RADIO SCIENCE Journal of Research NBS/USNC–URSI
Vol. 69D, No. 8, August 1965

# Selected Abstracts in Radio Science *

**Determination of the ionospheric electron content utilizing satellite signals,** P. R. Arendt, A. Papayoanou, and H. Soicher, *Proc. IEEE* **53,** *No. 3, 268–277 (Mar. 1965).*
Various methods for the determination of the ionospheric electron content are possible when satellite-borne signals can be used. The paper compares the results from Doppler shifts, Faraday rotation, Doppler data combined with Faraday rotation data, and topside and bottomside soundings. The often neglected prerequisite for the application of Doppler and Faraday methods is radio propagation along the same ionospheric path for the different frequencies involved. Criteria for correct application are discussed. The comparison of inflection time moments is chosen for data selection. The usage of the Doppler slopes at the time of simultaneous inflection provides reliable data of the electron content. The diurnal variation is given. The Faraday rotation rate measurement has been made a continuous one by special equipment of G. Vogt. The simultaneous use of two Doppler slopes at different frequencies and of the Faraday rotation rate at one of these frequencies results in the measurement of the effective component of the geomagnetic fields. Thus, a method free from any assumptions is on hand for the electron content. From the radio-frequency sounding of the topside-sounder satellites and from simultaneous bottomside soundings a complete ionospheric profile is obtained, the integration of which results in data for the total content. A comparison of the results of the different methods is permitted within the limitations brought about by the various theoretical and experimental assumptions made.

**Radiation resistance of an elementary loop antenna in a magnetoionic medium,** H. Weil and D. Walsh, *IEEE Trans. Ant. Prop.* **AP–13,** *No. 1, 21–27 (Jan. 1965).*
Radiation resistance for an elementary loop antenna immersed in a magnetoionic plasma is investigated. Based on an integral expression given by Kogelnik and Motz, extensive numerical results are obtained and their validity and utility are discussed. In addition a simple analytic expression is derived for the case of small magnetic fields.

**Admittance of a waveguide radiating into stratified plasma,** J. Galejs, *IEEE Trans. Ant. Prop.* **AP–13,** *No. 1, 64–70 (Jan. 1965).*
A slot covered by a stratified plasma is assumed to radiate into a wide waveguide instead of free space. The slot admittance approximates the free space admittance of the slot for waveguide diameters exceeding 6 to 10λ. For thick plasma layers the computed slot admittance checks with earlier admittance calculations for a laterally unbounded plasma. When approximating a plasma profile of a typical hypersonic re-entry, a multilayer plasma model in a wide waveguide appears to provide a more accurate slot admittance than a single-layer approximation in a laterally unbounded geometry.

**Radiation from a uniformly moving distribution of electric charge in an anisotropic, compressible plasma,** H. S. Tuan and S. R. Seshadri, *IEEE Trans. Ant. Prop.* **AP–13,** *No. 1, 71–78 (Jan. 1965).*
The radiation characteristics of a linear distribution of electric charge moving with a uniform velocity in a homogeneous electron plasma of infinite extent are investigated for the case in which a uniform static magnetic field is impressed externally throughout the medium. The linear distribution of charge and its direction of motion are assumed to be parallel and perpendicular, respectively, to the direction of the external magnetic field. Of the two possible modes of waves of small amplitude, namely, the modified electromagnetic mode and the modified electron plasma mode, the uniformly moving charge distribution excites the modified electron plasma mode. The emitted radiation has no frequencies less than the plasma frequency. For a particular value of the ratio of the gyrotropic to the plasma frequency of the electrons, the frequency and the angular spectrum of the emitted radiation are determined for two values of the velocity of the charge.

**Radiation from electromagnetic sources in a plasma,** S. R. Seshadri, *IEEE Trans. Ant. Prop.* **AP–13,** *No. 1, 79–88 (Jan. 1965).*
The radiation from electromagnetic sources in an unbounded, isotropic plasma is treated. Using a two-fluid magnetohydrodynamic approach, the problem is formulated in terms of three orthogonal modes, namely, i) the electromagnetic mode, ii) the electron plasma mode and iii) the ion plasma mode. When formulated in this manner, the radiation from simple electromagnetic sources are obtained easily. Three specific sources are treated, namely, i) a point source of electric current, ii) a uniformly moving charge and iii) a short filament with prescribed current distribution. For the case of the electric dipole and the current filament, the total power radiated in each of the three modes are obtained. A point charge moving uniformly with the velocity of sound, for example, is found to excite only the ion plasma mode. The frequency and the angular spectrum of the emitted radiation are obtained. It is found that at frequencies less than a critical frequency which is approximately equal to $\sqrt{2}$ times the ion plasma frequency, the radiation has the character of a simple sound wave.

**Leaky waves supported by uniaxial plasma layers,** G. Meltz and R. A. Shore, *IEEE Trans. Ant. Prop.* **AP–13,** *No. 1, 94–105 (Jan. 1965).*
Each discrete complex wave supported by a uniaxial layer corresponds to an isolated singularity in an appropriate Green's function. The location of a singularity depends on the geometry, plasma density, and the direction of the magnetic field, but not on the source. We have derived the discrete solutions for an infinite magnetic field that is parallel or perpendicular to the slab interfaces. For a parallel field, analytic expressions are obtained that yield the exact locations of the complex pole loci. Although similar expressions cannot be obtained if the field is perpendicular, the resonance relation which locates the poles can be solved by methods developed for an isotropic plasma. We find that improper modes and surface waves can be supported in the case of a parallel field, while a perpendicular field permits spectral complex modes as well.
These results are applied to a Kirchhoff-Huygens integration of the leaky-wave distribution excited by a magnetic line source or an annular slot. A close correlation is shown between the radiation pattern derived by this procedure and the exact pattern calculated by the method of steepest descent. In particular, it is shown that the appearance of a peak in the pattern can be analytically correlated with the contributing pole, provided it corresponds to a dominant leaky wave.

**Radiation propagating transverse to the external magnetic field from an electromagnetic source in an unbounded plasma,** S. R. Seshadri, *IEEE Trans. Ant. Prop.* **AP–12,** *No. 1, 106–115 (Jan. 1965).*
The radiation characteristics of a line source of magnetic current embedded in an unbounded plasma are investigated for the case in which a uniform magnetic field is impressed externally throughout the medium in the direction of the source. The plasma is assumed to be a homogeneous and macroscopically neutral mixture of compressible gas of electrons and ions. A two-fluid continuum theory of plasma dynamics is employed. It is shown that it is possible to define three suitable wave functions which satisfy separately simple wave equations whose solutions are written down by inspection. These wave functions specify the three possible modes which are identified, respectively, to be the modified forms of the electromagnetic, the electron plasma and the ion plasma modes. The limiting behavior of these modes are discussed for the following two

cases: 1) infinite source frequency and 2) vanishing external magnetic field. The dispersion relations for the three modes are examined in detail for the general case using a perturbation procedure. It is shown that the modified ion plasma (MIP) mode propagates for all frequencies whereas both the modified electron plasma (MEP) mode and the modified electromagnetic (MEM) mode have a low-frequency cutoff. Explicit expressions for the cutoff frequencies are obtained. The power radiated in each of the three modes is also evaluated. It is found that the power radiated in the MEM mode is always lower than that due to the line source in free space, whereas the power radiated in the two plasma modes is higher than that value for certain ranges of frequency.

**Admittance of waveguide radiating into plasma environment,** A. T. Villeneuve, *IEEE Trans. Ant. Prop.* **AP-13,** *No. 1, 115–121 (Jan. 1965).*
Several important effects on radio transmission occur during the reentry of a space vehicle into the earth's atmosphere. Of these effects, signal variation due to changes in antenna admittance may be significant. These changes result from the formation of an ionized sheath about the vehicle as it reenters the atmosphere. The sheath may have a profound effect on the propagation of electromagnetic waves and may thereby modify the antenna admittance characteristics. Knowledge of the input admittance of the antenna enables one to compute the field amplitudes at the antenna input terminals when fed by a specified power source and, from this, to determine the change in radiated signal level that results from antenna mismatch. This change in radiated signal level is in addition to that due to pattern distortion. Besides the change in radiated signal level, the reflected wave may adversely affect operation of the transmitter and may even result in transmitter burnout. This report investigates the changes in input admittance of a rectangular waveguide terminated in a groundplane covered by a uniform plasma slab contiguous with the groundplane. Such radiators provide wide angular pattern coverage and find application as telemetry and communication antennas in reentry vehicles. Numerical calculations have been performed for the case of lossless plasmas in which the electron densities are all below the critical density, i.e., the effective relative permittivity of the slab ranges between zero and unity. Curves of input conductance and susceptance for this configuration are given as a function of relative permittivity for several slab thicknesses. These addmittance values are used to compute reflection coefficients and signal loss resulting from mismatch. These are also presented graphically. The calculations show that, except for thin slabs, the aperture admittance is very close to that for a slab of infinite thickness. A qualitative explanation of this effect is also given.

**Scattering of radio waves by dense turbulent plasmas,** L. S. Taylor, *IEEE Trans. Ant. Prop.* **AP-13,** *No. 1, 122–126 (Jan. 1965).*
An analysis is made of the scattering of radio waves by plasmas in which turbulent variations of free-electron number density occur. Second-order terms for the scattered field are included. An additional term (as compared to the first-order Born approximation) is found in the expression for the scattering cross section. This term is proportional to $\gamma(\omega\rho/\omega)^2$ where $\gamma$ is a numerical factor determined by the scale of the turbulence.

**Electromagnetic scattering from an extended laminar plasma column,** H. S. Rothman, *IEEE Trans. Ant. Prop.* **AP-13,** *No. 1, 164–169.*
This paper is concerned with examining in the laboratory the backscattering from a simplified ionized target in the form of an extended laminar plasma column. Measured results, compared with calculations based on a homogeneous model approximation that incorporates the measured electrical parameters of the column, show that the column scatters electromagnetic energy that is polarized with the electric vector along the axis of the column, in the same manner as a homogeneous column of critical density with the column radius equal to that of the critical electron density contained within the column.

**Observations of the effect of magnetic fields on the radiation from plasma-covered antennas,** G. Meltz and H. J. Schmitt, *IEEE Trans. Ant. Prop.* **AP-13,** *No. 1, 169–173 (Jan. 1965).*
Measurements of the broadside radiation from an anisotropic plasma-covered slot are compared with theoretical predictions which neglect input impedance changes and coupling to electroacoustic or Tonks-Dattner resonances. For a magnetic field normal to the plasma layer, the results demonstrate transmission enhancement and underscore the necessity of a strong field ($\omega_c > \omega$). They also highlight some of the limitations of existing theoretical treatments. In particular, it is concluded that collisional damping, impedance variations, and electroacoustic resonances must be included for an accurate prediction of magnetic field effects. The experimental system consists of a narrow aperture in a large ground screen covered by a bank of long discharge tubes which are collectively equivalent to a plane layer. All measurements are performed at a fixed frequency of 565 Mc during the afterglow of the pulsed discharge.

**Cavity resonances for a spherical earth with a concentric anisotropic shell,** J. R. Wait, *J. Atmospheric Terrest. Phys.* **27,** *No. 1, 81–89 (Jan. 1965).*
A boundary-value problem of a concentric spherical system involving anisotropic media is considered. Rather gross simplifications are made in order to achieve tractability and yield physical insight. The principal idealization is the representation of the concentric plasma layer by a thin shell of ionization. The derived results have some relevance to the phenomenon of resonance in the concentric cavity formed by the earth and the ionosphere. For example, it is shown that the earth's magnetic field and the electron collisons both contribute to the damping of the cavity resonances.

**On the twilight sodium emission—2: A theoretical model of sodium abundance,** M. Gadsden, *Ann. Geophys.* **20,** *No. 4, 383–396 (Oct.–Dec. 1964).*
Hunten's theoretical treatment is examined and modified to take account of the changes in the negative ion density and in the chemical equilibrium of sodium from day to night. It is shown that the seasonal variation predicated from these considerations has too small an amplitude to agree with the observed diurnal variation; the inclusion of charge exchange from magnesium ions and the change in lengths of day and night due to mesospheric winds is insufficient to remove the discrepancy. It appears to be necessary to include a vertical wind term—subsidence and ascension of the mesospheric region—to reconcile the seasonal and diurnal variations. An appendix reviews the evidence from recent observations of lithium which is considered to confirm the existence of the mesospheric meridional wind system required to account for the postulated vertical wind.

**International intercomparison of standards for microwave power measurement,** G. F. Engen, *Acta Imeko 1964, Proc. Third Intern. Measurement Conf.* **1,** *337–346 (Budapest 1964).*
In compliance with a recommendation of the International Scientific Radio Union (URSI), intercomparisons of microwave power standards have been made between Japan, The United Kingdom, and the United States.
Initially, there was a rather large difference in Japan-United States comparisons; but after several improvements in the design of the bolometer mounts employed as a transfer standard, consistently good agreement of the order of a few tenths of a percent has been realized.
In intercomparisons between the United Kingdom and either Japan or the United States, there was a small but rather consistent difference in the initial results. Again, the agreement has improved with more recent comparisons.
In Japan and the United States the microcalorimetric and impedance methods were employed to evaluate the bolometer mount efficiency, whereas in the United Kingdom a combination of calorimetric, force-operated, and bolometric methods were used. The close agreement achieved is thus particularly significant because of the wide differences in the basic principles of the techniques employed.

**A waveguide noise-tube mount for use as an interlaboratory noise standard,** C. K. S. Miller, W. C. Daywitt, and E. Campbell, *Acta Imeko 1964, Proc. Third Intern. Measurement Conf.* **3,** *371–382 (Budapest 1964).*
Radio astronomy and noise measuring systems have laid heavy stress on the need for noise standards covering an increasingly larger frequency range. In response to this need, the National Bureau of Standards recently has completed work in National Stand-

ards and comparison systems for calibrating microwave noise sources in WR90 (8.2 to 12.4 Gc) and WR62 (12.4 to 18.0 Gc) waveguide. This availability has, in turn, placed more emphasis on the need for good interlaboratory noise standards. The gas-discharge noise tube makes a very stable, long-life source for use in an interlaboratory standard. However, the available noise source mounts examined did not have the required characteristics for use in this quality of standard. This paper discusses experimental data of gas-discharge noise sources gathered over a period of two years and indicates where improvements can be made. Using this knowledge, an experimental gas-discharge noise tube mount was designed and constructed. The data taken using this mount indicated that the new design was suitable for interlaboratory work and provided a possible means of using the improved mount with different gas tubes to form more than one standard.

**The accurate measurement of voltage ratios of inductive voltage dividers,** T. L. Zapf, *Acta Imeko 1964, Proc. Third Intern. Measurement Conf.* **3,** *317–331 (Budapest 1964).*
Several methods have been developed at the National Bureau of Standards for the very accurate measurement of audio frequency voltage ratios associated with inductive voltage dividers. Uncertainties in voltage ratio of less than $2\times10^{-7}$ have been obtained in measurements with transformer-type capacitance bridges. The attainment of such accuracy has provided a firm base for further investigations on inductive voltage dividers. An inherent major error arises from the interaction between distributed shunt impedances and leakage impedances in the windings. In specific designs of inductive voltage dividers the relative magnitudes of such errors are calculable and are characteristic of the design. A divider may be completely characterized by the designation of the characteristic relative errors combined with an absolute measurement. A method involving complementary measurements has been developed to yield an absolute measurement of the inphase and quadrature components of the voltage ratio characteristic. Single-decade inductive voltage dividers have been constructed with ratio magnitude characteristics and residual errors less than $5\times10^{-8}$. This recent work has verified the accuracy of measurements made by other methods.

**Microwave calibration techniques at the National Bureau of Standards,** R. E. Larson, *Acta Imeko 1964, Proc. Third Intern. Measurement Conf.* **3,** *383–393 (Budapest 1964).*
The measurement techniques employed in the microwave calibration systems of the National Bureau of Standards are described. Calibration systems in the microwave region have been developed for the measurement of low-level cw power, reflection coefficient magnitude, frequency, attenuation, and noise power. The operating frequency for the calibration systems, all utilizing rectangular waveguide, ranges from 2.6 GHz for all quantities to as high as 90 GHz for the calibration of cavity wavemeters. The present status in the development of this large number of microwave calibration systems is reviewed briefly. An error analysis considering both systematic and random errors is given briefly for each of the quantities measured, and the resulting overall accuracy reported for the calibration of interlaboratory standards is stated.

**Microwave discharge cavities operating at 2450 MHz,** F. C. Fehsenfeld, K. M. Evenson, and H. P. Broida, *Rev. Sci. Instr.* **36,** *No. 3, 294–298 (Mar. 1965).*
Five simple microwave cavities for producing discharges in gases were tested in He and $H_2$ at pressures from 1 $\mu$ to 1 atm. Three of the cavities are commonly used, and two have been recently designed. One of the newly designed cavities offered a considerable improvement over early models with respect to compactness, ease of attachment to the system, and efficiency.

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