radial velocity measures; some differential effects are noted.

Pleinone: The Shell Episode; Merrill, P.W.; Ap.J., 115, 145, 1952.

After a 33-year period of quiescence, this star again showed a shell spectrum which persisted from 1938 for about 13 years. The development and course of the shell activity is studied, with emphasis on the radial velocities of the Balmer absorption lines, which show a progression of velocity with quantum number. The shell was probably formed by ejection of matter from the star's photosphere.

The Variable Magnetic Field of α^2 Canum Venaticorum; Babcock, H.W., and Burd, S.; Ap.J., 116, 8, 1952.

The period of magnetic variations agrees with the period of spectrum variation. The cross-over effect for this star is such that the region of positive effective polarity is approaching the observer. Velocity-curves vary for the different chemical elements, though all curves agree in giving about the same mean velocity for the star.

The Cepheid Variable S. Sagittae; Herbig, G.H.; Ap.J., 116, 369, 1952.

Bright H and K lines found in the spectrum of this 8.4-day classical cepheid are displaced relative to the Fe I absorptions by -68 km/sec and appear on the rising branch of the light curve. The emission lines originate in a region below the level of formation of the H and K absorption cores, this emitting material subsequently moving upward relative to the reversing stratum.

Theoretical Line Profiles for Stars of P Cygni Type; Rottenberg, J.A.; M.N., 112, 125, 1952.

First model: Star emitting continuum is surrounded by thin expanding shell in which coherent scattering occurs. This leads to P Cygni profiles with total emission intensity $\leq$ total absorption, with central reversal of emission if v_{exp}/v_{random} is big enough. Second model includes additional fluorescent shell leading to enhanced emission, central reversal depending on v_{exp}, and filling in or displacement of the violet absorption border. Similar mechanism can explain Be profiles.

The Preminimum Spectrum of R. Leonis; Merrill, P.W.; Ap.J., 116, 337, 1952.

A study of high-dispersion spectra taken on the descending branch of the light curve of this 313-day M8e variable. Emission lines show algebraically smaller velocities than do absorption lines; the various elements and even lines of different excitation potential for the same element seem to show systematically different velocities.

Spectrograms of Ten High-Velocity Me Variable Stars; Merrill, P.W.; Ap.J., 116, 523, 1952.

The shortward displacement of the bright emission lines with respect to absorption lines has about the same range and these emissions behave in much the same way as in other Me variables of the same types and periods.

The Radii of δ Cephei and η Aquilae; Whitney, C.; Ap.J., 121, 682, 1955.

Determination of radial variation from color and radial velocity data. Results imply a restriction on the extent of the outer convection zone of the Cepheids.

Nonthermal Component in the Radiation of Nonstationary Stars and Main Peculiarities of Their Spectra; Gordon, J.M.; AJ USSR, 34, No 5, 739, 1957.

The Spectrum and Radial Velocities of W Virginis; Sanford, R.F.; Ap.J., 116, 331, 1952.

Near maximum light the spectrum shows double absorption lines, beginning at $0^p.95$ and lasting until $0^p.10$. The new cycle furnishes the shortward components and the old cycle the longward components. After $0^p.10$ the remaining components show a steady drift towards algebraically larger velocities. Emission lines of hydrogen are seen from $0^p.65$ to about $0^p.10$, each emission being divided by a superposed absorption line which is always longward from the center of emission. These superposed absorptions yield velocities which agree with the velocities from the absorption lines of other elements if these lines are single, and with their longward components if they are double.

The Radial Velocity of Nu Eridani; Struve, O., et al.; Ap.J., 116, 398, 1952.

This star shows the βCMa beat phenomenon, and large and perhaps irregular variations of K_1 are found.

The Oscillation Theory of Magnetic Variable Stars; Cowling, T.G.; M.N., 112, 527, 1952.

Mechanical forces by themselves produce oscillations with even shorter periods than observed, removing the need for a large magnetic field. Indeed the motions must be nearly horizontal gravity oscillations near the surface to get the period long enough, and this demands a source of energy near the surface such as a convection zone. This oscillation can produce the observed field reversals only by transporting patches of different polarity from the invisible to the visible side at different phases. A third difficulty: why is this particular free oscillation mode preferred?

The Velocity of Shells Expelled by Novae; Lebedinsky, A.I.; AJ USSR, 29, No 2, 135-143, 1952.

Oscillations of a Star in Its Own Magnetic Field, An Illustrative Problem; Ferraro, V.C.A., and Memory, D.J.; M.N., 112, 361, 1952.

Free oscillations are considered in the case where the field increases inwards and Schwarschild's identification of the effective uniform field with the central field found to be wrong. Hence HD 125248 with surface field 7,000 gauss has period 2 years, not several days. But gravity variations should be included as well.

The Spectra of Novae Near Minimum; McLaughlin, D.B.; Ap.J., 117, 279, 1953.

The spectra of several novae near the end of decline to minimum are discussed in relation to velocities of escape of the emitting atoms. Several alternative mechanisms are suggested to explain the observed broadening, including turbulence in the chromospheres, continuous prominence activity, and stellar rotation.

A Peculiarity of the Spectrum of Pi Pegasi; Greenstein, J.L.; Ap.J., 117, 269, 1953.

A large rotational broadening is observed. As a result of the rotation this star is believed to have a shell.

On the Theory of Variable Stars; Zhevakin, S.A.; 1) AJ USSR, 30, No 2, 161-179, 1953; 2) AJ USSR, 31, No 2, 141-153, 1954; 3) AJ USSR, 31, No 4, 335-357, 1954; 4) AJ USSR, 32, No 2, 124-138, 1954.

The variation of luminosity and movement of outer parts of the stars are connected with a convective zone under the photospheric layers.

The Profiles of Spectral Lines Formed in the Moving Envelopes; Bogorodsky, A.P., and Khinkulova, N.A.; Pub. Kiev AO, No 6, 3-14, 1954.

Emission-Line Profiles from Expanding Envelopes; Bappu, M.K.V., and Menzel, D.H.; Ap.J., 119, 508, 1954.

A method for calculating the profile of an emission line in an expanding envelope is developed.

The Magnetic Variable HD 188041; Babcock, H.W.; Ap.J., 120, 66, 1954.

The measured magnetic field varies between +600 and +4800 gauss in about 226 days. Radial velocity measures define a double-wave curve of amplitude 1.5 km/sec, on which random fluctuations are superposed. This is not incompatible with idea of slow, large-scale hydromagnetic turbulence, expecially since the greatest expected velocity amplitude from a rotator model is 0.4 km/sec.

Note on the Spectrum of 16 Lacertae; Hoof, A.v., Ridder, M.d., and Struve, O.; Ap.J., 120, 181, 1954.

As in β CMa, the radial velocities of the hydrogen lines tend to lag behind the velocities of other lines by 0.04 of the period.

Spectroscopic Observations of Mira Ceti, 1934-1952; Joy, A.H.; Ap.J. Supplement, 1, 39, 1954.

The highest velocities from absorption lines in different cycles may vary by several kilometers per second. Usually the greatest velocities of recession accompany the brighter maxima, with maximum velocity occurring 20-25 days after maximum light. Emission velocities are always negative relative to the absorption velocities; the velocity curves for hydrogen emission and for the metallic emissions are different. The evidence for volume pulsation of the whole star is open to question.

An Analysis of W Virginis; Abt, H.A.; Ap.J. Supplement, 1, 63, 1954.

An analysis of the radial velocity data suggests that the region of line-formation behaves essentially as a shell, rising and falling essentially through a vacuum. A curve of growth analysis suggests that small-scale velocity broadening increases with time from 5 km/sec in new lines to 10 km/sec in old lines. The behavior of the spectrum is summarized in detail.

The Velocity-Curve of Beta Canis Majoris; Struve, O., McNamara, D.H., Kung, S.M., Hoof, A.v., and Deurink, R.; Ap.J., 119, 168, 1954.

The two interfering oscillations have maintained their same periods over the past five years; but the amplitude of the smaller oscillation has increased.

A Possible Clue to the Wolf-Rayet Atmosphere from Flare and Auroral Mechanisms; Johnson, M.; Obs., 74, 124, 1954.

Evidence against large expanding envelope suggests excitation by electric discharges according to Giovanelli's flare theory. Interaction with O companions is discussed. Band width may be due to Stark broadening.

Note on the Discontinuous Velocity Curves of Population II Cepheids; Whitney, C.A.; Ann. d'Ap., 18, 375, 1955.

An inquiry into the significance of the sequence of increasingly discontinuous velocity curves exhibited by classical, RR Lyrae, W Virginis, and RV Tauri Cepheids; interpretation in terms of increasing departure from hydrostatic equilibrium and increasing extent of atmosphere relative to wave-length.

Stellar Pulsation: I. Momentum Transfer by Compression Waves of Finite Amplitude; Whitney, C.A.; Ann. d'Ap., 19, 34, 1956.

A graphical solution of the hydrodynamic equations for the motion in a cepheid atmosphere, mimicing the boundary condition set by the oscillation of the interior as the oscillation of a piston, and assuming an isothermal atmosphere and shock-wave.

Stellar Pulsation: II. A Kinematic-model for the Atmosphere of W Virginis; Whitney, C.A.; Ann. d'Ap., 19, 142, 1956.

Application of results from Paper I to give atmospheric density and velocity as functions of time; opacity fixed by assuming radiative equilibrium; last assumption tested by computing temperature variations produced by gas motions.

Emission Lines in RU Camelopardis; Jehoulet, D.; Bull. Ac. Roy. Belg., Cl. Sc., Ser. 5e, 40, 377-381, 1954.

The author describes the spectrum of RU Camelopardalis at different phases of the light curve and notes the variations of the shape of different lines (H and K of CaII, SrII 4077) which may go as far as a doubling of the line at some phases and also the presence of emission components (K line) strongly displaced towards the violet. All this points to important differential motions in the atmosphere of this Cepheid of type II.

The Analysis of the Magnetic Variable α^2 Canum Venaticorum; Burbidge, G.R., and Burbidge, E.M.; Ap.J. Supp. Ser., 1, 431, 1955.

Brief mention of velocity fields are made in the following connections: (1) relationship of the apparent velocities determined from the curve of growth and magnetic intensification and (2) a mechanism for accelerating ions in a magnetic star.

Quasi-static Oscillations in the Atmosphere of η Aquilae; Ledoux, P., and Grandjean, J.; Bull. Acad. Roy. Belg., Cl., Sc., Ser. 5e, 41, 110-1028, 1955.

This paper which is mainly concerned with the discussion of the pulsation in the very external layers of a cepheid, contains incidentally a short discussion of the effects of isotropic turbulence on the effective value of gravity in these layers and some remarks on the effects of strong anisotropic motions.

The Physical Processes Accompanying the Nova Outburst Taking Place in the Shells of Wolf-Rayet and P Cyg Stars and the Origin of Cosmic Rays; Gordon, J.M.; CRAS USSR, 102, 233, 1955.

Red Stars; Merrill, P.W.; Pub. A.S.P., 67, 199, 1955.
One section contains a general discussion of the motion of "hot fronts" (possibly shock waves) outward in the atmosphere of long period variables.

Surface Energy Sources in the Flaring dMe and T Tauri Stars; Burbidge, G.R., and Burbidge, E.M.; Obs., 75, 212, 1955.
The most plausible energy source is electromagnetic; compare transmutation in magnetic variables, but much smaller energies are required and nuclear reactions are only of minor importance here. Spot fields of a few thousand gauss would have enough energy, T Tauri effects being due to hydromagnetic processes outside the star, and dMe flare effects due to internal processes.

A Microphotometric Study of the Spectrum of Sigma Scorpii; Huang, S.-S., and Struve, O.; Ap.J., 122, 103, 1955.
On the descending branch of the radial velocity each line splits into two components which is explained by macroscopic motion. Two streams are thought to be moving in different parts of the star's disc.

Differential Velocities in the Atmosphere of η Aquilae and ζ Geminorum; Grandjean, J.; Mém. Acad. Roy. Belg., Cl. Sc., 29, 1-60, 1956.
The author describes the results of his radial velocity measurements on a group of 600 selected lines in the spectra of η Aquilae and ζ Geminorum at two phases, one close to maximum and one close to minimum light. In both cases, the radial velocities are correlated: 1) with the chromospheric heights of Mitchell (all lines), 2) with the residual central intensities (all lines), 3) with the excitation potentials (lines of FeI and FeII). This shows a variation of the radial velocities with depth in the atmospheres of cepheids. The effect is small but definitely larger than the probable error. It can be interpreted as a phase-shift with depth of the velocity curve, but the two phases considered are too few to exclude other possible interpretations.

On the Pulsation of a Red Giant Model; Schatzman, E.; Ann. Astrophys., 19, 51, 1956.
Study of amplitude and stability of pulsations in a red giant model (P. Dumezil-Curien). Importance of the superficial zones (extension, departures from the adiabaticity in the convective zone).

On the Magnetic Fields of Novae; Mustel, E.R.; AJ USSR, 33, No 2, 182-204, 1956.

The Variation of the Intensity of Bright Bands in the Spectrum of Nova Her 1934; Bajenov, M.A.; AJ SSSR, 33, No 3, 368-376, 1956.

The Circumstellar Envelope of Alpha Herculis; Deutsch, A.J.; Ap.J., 123, 210, 1956.

Evidence presented for a circumstellar envelope surrounding the system; the envelope probably composed of material ejected from the M supergiant. The material apparently moves outward from the photosphere with much less than the velocity of escape. Means of reducing the effective gravity are suggested.

Radial-Velocity-Curves of T Monocerotis and S V Vulpeculae; Sanford, R.F.; Ap.J., 123, 201, 1956.

The Fe I velocity curves lag behind the light curves for these classical cepheids, the lag being larger for the longer period. Velocity residuals (as compared to Fe I) for H, Sr II, Ti II and Fe II are compared. The first three of these show large positive peaks just before light maxima, a behavior which correlates with widening of these lines; the lines involved may be the blends of lines of a new outward surge of gas and the lines of a previous surge.

The Radial Velocity of DQ Cephei = HD 199908; Sahade, J., Struve, O., Wilson, O.C., and Zebergs, V.; Ap.J., 123, 399, 1956.

Radial velocity curves indicate a beat period of 0.38 days. Maximum brightness occurs midway on the descending branch of the velocity curve.

Simultaneous Spectrographic and Photometric Observations of the Short-Period Variables SX Phoenicis and CC Andromedae; Wilson, O.C., and Walker, M.F.; Ap.J., 124, 325, 1956.

Maximum brightness lags one quarter period behind maximum size as deduced from radial velocities.

The Magnetic Variable HD 71866; Babcock, H.W.; Ap.J., 124, 489, 1956.

The field (H_p = 6000 gauss) shows nearly symmetric reversals of polarity in a period of 6.8 days. Velocity measures reveal only random fluctuations. The velocity associated with the cross-over effect is 5 km/sec.

Ca II Emission in Classical Cepheid Variables; Kraft, R.P.; Ap.J., 125, 336, 1957.

Observational evidence on the transitory development of Ca II emission is presented to support the theory that the cepheid disturbance is directly related to the properties of the hydrogen convection zone.

The Mechanism at Work in the β-Canis Majoris Stars; Hoof, A.v.; Pub. A.S.P., 69, 308, 1957.

A discussion of effects of turbulence in connection with the coupling hypothesis of pulsations of β-Canis Majoris stars.

The Be and P Cygni Stars--Introductory Report; Kourganoff, V.; Colloque Liège, 1957.

The author summarizes the hypotheses that have been made to explain the observed profiles in Be and P Cygni stars. He examines the consequences of the differential Doppler effect in expanding atmospheres, of the dilution of radiation and of the lowering of the continuous spectrum due to scattering by free electrons in the atmospheres of hot stars. This paper contains a fairly complete bibliography of the subject.

Communication 34: The CaII emission of Classical Cepheids; Whitney, C.; VIIIth Colloque International d'Astrophysique, 1957.

After a summary of the data on CaII emission in classical cepheids, the author recalls the three possible mechanisms of emission: 1) A region of high kinetic temperature low in the atmosphere (behind a shock wave), 2) A region of high kinetic temperature high in the atmosphere (chromosphere), 3) A region of excess recombinations at the top of the external convection zone. After a few remarks on the two first mechanisms, the third one is discussed in great detail, the two possible causes of an excess recombination being taken into account, 1) rising element hotter 2) lack of thermodynamical equilibrium in ascending elements so that an excess of ionized atoms is brought to the surface. The evaluation of the two effects requires a description of the convective velocity field and its variations in the course of the period and a kinetic treatment of ionization in the moving elements. The author's computations do not support the excess-recombination hypothesis.

Communication 36: Emission Lines in Late Type Variables; Wurm, E.; VIIIth Colloque International d'Astrophysique, 1957.

The author describes the spectra of late type variables, with emphasis on the presence of bright lines and on the radial velocity measurements. Some mechanisms are proposed for energy sources of bright lines.

Communication 33: Emission Lines in Pulsating Variables; Schatzmann, E.; VIIIth Colloque International d'Astrophysique, 1957.

The author discusses the principal features of emission lines in pulsating stars and certain theoretical explanations that are not included in Whitney's paper (Ibid., paper No 34). It is found that the emitting layer is located under an absorbing layer and in the chromospheric region of the star. This emission layer is scarcely hotter than the absorbing one. According to the author, the width of the emission lines increases as $\sqrt{\tau}$, and this could explain the different widths observed for CaII emission in long period variables and in classical cepheids, without necessitating high turbulent velocities.

On the Atmospheric Pulsations of Cepheids; Lautman, D.A.; Ap.J., 126, 537, 1957.

Numerical solutions of the hydrodynamic equations under the assumption of adiabatic pulsations of an atmosphere whose original ambient state is isothermal and in hydrostatic equilibrium, with solution carried through until whole atmosphere was in periodic motion. A consideration of lesser imposed frequencies than Whitney's treatment.

Communication 39: Excitation and Gas Movements in the Long Period Variable Stars; Bruce, C.E.R.; VIIIth Colloque International d'Astrophysique, 1957.

The author explains the appearance of highly excited atoms by the occurrence of electrical discharges in the atmosphere of long period variables and symbiotic stars. Magnetic pinch effect would gather the gas towards the axial regions of the discharge, and cause a pressure rise that can be released by an axial jet of gas which is directed outwards along the discharge channel.

Gas Movements in Long-Period Variables--II; Bruce, C.E.R.; Obs., 77, 153, 1957.

After cooling by expansion, gas velocity can exceed that of sound in compression region. This agrees with Merrill's observation of increased velocity accompanied by decreased excitation of Fe I and Fe II in χ Cygni. Velocities of 100 km/sec observed in AX Per demand million degree temperatures, in agreement with Swing's and Struve's identification of Fe V to VII and probably Fe X.

Radius Variation and Population Type of Cepheid Variables; Rodgers, A.W.; M.N., 117, 85, 1957.

Wesselink's method is applied to κ Pav, l Car, and β Dor, which latter has abnormally high radius for its period. From these and other data, relative radius amplitude increases slowly with period for classical cepheids and light variations are mainly due to temperature changes. For Type II cepheids, relative radius amplitude increases rapidly with period, finally reaching nearly 1.0.

Gas Movements in the Long-Period Variables; Bruce, C.E.R.; Obs., 77, 107, 1957.

Emission lines of these stars are attributed to electric discharges, which lead to pinch effect, followed by axial pressure rise and outflow, especially near the electrodes. In stars, pressure is greatest in the lower atmosphere; velocities may reach sonic and temperature rise increases with period. Predicted violet shift of emission by about 8 km/sec, increasing with period, agrees with Merrill's observations.

Investigations in Pulsating Stars; Thiessen, G.; Z.f.Ap., 46, 1, 1958.

It has been found that the star rotates with a mean effective equatorial velocity of about 15 km/sec. No significant macro-turbulence seems to exist in the photosphere.

The Radial Velocity of δ Cephei; Shane, W.W.; Ap.J., 127, 573, 1958.

Combination of spectrographic observations made in 1950, 1923 and 1907 allows the conclusions: (i) there is no long-period change in the form of the velocity curve, (ii) there is no long-period change in the mean velocity. Differential or stratification effects in the spectrum lines, if present, have not contributed to these results.

T Sextantis, An RR Lyrae Star of Type "c"; Tiffts,W.G., and Smith, H.J.; Ap.J., 127, 591, 1958.

A discussion of the light and velocity curves leads the authors to propose a stratified model for T Sex, in which an outer, pulsating layer of material undergoes, periodically, collisional interaction with the remainder of the atmosphere.

Radial Velocities and Spectral Characteristics of the Population II Cepheids M5 No. 42, M5 No. 84 and TW Capricorni; Ap.J., 127, 583, 1958.

Double lines are noted in the spectra of TW Cap and M5 No. 42; they are not present in M5 No. 84, though it is noted that lines are widened at the appropriate phase. No. 84 shows different velocity curves for odd and even cycles: when the secondary maximum in the light-curve is strong, the velocity declines late by $0\overset{p}{.}3$. No. 42 and TW Cap have discontinous velocity curves. The velocity-curves of all Population II Cepheids of period greater than 15 days are probably discontinuous.

Magnetic Fields of the A-Type Stars; Babcock, H.W.; Ap.J., 128, 222, 1958.

There is now strong support for the contention that magnetic fields of physically significant intensity probably occur in virtually all stars. The magnetic variables are divided into groups typified by particular observed behavior. The α-variables, which show more or less regular magnetic variation of large amplitude and changing sign, tend to show spectrum variations synchronous with magnetic fluctuations, and sometimes small systematic velocity variations are noted. On the other hand, the irregular magnetic variables do not show clearly correlations of this sort. Conjecture that the principal difference between them is that the atmospheric motions in the former have become co-ordinated in a large-scale hydromagnetic cycle that dominates the surface layers.

Some Remarks on the Mechanisms at Work in the Beta Canis Majoris Stars; Ledoux, P.; Ap.J., 128, 336, 1958.

In a star performing linear radial oscillations at two nearly equal frequencies the external layers cannot be spatially affected in different ways by each of the frequencies of oscillation. If, however, the interaction of pulsation and convection be considered, the effect of the fundamental mode will be stronger than the effect of any other mode. The author remarks on non-radial oscillations as a preferred explanation for the β CMa phenomenon.

The Behavior of Theta Ophiuchi During Four Cycles in April, 1956; Hoof, A.v., and Blaauw, A.; Ap.J., 128, 273, 1958.

Secondary fluctuations are present in the velocity curves, and there is evidence of differential motions when the velocities of hydrogen, helium and Ca II are compared.

The Dissipation of the Energy of Oscillation of a Pulsating Star; Zhevakin, S.A.; AJ USSR, 35, No 4, 583, 1958.

The Evaluation of Nonadiabatic Stellar Pulsations by Use of a Discrete Model; Zhevakin, S.A.; AJ USSR, 36, No 2, 269, 1959.

Line Profiles for Classical Cepheid SV Vulpeculae and for Supergiants Beta Aquarii and 9 Pegasi; Kraft, R.P.; Ap.J., 129, 50, 1959.

Curves of growth and calculated profiles are used to conclude that macrotrubulence rather than rigid rotation is mainly responsible for the shape of the observed profiles.

The Cooling of an Atmosphere Behind a Shock Wave Front; Kulikowski, J.; Ann. Astrophys., 1959, in press.

For a W Viri type star, calculations of the rate of cooling in the outer layers of the atmosphere heated by a shock wave. Influence of this wave on the lines.

Effective Temperatures, Radii, Masses, and Pulsation Properties of the Population II Cepheids M5 No. 42 and W Virginis; Wallerstein,G.; Ap.J., 129,356, 1959.

An analysis of radial-velocity and color data to determine whether they require the presence of a shock wave travelling through the atmosphere and whether they permit an independent specification of absolute magnitude.

On the Light Curves of Cepheids; Schwarzschild, M.; Harv. Coll. Obs. Circ., 431, December, 1938.

Application of formulation of preceding paper to observations of Cephei, and interpretation in terms of thermodynamic state of atmospheric layers. These three papers are the 'classic' papers of the running-wave suggestions for cepheids.

The Line-Spectrum of δ Cephei; Walraven, The Publ. Aston. Inst.; Univ. Amsterdam, No. 8, 1948.

A curve-of-growth analysis of observations of δ Cephei leads to values of turbulence, and thermodynamic parameters of the atmosphere. Suggests accord with Schwarzschild's running-wave model, and possibly Pannekoek's suggestion of expulsion of shells.

Spectrophotometric Study of the Cepheid Variables Aquilae and δ Cephei; Whipple, F.L.; Lick Observatory Bulletin, No. 442, March, 1932.

One of the earliest spectrophotometric studies of cepheids to investigate low effective gravity problem. Spectral energy distribution found in good accord with normal supergiant. Suggests Menzel's 'hot spot' theory may be applicable.

U.S. DEPARTMENT OF COMMERCE
Frederick H. Mueller, Secretary

NATIONAL BUREAU OF STANDARDS
A. V. Astin, Director

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D.C.

Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer. Concreting Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

• Office of Basic Instrumentation. • Office of Weights and Measures.

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research. Radio Warning Services. Airglow and Aurora. Radio Astronomy and Arctic Propagation.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Research. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation Obstacles Engineering. Radio-Meteorology. Lower Atmosphere Physics.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.

Radio Communication and Systems. Low Frequency and Very Low Frequency Research. High Frequency and Very High Frequency Research. Ultra High Frequency and Super High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Systems Analysis. Field Operations.

NBS