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Tables for the Evaluation of the Faxén Approximation to the Solution of the Lamm Equation

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A table is presented to facilitate the calculation of the Faxén approximation to the concentration and concentration gradient. The table is accurate to within one figure in the last place, and can be used both for no sedimentation dependence on concentration and for the dependence $s=s_0(1-kc)$.

Key Words: Faxén approximation, Lamm equation, ultracentrifuge, theory of noise, theory of ion exchange columns.

The Faxén approximation to the solution of the Lamm equation has proved to be of considerable utility in the analysis of data from velocity sedimentation experiments with the ultracentrifuge [1].[1] It has recently been shown that the Faxén solution to the nonlinear Lamm equation which arises when the sedimentation coefficient s is related to concentration c by $s=s_0\,(1-kc)$ can be written in terms of the Faxén solution for $k=0$ [2]. Because of this wide range of applicability of the Faxén solution, it is appropriate to present a table to facilitate the calculation of concentration and concentration gradients in that approximation. The best known of earlier, equivalent tables, are those of Opler and Hiester [3]. Their tabulation gives very few values of the relevant function in the range of interest for ultracentrifuge work. A thorough analysis of mathematical properties of the function arising from the Faxén solution has been published by Goldstein [4]. Other applications of the tabulated function are to be found in the theory of noise [5], and in the theory of ion exchange columns [6].

Let us summarize the relevant facts on the Faxén solution. It is assumed that the concentration in the ultracentrifuge is $c(r, t)$, where r is the radius and t the time, with $c(r, 0)=c_0$, a constant. Let r_0 denote radial distance to the meniscus, ω the frequency of revolution, D the diffusion coefficient. The Faxén solution is most conveniently written in terms of the new variables:

$$\theta=c/c_0, \qquad x=(r/r_0)^2, \qquad \tau=2\omega^2 s_0 t,$$
$$\alpha=kc_0, \qquad \epsilon\doteq 2D/(s_0\omega^2 r_0^2), \qquad z=2\sqrt{xe^{-\tau}}, \qquad \zeta=1-e^{-\tau}. \tag{1}$$

When $k=0$, or equivalently, when $\alpha=0$, the Faxén expression for $\theta(z, \zeta)$ is

$$\theta_0(z, \zeta)=\frac{1-\zeta}{2\epsilon\zeta}\int_2^{\infty} \sigma e^{-\frac{(\sigma^2+z^2)}{4\epsilon\zeta}} I_0\left(\frac{z\sigma}{2\epsilon\zeta}\right) d\sigma. \tag{2}$$

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[1] Figures in brackets indicate the literature references at the end of this paper.

When $\alpha > 0$ we have

$$\theta_\alpha(z, \zeta) = \left[\frac{1-\zeta}{1-(1+\alpha)\zeta}\right] \frac{\theta_0(z^*, \zeta^*) e^{-\frac{\alpha}{\epsilon}\left[1-\frac{z^2}{4(1-\alpha\zeta)}\right]}}{\left\{1 + \frac{1-\alpha\zeta}{1-(1+\alpha)\zeta} \theta_0(z^*, \zeta^*) e^{-\frac{\alpha}{\epsilon}\left[1-\frac{z^2}{4(1-\alpha\zeta)}\right]} - \frac{1}{1-\zeta} \theta_0(z, \zeta)\right\}} \tag{3}$$

where

$$z^* = z(1-\alpha\zeta)^{-1}, \qquad \zeta^* = \zeta(1-\alpha\zeta)^{-1}. \tag{4}$$

Hence $\theta_\alpha(z, \zeta)$ can be represented in terms of $\theta_0(z, \zeta)$.

In the following pages we tabulate values of the functions

$$\psi(y, \eta) = \frac{1}{2\eta} \int_2^\infty \sigma e^{-\frac{(\sigma^2+y^2)}{4\eta}} I_0\left(\frac{\sigma y}{2\eta}\right) d\sigma \tag{5}$$

$$\frac{\partial\psi(y, \eta)}{\partial y} = \frac{1}{4\eta^2} \int_2^\infty \sigma e^{-\frac{(\sigma^2+y^2)}{4\eta}} \left[\sigma I_1\left(\frac{\sigma y}{2\eta}\right) - y I_0\left(\frac{\sigma y}{2\eta}\right)\right] d\sigma \tag{6}$$

accurate to at least four places with a possible error of 1 in the last place. The intervals of tabulation in η are $\eta = 10^{-6}\ (10^{-6})\ 10^{-5}\ (10^{-5})\ 10^{-4}\ (10^{-4})\ 10^{-3}$. For each value of η we choose from 28 to 80 steps in y so that $\psi(y, \eta)$ lies in the range (0.005, 0.995).

The solutions for concentration and concentration gradients in terms of the tabulated functions are

$$\theta_0(z, \zeta) = (1-\zeta)\psi(z, \epsilon\zeta) \tag{7}$$

$$\frac{\partial\theta_0(z, \zeta)}{\partial(r/r_0)} = 2(1-\zeta)^{3/2} \frac{\partial\psi(z, \epsilon\zeta)}{\partial z} \tag{8}$$

for $\alpha = 0$, and

$$\begin{aligned} \frac{\partial\theta_\alpha(z, \zeta)}{\partial(r/r_o)} = {} & \frac{1}{(1-\alpha\zeta)F} \frac{\partial\theta_0(z, \zeta)}{\partial(r/r_0)} + \frac{1-\zeta-\theta_0(z, \zeta)}{(1-\alpha\zeta)F^2} \times \Bigg\{ \frac{1}{1-(1+\alpha)\zeta} \\ & \left[(1-\alpha\zeta) \frac{\partial\theta_0(z^*, \zeta^*)}{\partial(r/r_0)} + \frac{\alpha z}{\epsilon} (1-\zeta)^{1/2} \theta_0(z^*, \zeta^*)\right] e^{-\frac{\alpha}{\epsilon}\left[1-\frac{z^2}{4(1-\alpha\zeta)}\right]} - \frac{1}{1-\zeta} \frac{\partial\theta_0(z, \zeta)}{\partial(r/r_0)} \Bigg\} \end{aligned} \tag{9}$$

for $\alpha > 0$, where

$$F = 1 + \frac{1-\alpha\zeta}{1-(1+\alpha)\zeta} \theta_0(z^*, \zeta^*) e^{-\frac{\alpha}{\epsilon}\left[1-\frac{z^2}{4(1-\alpha\zeta)}\right]} - \frac{1}{1-\zeta} \theta_0(z, \zeta). \tag{10}$$

The integrals were evaluated using Simpson's rule. The interval of integration h was varied from 2×10^{-5} to 10^{-3} for different values of y and η, so as always to meet the requirements of accuracy. The integration was stopped when the integrand was less than 10^{-25}. As a check on our accuracy, the integration was performed twice; once over the interval $(2, \infty)$ and once over the interval (0, 2) with the appropriate integrals derived from the formulas

$$\frac{1}{2\eta}\int_2^\infty \sigma e^{-\frac{(\sigma^2+y^2)}{4\eta}} I_0\left(\frac{\sigma y}{2\eta}\right)d\sigma=1-\frac{1}{2\eta}\int_0^2 \sigma e^{-\frac{(\sigma^2+y^2)}{4\eta}} I_0\left(\frac{\sigma y}{2\eta}\right)d\sigma \tag{11}$$

and

$$\int_2^\infty \sigma e^{-\frac{(\sigma^2+y^2)}{4\eta}}\left[\sigma I_1\left(\frac{\sigma y}{2\eta}\right)-yI_0\left(\frac{\sigma y}{2\eta}\right)\right]d\sigma=-\int_0^2 \sigma e^{-\frac{(\sigma^2+y^2)}{4\eta}}\left[\sigma I_1\left(\frac{\sigma y}{2\eta}\right)-yI_0\left(\frac{\sigma y}{2\eta}\right)\right]d\sigma\cdot \tag{12}$$

Since the argument of the Bessel functions was always greater than 1200, the asymptotic expansions

$$I_0(x)\sim\frac{e^x}{\sqrt{2\pi x}}\left[1+\frac{1}{1!(8x)}+\frac{3^2}{2!(8x)^2}+\frac{3^2 5^2}{3!(8x)^3}+\ldots\right] \tag{13}$$

$$I_1(x)\sim\frac{e^x}{\sqrt{2\pi x}}\left[1-\frac{3}{1!8x}-\frac{3.5}{2!(8x)^2}-\frac{3^2 5.7}{3!(8x)^3}-\ldots\right] \tag{14}$$

were used to evaluate these Bessel functions.

All the calculations are accurate to within one figure in the fifth place. Eight place tables are available from the authors, as well as a tabulation for the range $0.001<\eta\leqslant 0.01$.

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TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

                                    ETA = 0.000001

   Y           PSI(Y,ETA)     DPSI(Y,ETA)/DY            Y          PSI(Y,ETA)      DPSI(Y,ETA)/DY

1.9960        0.23414D-02     0.51718D 01            2.0002       0.55637D 00      0.27927D 03
1.9965        0.66707D-02     0.13205D 02            2.0004       0.61149D 00      0.27101D 03
1.9970        0.16962D-01     0.29755D 02            2.0006       0.66444D 00      0.25778D 03
1.9975        0.38579D-01     0.59167D 02            2.0008       0.71432D 00      0.24034D 03
1.9980        0.78701D-01     0.10383D 03            2.0010       0.76036D 00      0.21964D 03

1.9982        0.10161D-00     0.12555D 03            2.0012       0.80203D 00      0.19675D 03
1.9984        0.12902D-00     0.14881D 03            2.0014       0.83899D 00      0.17276D 03
1.9986        0.16119D-00     0.17288D 03            2.0016       0.87112D 00      0.14869D 03
1.9988        0.19817D-00     0.19687D 03            2.0018       0.89852D 00      0.12544D 03
1.9990        0.23986D-00     0.21975D 03            2.0020       0.92140D 00      0.10373D 03


1.9992        0.28592D-00     0.24043D 03            2.0022       0.94014D 00      0.84076D 02
1.9994        0.33581D-00     0.25785D 03            2.0025       0.96148D 00      0.59093D 02
1.9996        0.38878D-00     0.27106D 03            2.0030       0.98307D 00      0.29710D 02
1.9998        0.44391D-00     0.27930D 03            2.0035       0.99334D 00      0.13182D 02
2.0000        0.50014D 00     0.28209D 03            2.0040       0.99766D 00      0.51616D 01
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TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION


                                  ETA = 0.000002


   Y            PSI(Y,ETA)     DPSI(Y,ETA)/DY           Y           PSI(Y,ETA)     DPSI(Y,ETA)/DY

1.9950        0.62184D-02       0.87750D 01          2.0002        0.54003D 00       0.19847D 03
1.9955        0.12240D-01       0.15888D 02          2.0004        0.57946D 00       0.19550D 03
1.9960        0.22777D-01       0.27022D 02          2.0006        0.61810D 00       0.19067D 03
1.9965        0.40102D-01       0.43176D 02          2.0008        0.65561D 00       0.18410D 03
1.9970        0.66873D-01       0.64808D 02          2.0010        0.69164D 00       0.17599D 03

1.9972        0.80832D-01       0.74917D 02          2.0012        0.72591D 00       0.16656D 03
1.9974        0.96887D-01       0.85740D 02          2.0014        0.75819D 00       0.15607D 03
1.9976        0.11517D-00       0.97152D 02          2.0016        0.78829D 00       0.14479D 03
1.9978        0.13578D-00       0.10899D 03          2.0018        0.81607D 00       0.13298D 03
1.9980        0.15878D-00       0.12105D 03          2.0020        0.84147D 00       0.12092D 03


1.9982        0.18419D-00       0.13310D 03          2.0022        0.86444D 00       0.10887D 03
1.9984        0.21200D-00       0.14490D 03          2.0024        0.88503D 00       0.97034D 02
1.9986        0.24212D-00       0.15618D 03          2.0026        0.90329D 00       0.85628D 02
1.9988        0.27442D-00       0.16666D 03          2.0028        0.91932D 00       0.74811D 02
1.9990        0.30871D-00       0.17608D 03          2.0030        0.93326D 00       0.64710D 02

1.9992        0.34476D-00       0.18417D 03          2.0032        0.94526D 00       0.55416D 02
1.9994        0.38228D-00       0.19072D 03          2.0035        0.95998D 00       0.43101D 02
1.9996        0.42094D-00       0.19554D 03          2.0040        0.97728D 00       0.26968D 02
1.9998        0.46037D-00       0.19849D 03          2.0045        0.98779D 00       0.15852D 02
2.0000        0.50020D 00       0.19947D 03          2.0050        0.99380D 00       0.87531D 01
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TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION


                                  ETA = 0.000003


   Y            PSI(Y,ETA)     DPSI(Y,ETA)/DY           Y           PSI(Y,ETA)     DPSI(Y,ETA)/DY

                                                     2.0002        0.53278D 00       0.16232D 03
1.9935        0.39890D-02       0.48246D 01          2.0004        0.56510D 00       0.16069D 03
1.9940        0.71651D-02       0.81208D 01          2.0006        0.59699D 00       0.15803D 03
1.9945        0.12392D-01       0.13111D 02          2.0008        0.62825D 00       0.15438D 03
1.9950        0.20644D-01       0.20305D 02          2.0010        0.65868D 00       0.14981D 03

1.9955        0.33141D-01       0.30161D 02          2.0012        0.68811D 00       0.14441D 03
1.9960        0.51299D-01       0.42974D 02          2.0014        0.71639D 00       0.13828D 03
1.9965        0.76609D-01       0.58732D 02          2.0016        0.74338D 00       0.13153D 03
1.9968        0.95814D-01       0.69436D 02          2.0018        0.76897D 00       0.12427D 03
1.9970        0.11045D-00       0.76991D 02          2.0020        0.79307D 00       0.11664D 03


1.9972        0.12663D-00       0.84801D 02          2.0022        0.81561D 00       0.10875D 03
1.9974        0.14438D-00       0.92782D 02          2.0024        0.83656D 00       0.10072D 03
1.9976        0.16375D-00       0.10084D 03          2.0026        0.85590D 00       0.92661D 02
1.9978        0.18472D-00       0.10887D 03          2.0028        0.87363D 00       0.84682D 02
1.9980        0.20728D-00       0.11676D 03          2.0030        0.88978D 00       0.76875D 02

1.9982        0.23140D-00       0.12439D 03          2.0032        0.90440D 00       0.69325D 02
1.9984        0.25701D-00       0.13163D 03          2.0034        0.91753D 00       0.62101D 02
1.9986        0.28402D-00       0.13837D 03          2.0037        0.93462D 00       0.51997D 02
1.9988        0.31232D-00       0.14449D 03          2.0040        0.94883D 00       0.42889D 02
1.9990        0.34177D-00       0.14988D 03          2.0045        0.96695D 00       0.30094D 02


1.9992        0.37222D-00       0.15444D 03          2.0050        0.97942D 00       0.20254D 02
1.9994        0.40349D-00       0.15808D 03          2.0055        0.98765D 00       0.13076D 02
1.9996        0.43538D-00       0.16073D 03          2.0060        0.99286D 00       0.80967D 01
1.9998        0.46771D-00       0.16233D 03          2.0065        0.99603D 00       0.48091D 01
2.0000        0.50025D 00       0.16287D 03
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TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000004

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
			2.0002	0.52847D 00	0.14069D 03
			2.0004	0.55651D 00	0.13963D 03
			2.0006	0.58427D 00	0.13789D 03
1.9930	0.66773D-02	0.66084D 01	2.0008	0.61162D 00	0.13549D 03
1.9935	0.10798D-01	0.10075D 02	2.0010	0.63843D 00	0.13247D 03
1.9940	0.16977D-01	0.14888D 02	2.0012	0.66457D 00	0.12887D 03
1.9945	0.25957D-01	0.21324D 02	2.0014	0.68994D 00	0.12474D 03
1.9950	0.38609D-01	0.29602D 02	2.0016	0.71444D 00	0.12014D 03
1.9955	0.55885D-01	0.39829D 02	2.0018	0.73797D 00	0.11514D 03
1.9960	0.78754D-01	0.51940D 02	2.0020	0.76047D 00	0.10979D 03
1.9962	0.89669D-01	0.57257D 02	2.0022	0.78187D 00	0.10417D 03
1.9964	0.10167D-00	0.62803D 02	2.0024	0.80213D 00	0.98346D 02
1.9966	0.11480D-00	0.68542D 02	2.0026	0.82120D 00	0.92383D 02
1.9968	0.12910D-00	0.74433D 02	2.0028	0.83907D 00	0.86349D 02
1.9970	0.14458D-00	0.80427D 02	2.0030	0.85574D 00	0.80306D 02
1.9972	0.16127D-00	0.86470D 02	2.0032	0.87120D 00	0.74314D 02
1.9974	0.17917D-00	0.92504D 02	2.0034	0.88547D 00	0.68425D 02
1.9976	0.19827D-00	0.98465D 02	2.0036	0.89858D 00	0.62689D 02
1.9978	0.21855D-00	0.10429D 03	2.0038	0.91056D 00	0.57148D 02
1.9980	0.23997D-00	0.10990D 03	2.0040	0.92145D 00	0.51836D 02
1.9982	0.26249D-00	0.11524D 03	2.0042	0.93131D 00	0.46784D 02
1.9984	0.28604D-00	0.12024D 03	2.0045	0.94427D 00	0.39740D 02
1.9986	0.31056D-00	0.12483D 03	2.0050	0.96151D 00	0.29528D 02
1.9988	0.33595D-00	0.12895D 03	2.0055	0.97413D 00	0.21266D 02
1.9990	0.36210D-00	0.13253D 03	2.0060	0.98308D 00	0.14844D 02
1.9992	0.38892D-00	0.13554D 03	2.0065	0.98924D 00	0.10043D 02
1.9994	0.41628D-00	0.13793D 03	2.0070	0.99335D 00	0.65854D 01
1.9996	0.44405D-00	0.13966D 03			
1.9998	0.47210D-00	0.14070D 03			
2.0000	0.50028D 00	0.14105D 03			

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000005

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
1.9920	0.57189D-02	0.51527D 01	2.0002	0.52553D 00	0.12590D 03
1.9925	0.88720D-02	0.75905D 01	2.0004	0.55064D 00	0.12514D 03
1.9930	0.13456D-01	0.10906D 02	2.0006	0.57555D 00	0.12389D 03
1.9935	0.19955D-01	0.15282D 02	2.0008	0.60016D 00	0.12216D 03
1.9940	0.28942D-01	0.20885D 02	2.0010	0.62438D 00	0.11997D 03
1.9945	0.41065D-01	0.27838D 02	2.0012	0.64812D 00	0.11736D 03
1.9950	0.57014D-01	0.36190D 02	2.0014	0.67130D 00	0.11434D 03
1.9955	0.77479D-01	0.45886D 02	2.0016	0.69384D 00	0.11096D 03
1.9958	0.92193D-01	0.52278D 02	2.0018	0.71566D 00	0.10724D 03
1.9960	0.10309D-00	0.56742D 02	2.0020	0.73671D 00	0.10324D 03
1.9962	0.11490D-00	0.61342D 02	2.0022	0.75694D 00	0.98986D 02
1.9964	0.12764D-00	0.66051D 02	2.0024	0.77629D 00	0.94531D 02
1.9966	0.14132D-00	0.70836D 02	2.0026	0.79474D 00	0.89916D 02
1.9968	0.15597D-00	0.75665D 02	2.0028	0.81225D 00	0.85185D 02
1.9970	0.17159D-00	0.80501D 02	2.0030	0.82881D 00	0.80381D 02
1.9972	0.18817D-00	0.85304D 02	2.0032	0.84440D 00	0.75545D 02
1.9974	0.20571D-00	0.90033D 02	2.0034	0.85903D 00	0.70716D 02
1.9976	0.22418D-00	0.94644D 02	2.0036	0.87269D 00	0.65932D 02
1.9978	0.24355D-00	0.99094D 02	2.0038	0.88541D 00	0.61226D 02
1.9980	0.26380D-00	0.10334D 03	2.0040	0.89719D 00	0.56629D 02
1.9982	0.28487D-00	0.10734D 03	2.0042	0.90807D 00	0.52168D 02
1.9984	0.30672D-00	0.11104D 03	2.0044	0.91807D 00	0.47867D 02
1.9986	0.32927D-00	0.11442D 03	2.0047	0.93150D 00	0.41756D 02
1.9988	0.35246D-00	0.11743D 03	2.0050	0.94317D 00	0.36099D 02
1.9990	0.37621D-00	0.12003D 03	2.0055	0.95907D 00	0.27762D 02
1.9992	0.40045D-00	0.12221D 03	2.0060	0.97116D 00	0.20822D 02
1.9994	0.42507D-00	0.12392D 03	2.0065	0.98012D 00	0.15232D 02
1.9996	0.44998D-00	0.12516D 03	2.0070	0.98660D 00	0.10868D 02
1.9998	0.47510D-00	0.12591D 03	2.0075	0.99117D 00	0.75621D 01
2.0000	0.50031D 00	0.12616D 03	2.0080	0.99431D 00	0.51322D 01

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000006

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
1.9910	0.46992D-02	0.39496D 01
1.9915	0.70860D-02	0.56864D 01
1.9920	0.10485D-01	0.80181D 01
1.9925	0.15225D-01	0.11073D 02
1.9930	0.21699D-01	0.14976D 02
1.9935	0.30360D-01	0.19837D 02
1.9940	0.41709D-01	0.25735D 02
1.9945	0.56274D-01	0.32698D 02
1.9950	0.74579D-01	0.40689D 02
1.9953	0.87564D-01	0.45930D 02
1.9956	0.10217D-00	0.51460D 02
1.9958	0.11284D-00	0.55280D 02
1.9960	0.12428D-00	0.59187D 02
1.9962	0.13652D-00	0.63158D 02
1.9964	0.14955D-00	0.67172D 02
1.9966	0.16339D-00	0.71204D 02
1.9968	0.17803D-00	0.75226D 02
1.9970	0.19348D-00	0.79211D 02
1.9972	0.20971D-00	0.83129D 02
1.9974	0.22672D-00	0.86951D 02
1.9976	0.24448D-00	0.90646D 02
1.9978	0.26297D-00	0.94184D 02
1.9980	0.28214D-00	0.97533D 02
1.9982	0.30197D-00	0.10067D 03
1.9984	0.32239D-00	0.10355D 03
1.9986	0.34337D-00	0.10617D 03
1.9988	0.36484D-00	0.10849D 03
1.9990	0.38675D-00	0.11049D 03
1.9992	0.40902D-00	0.11216D 03
1.9994	0.43159D-00	0.11347D 03
1.9996	0.45438D-00	0.11441D 03
1.9998	0.47732D-00	0.11498D 03
2.0000	0.50035D 00	0.11516D 03
2.0002	0.52336D 00	0.11497D 03
2.0004	0.54631D 00	0.11439D 03
2.0006	0.56910D 00	0.11343D 03
2.0008	0.59166D 00	0.11211D 03
2.0010	0.61392D 00	0.11044D 03
2.0012	0.63581D 00	0.10843D 03
2.0014	0.65727D 00	0.10610D 03
2.0016	0.67823D 00	0.10347D 03
2.0018	0.69864D 00	0.10058D 03
2.0020	0.71844D 00	0.97436D 02
2.0022	0.73760D 00	0.94080D 02
2.0024	0.75606D 00	0.90537D 02
2.0026	0.77380D 00	0.86838D 02
2.0028	0.79079D 00	0.83013D 02
2.0030	0.80700D 00	0.79092D 02
2.0032	0.82242D 00	0.75106D 02
2.0034	0.83704D 00	0.71083D 02
2.0036	0.85085D 00	0.67052D 02
2.0038	0.86386D 00	0.63039D 02
2.0040	0.87607D 00	0.59068D 02
2.0042	0.88749D 00	0.55164D 02
2.0044	0.89814D 00	0.51347D 02
2.0046	0.90804D 00	0.47634D 02
2.0048	0.91720D 00	0.44043D 02
2.0050	0.92566D 00	0.40587D 02
2.0055	0.94392D 00	0.32608D 02
2.0060	0.95844D 00	0.25658D 02
2.0065	0.96976D 00	0.19773D 02
2.0070	0.97839D 00	0.14924D 02
2.0075	0.98484D 00	0.11031D 02
2.0080	0.98956D 00	0.79860D 01
2.0085	0.99295D 00	0.56622D 01
2.0090	0.99532D 00	0.39318D 01

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000007

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
1.9905	0.55736D-02	0.42565D 01	2.0002	0.52169D 00	0.10646D 03
1.9910	0.80991D-02	0.59220D 01	2.0004	0.54294D 00	0.10600D 03
1.9915	0.11580D-01	0.80934D 01	2.0006	0.56407D 00	0.10524D 03
1.9920	0.16293D-01	0.10865D 02	2.0008	0.58502D 00	0.10419D 03
1.9925	0.22560D-01	0.14328D 02	2.0010	0.60573D 00	0.10286D 03
1.9930	0.30749D-01	0.18560D 02	2.0012	0.62614D 00	0.10125D 03
1.9935	0.41259D-01	0.23617D 02	2.0014	0.64621D 00	0.99379D 02
1.9940	0.54508D-01	0.29520D 02	2.0016	0.66588D 00	0.97267D 02
1.9945	0.70916D-01	0.36245D 02	2.0018	0.68510D 00	0.94928D 02
1.9950	0.90877D-01	0.43714D 02	2.0020	0.70383D 00	0.92382D 02
1.9952	0.99936D-01	0.46882D 02	2.0022	0.72204D 00	0.89647D 02
1.9954	0.10964D-00	0.50135D 02	2.0024	0.73968D 00	0.86745D 02
1.9956	0.11999D-00	0.53461D 02	2.0026	0.75673D 00	0.83698D 02
1.9958	0.13102D-00	0.56845D 02	2.0028	0.77315D 00	0.80527D 02
1.9960	0.14274D-00	0.60271D 02	2.0030	0.78893D 00	0.77255D 02
1.9962	0.15513D-00	0.63721D 02	2.0032	0.80405D 00	0.73905D 02
1.9964	0.16822D-00	0.67177D 02	2.0034	0.81849D 00	0.70498D 02
1.9966	0.18200D-00	0.70618D 02	2.0036	0.83224D 00	0.67056D 02
1.9968	0.19647D-00	0.74023D 02	2.0038	0.84531D 00	0.63601D 02
1.9970	0.21161D-00	0.77371D 02	2.0040	0.85769D 00	0.60151D 02
1.9972	0.22741D-00	0.80639D 02	2.0042	0.86937D 00	0.56726D 02
1.9974	0.24386D-00	0.83806D 02	2.0044	0.88038D 00	0.53344D 02
1.9976	0.26093D-00	0.86849D 02	2.0046	0.89071D 00	0.50020D 02
1.9978	0.27859D-00	0.89746D 02	2.0048	0.90039D 00	0.46770D 02
1.9980	0.29681D-00	0.92474D 02	2.0050	0.90943D 00	0.43605D 02
1.9982	0.31557D-00	0.95014D 02	2.0052	0.91784D 00	0.40539D 02
1.9984	0.33480D-00	0.97345D 02	2.0055	0.92934D 00	0.36146D 02
1.9986	0.35449D-00	0.99448D 02	2.0060	0.94570D 00	0.29432D 02
1.9988	0.37457D-00	0.10131D 03	2.0065	0.95891D 00	0.23541D 02
1.9990	0.39499D-00	0.10291D 03	2.0070	0.96938D 00	0.18496D 02
1.9992	0.41571D-00	0.10423D 03	2.0075	0.97754D 00	0.14275D 02
1.9994	0.43667D-00	0.10528D 03	2.0080	0.98378D 00	0.10822D 02
1.9996	0.45780D-00	0.10602D 03	2.0085	0.98848D 00	0.80591D 01
1.9998	0.47906D-00	0.10647D 03	2.0090	0.99194D 00	0.58954D 01
2.0000	0.50037D 00	0.10662D 03	2.0095	0.99446D 00	0.42363D 01

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000008

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
			2.0002	0.52034D 00	0.99606D 02
			2.0004	0.54022D 00	0.99228D 02
			2.0006	0.56001D 00	0.98605D 02
1.9895	0.43452D-02	0.31894D 01	2.0008	0.57965D 00	0.97741D 02
1.9900	0.62272D-02	0.43930D 01	2.0010	0.59909D 00	0.96643D 02
1.9905	0.87982D-02	0.59571D 01	2.0012	0.61829D 00	0.95318D 02
1.9910	0.12256D-01	0.79528D 01	2.0014	0.63721D 00	0.93777D 02
1.9915	0.16835D-01	0.10452D 02	2.0016	0.65579D 00	0.92031D 02
1.9920	0.22804D-01	0.13525D 02	2.0018	0.67400D 00	0.90091D 02
1.9925	0.30465D-01	0.17229D 02	2.0020	0.69181D 00	0.87972D 02
1.9930	0.40145D-01	0.21607D 02	2.0022	0.70918D 00	0.85689D 02
1.9935	0.52188D-01	0.26678D 02	2.0024	0.72608D 00	0.83256D 02
1.9940	0.66937D-01	0.32428D 02	2.0026	0.74248D 00	0.80691D 02
1.9945	0.84721D-01	0.38806D 02	2.0028	0.75835D 00	0.78009D 02
1.9950	0.10583D-00	0.45719D 02	2.0030	0.77367D 00	0.75228D 02
1.9952	0.11526D-00	0.48605D 02	2.0032	0.78843D 00	0.72365D 02
1.9954	0.12528D-00	0.51543D 02	2.0034	0.80261D 00	0.69437D 02
1.9956	0.13588D-00	0.54523D 02	2.0036	0.81621D 00	0.66461D 02
1.9958	0.14709D-00	0.57531D 02	2.0038	0.82920D 00	0.63454D 02
1.9960	0.15890D-00	0.60553D 02	2.0040	0.84159D 00	0.60432D 02
1.9962	0.17131D-00	0.63575D 02	2.0042	0.85337D 00	0.57410D 02
1.9964	0.18433D-00	0.66581D 02	2.0044	0.86455D 00	0.54403D 02
1.9966	0.19794D-00	0.69555D 02	2.0046	0.87513D 00	0.51425D 02
1.9968	0.21215D-00	0.72481D 02	2.0048	0.88512D 00	0.48488D 02
1.9970	0.22693D-00	0.75341D 02	2.0050	0.89453D 00	0.45605D 02
1.9972	0.24228D-00	0.78118D 02	2.0052	0.90337D 00	0.42786D 02
1.9974	0.25817D-00	0.80795D 02	2.0055	0.91559D 00	0.38700D 02
1.9976	0.27459D-00	0.83356D 02	2.0060	0.93332D 00	0.32331D 02
1.9978	0.29150D-00	0.85783D 02	2.0065	0.94803D 00	0.26591D 02
1.9980	0.30889D-00	0.88060D 02	2.0070	0.96003D 00	0.21532D 02
1.9982	0.32672D-00	0.90172D 02	2.0075	0.96967D 00	0.17164D 02
1.9984	0.34495D-00	0.92104D 02	2.0080	0.97730D 00	0.13471D 02
1.9986	0.36354D-00	0.93843D 02	2.0085	0.98325D 00	0.10408D 02
1.9988	0.38247D-00	0.95375D 02	2.0090	0.98781D 00	0.79170D 01
1.9990	0.40168D-00	0.96691D 02	2.0095	0.99125D 00	0.59289D 01
1.9992	0.42113D-00	0.97780D 02	2.0100	0.99381D 00	0.43711D 01
1.9994	0.44078D-00	0.98634D 02	2.0105	0.99568D 00	0.31727D 01
1.9996	0.46057D-00	0.99248D 02			
1.9998	0.48046D-00	0.99616D 02			
2.0000	0.50040D 00	0.99735D 02			

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000009

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
			2.0002	0.51922D 00	0.93922D 02
1.9890	0.47757D-02	0.32716D 01	2.0004	0.53798D 00	0.93605D 02
1.9895	0.66840D-02	0.44095D 01	2.0006	0.55665D 00	0.93082D 02
1.9900	0.92374D-02	0.58612D 01	2.0008	0.57520D 00	0.92356D 02
1.9905	0.12607D-01	0.76834D 01	2.0010	0.59358D 00	0.91433D 02
1.9910	0.16992D-01	0.99332D 01	2.0012	0.61176D 00	0.90317D 02
1.9915	0.22620D-01	0.12665D 02	2.0014	0.62969D 00	0.89018D 02
1.9920	0.29745D-01	0.15924D 02	2.0016	0.64735D 00	0.87542D 02
1.9925	0.38639D-01	0.19747D 02	2.0018	0.66470D 00	0.85900D 02
1.9930	0.49589D-01	0.24150D 02	2.0020	0.68170D 00	0.84101D 02
1.9935	0.62884D-01	0.29126D 02	2.0022	0.69833D 00	0.82157D 02
1.9940	0.78805D-01	0.34644D 02	2.0024	0.71456D 00	0.80080D 02
1.9945	0.97609D-01	0.40639D 02	2.0026	0.73035D 00	0.77883D 02
1.9948	0.11036D-00	0.44426D 02	2.0028	0.74570D 00	0.75577D 02
1.9950	0.11951D-00	0.47014D 02	2.0030	0.76058D 00	0.73177D 02
1.9952	0.12917D-00	0.49642D 02	2.0032	0.77497D 00	0.70696D 02
1.9954	0.13937D-00	0.52300D 02	2.0034	0.78885D 00	0.68147D 02
1.9956	0.15009D-00	0.54979D 02	2.0036	0.80222D 00	0.65545D 02
1.9958	0.16136D-00	0.57667D 02	2.0038	0.81507D 00	0.62901D 02
1.9960	0.17316D-00	0.60352D 02	2.0040	0.82738D 00	0.60231D 02
1.9962	0.18550D-00	0.63021D 02	2.0042	0.83916D 00	0.57546D 02
1.9964	0.19837D-00	0.65663D 02	2.0044	0.85040D 00	0.54858D 02
1.9966	0.21176D-00	0.68263D 02	2.0046	0.86110D 00	0.52180D 02
1.9968	0.22567D-00	0.70809D 02	2.0048	0.87127D 00	0.49523D 02
1.9970	0.24008D-00	0.73287D 02	2.0050	0.88091D 00	0.46896D 02
1.9972	0.25498D-00	0.75683D 02	2.0052	0.89003D 00	0.44310D 02
1.9974	0.27035D-00	0.77984D 02	2.0054	0.89864D 00	0.41774D 02
1.9976	0.28616D-00	0.80176D 02	2.0057	0.91062D 00	0.38081D 02
1.9978	0.30241D-00	0.82248D 02	2.0060	0.92151D 00	0.34541D 02
1.9980	0.31905D-00	0.84185D 02	2.0065	0.93738D 00	0.29032D 02
1.9982	0.33607D-00	0.85977D 02	2.0070	0.95063D 00	0.24065D 02
1.9984	0.35344D-00	0.87612D 02	2.0075	0.96154D 00	0.19673D 02
1.9986	0.37111D-00	0.89080D 02	2.0080	0.97040D 00	0.15861D 02
1.9988	0.38906D-00	0.90372D 02	2.0085	0.97749D 00	0.12611D 02
1.9990	0.40724D-00	0.91478D 02	2.0090	0.98310D 00	0.98887D 01
1.9992	0.42563D-00	0.92393D 02	2.0095	0.98746D 00	0.76471D 01
1.9994	0.44419D-00	0.93110D 02	2.0100	0.99082D 00	0.58320D 01
1.9996	0.46286D-00	0.93624D 02	2.0105	0.99336D 00	0.43865D 01
1.9998	0.48162D-00	0.93932D 02	2.0110	0.99525D 00	0.32537D 01
2.0000	0.50042D 00	0.94031D 02			

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000010

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
1.9885	0.50797D-02	0.32791D 01	2.0002	0.51828D 00	0.89112D 02
1.9890	0.69749D-02	0.43436D 01	2.0004	0.53608D 00	0.88841D 02
1.9895	0.94690D-02	0.56822D 01	2.0006	0.55381D 00	0.88394D 02
1.9900	0.12710D-01	0.73408D 01	2.0008	0.57142D 00	0.87773D 02
1.9905	0.16871D-01	0.93659D 01	2.0010	0.58890D 00	0.86982D 02
1.9910	0.22145D-01	0.11801D 02	2.0012	0.60621D 00	0.86026D 02
1.9915	0.28747D-01	0.14685D 02	2.0014	0.62330D 00	0.84911D 02
1.9920	0.36909D-01	0.18047D 02	2.0016	0.64016D 00	0.83642D 02
1.9925	0.46876D-01	0.21902D 02	2.0018	0.65675D 00	0.82228D 02
1.9930	0.58894D-01	0.26251D 02	2.0020	0.67304D 00	0.80677D 02
1.9935	0.73206D-01	0.31073D 02	2.0022	0.68901D 00	0.78996D 02
1.9940	0.90038D-01	0.36323D 02	2.0024	0.70463D 00	0.77196D 02
1.9945	0.10959D-00	0.41933D 02	2.0026	0.71988D 00	0.75286D 02
1.9948	0.12269D-00	0.45433D 02	2.0028	0.73474D 00	0.73277D 02
1.9950	0.13202D-00	0.47808D 02	2.0030	0.74919D 00	0.71179D 02
1.9952	0.14182D-00	0.50207D 02	2.0032	0.76321D 00	0.69003D 02
1.9954	0.15210D-00	0.52620D 02	2.0034	0.77678D 00	0.66760D 02
1.9956	0.16286D-00	0.55039D 02	2.0036	0.78991D 00	0.64460D 02
1.9958	0.17411D-00	0.57455D 02	2.0038	0.80257D 00	0.62116D 02
1.9960	0.18585D-00	0.59856D 02	2.0040	0.81475D 00	0.59737D 02
1.9962	0.19806D-00	0.62234D 02	2.0042	0.82646D 00	0.57334D 02
1.9964	0.21074D-00	0.64576D 02	2.0044	0.83768D 00	0.54919D 02
1.9966	0.22388D-00	0.66873D 02	2.0046	0.84843D 00	0.52499D 02
1.9968	0.23748D-00	0.69113D 02	2.0048	0.85868D 00	0.50086D 02
1.9970	0.25152D-00	0.71286D 02	2.0050	0.86846D 00	0.47689D 02
1.9972	0.26599D-00	0.73380D 02	2.0052	0.87776D 00	0.45316D 02
1.9974	0.28087D-00	0.75384D 02	2.0054	0.88659D 00	0.42974D 02
1.9976	0.29614D-00	0.77289D 02	2.0057	0.89896D 00	0.39539D 02
1.9978	0.31178D-00	0.79083D 02	2.0060	0.91032D 00	0.36214D 02
1.9980	0.32776D-00	0.80757D 02	2.0065	0.92710D 00	0.30972D 02
1.9982	0.34407D-00	0.82302D 02	2.0070	0.94137D 00	0.26159D 02
1.9984	0.36068D-00	0.83709D 02	2.0075	0.95334D 00	0.21820D 02
1.9986	0.37755D-00	0.84970D 02	2.0080	0.96327D 00	0.17975D 02
1.9988	0.39465D-00	0.86078D 02	2.0085	0.97140D 00	0.14623D 02
1.9990	0.41197D-00	0.87025D 02	2.0090	0.97797D 00	0.11748D 02
1.9992	0.42945D-00	0.87808D 02	2.0095	0.98322D 00	0.93216D 01
1.9994	0.44708D-00	0.88420D 02	2.0100	0.98736D 00	0.73043D 01
1.9996	0.46481D-00	0.88859D 02	2.0105	0.99059D 00	0.56524D 01
1.9998	0.48261D-00	0.89121D 02	2.0110	0.99307D 00	0.43198D 01
2.0000	0.50045D 00	0.89206D 02	2.0115	0.99495D 00	0.32604D 01

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000020

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
			2.0010	0.56344D 00	0.62279D 02
1.9825	0.28426D-02	0.13780D 01	2.0020	0.62469D 00	0.59972D 02
1.9850	0.88911D-02	0.38024D 01	2.0030	0.68294D 00	0.56324D 02
1.9875	0.24143D-01	0.89744D 01	2.0040	0.73697D 00	0.51592D 02
1.9900	0.57105D-01	0.18118D 02	2.0050	0.78586D 00	0.46091D 02
1.9910	0.77595D-01	0.22969D 02	2.0060	0.82901D 00	0.40160D 02
1.9920	0.10324D-00	0.28400D 02	2.0070	0.86615D 00	0.34128D 02
1.9930	0.13453D-00	0.34248D 02	2.0080	0.89733D 00	0.28286D 02
1.9940	0.17179D-00	0.40281D 02	2.0090	0.92286D 00	0.22865D 02
1.9950	0.21506D-00	0.46207D 02	2.0100	0.94326D 00	0.18027D 02
1.9960	0.26406D-00	0.51696D 02	2.0110	0.95914D 00	0.13862D 02
1.9970	0.31819D-00	0.56409D 02	2.0125	0.97604D 00	0.89185D 01
1.9980	0.37652D-00	0.60032D 02	2.0150	0.99118D 00	0.37740D 01
1.9990	0.43781D-00	0.62310D 02	2.0175	0.99718D 00	0.13660D 01
2.0000	0.50063D 00	0.63078D 02			

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000030

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
1.9800	0.49394D-02	0.18466D 01	2.0010	0.55213D 00	0.51063D 02
1.9825	0.11995D-01	0.40307D 01	2.0020	0.60262D 00	0.49790D 02
1.9850	0.26523D-01	0.79280D 01	2.0030	0.65145D 00	0.47746D 02
1.9875	0.53503D-01	0.14051D 02	2.0040	0.69789D 00	0.45029D 02
1.9900	0.98690D-01	0.22439D 02	2.0050	0.74132D 00	0.41765D 02
1.9910	0.12303D-00	0.26282D 02	2.0060	0.78128D 00	0.38097D 02
1.9920	0.15130D-00	0.30275D 02	2.0070	0.81743D 00	0.34177D 02
1.9930	0.18359D-00	0.34297D 02	2.0080	0.84960D 00	0.30154D 02
1.9940	0.21986D-00	0.38212D 02	2.0090	0.87775D 00	0.26164D 02
1.9950	0.25993D-00	0.41869D 02	2.0100	0.90198D 00	0.22327D 02
1.9960	0.30347D-00	0.45119D 02	2.0110	0.92249D 00	0.18738D 02
1.9970	0.34999D-00	0.47817D 02	2.0125	0.94692D 00	0.13963D 02
1.9980	0.39887D-00	0.49839D 02	2.0150	0.97371D 00	0.78687D 01
1.9990	0.44941D-00	0.51088D 02	2.0175	0.98813D 00	0.39956D 01
2.0000	0.50077D 00	0.51503D 02	2.0200	0.99512D 00	0.18282D 01

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              TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTICN OF THE LAMM EQUATICN


                                              ETA = 0.000040


      Y           PSI(Y,ETA)      DPSI(Y,ETA)/DY               Y           PSI(Y,ETA)        DPSI(Y,ETA)/DY

                                                              2.0010       0.54540D 00       0.44314D 02
                                                              2.0020       0.58934D 00       0.43480D 02
                                                              2.0030       0.63218D 00       0.42132D 02
                                                              2.0040       0.67345D 00       0.40318D 02
    1.9775          0.59799D-02      0.18953D 01              2.0050       0.71269D 00       0.38103D 02

    1.9800          0.12747D-01      0.36797D 01              2.0060       0.74954D 00       0.35563D 02
    1.9825          0.25332D-01      0.66070D 01              2.0070       0.78373D 00       0.32779D 02
    1.9875          0.81463D-01      0.16850D 02              2.0080       0.81505D 00       0.29838D 02
    1.9890          0.10980D-00      0.20995D 02              2.0090       0.84338D 00       0.26824D 02
    1.9900          0.13226D-00      0.23934D 02              2.0100       0.86870D 00       0.23815D 02


    1.9910          0.15769D-00      0.26945D 02              2.0110       0.89104D 00       0.20880D 02
    1.9920          0.18615D-00      0.29958D 02              2.0125       0.91921D 00       0.16745D 02
    1.9930          0.21758D-00      0.32894D 02              2.0150       0.95345D 00       0.10890D 02
    1.9940          0.25188D-00      0.35670D 02              2.0175       0.97493D 00       0.65494D 01
    1.9950          0.28884D-00      0.38199D 02              2.0200       0.98740D 00       0.36431D 01

    1.9960          0.32817D-00      0.40399D 02              2.0225       0.99410D 00       0.18741D 01
    1.9970          0.36950D-00      0.42195D 02
    1.9980          0.41240D-00      0.43523D 02
    1.9990          0.45638D-00      0.44336D 02
    2.0000          0.50089D 00      0.44603D 02
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              TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTICN OF THE LAMM EQUATICN


                                              ETA = 0.000050


      Y           PSI(Y,ETA)      DPSI(Y,ETA)/DY               Y           PSI(Y,ETA)        DPSI(Y,ETA)/DY

                                                              2.0010       0.54082D 00       0.39685D 02
    1.9750          0.62539D-02      0.17639D 01              2.0020       0.58024D 00       0.39084D 02
    1.9775          0.12304D-01      0.31919D 01              2.0030       0.61886D 00       0.38110D 02
    1.9800          0.22886D-01      0.54262D 01              2.0040       0.65634D 00       0.36790D 02
    1.9825          0.40276D-01      0.86656D 01              2.0050       0.69234D 00       0.35162D 02

    1.9850          0.67133D-01      0.13001D 02              2.0060       0.72658D 00       0.33272D 02
    1.9865          0.88911D-01      0.16093D 02              2.0070       0.75881D 00       0.31171D 02
    1.9880          0.11556D-00      0.19477D 02              2.0080       0.78887D 00       0.28911D 02
    1.9890          0.13621D-00      0.21845D 02              2.0090       0.81660D 00       0.26549D 02
    1.9900          0.15926D-00      0.24258D 02              2.0100       0.84195D 00       0.24137D 02


    1.9910          0.18473D-00      0.26668D 02              2.0110       0.86488D 00       0.21725D 02
    1.9920          0.21258D-00      0.29027D 02              2.0120       0.88541D 00       0.19360D 02
    1.9930          0.24275D-00      0.31280D 02              2.0130       0.90363D 00       0.17081D 02
    1.9940          0.27509D-00      0.33372D 02              2.0140       0.91962D 00       0.14920D 02
    1.9950          0.30942D-00      0.35250D 02              2.0150       0.93351D 00       0.12903D 02

    1.9960          0.34550D-00      0.36864D 02              2.0175       0.96016D 00       0.85901D 01
    1.9970          0.38304D-00      0.38167D 02              2.0200       0.97738D 00       0.53722D 01
    1.9980          0.42172D-00      0.39123D 02              2.0225       0.98785D 00       0.31562D 01
    1.9990          0.46116D-00      0.39705D 02              2.0250       0.99383D 00       0.17420D 01
    2.0000          0.50100D 00      0.39894D 02
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TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000060

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
			2.0010	0.53746D 00	0.36257D 02
			2.0020	0.57351D 00	0.35798D 02
			2.0030	0.60896D 00	0.35051D 02
			2.0040	0.64352D 00	0.34035D 02
1.9725	0.60771D-02	0.15698D 01	2.0050	0.67694D 00	0.32774D 02
1.9750	0.11321D-01	0.27106D 01	2.0060	0.70900D 00	0.31298D 02
1.9775	0.20123D-01	0.44430D 01	2.0070	0.73948D 00	0.29641D 02
1.9800	0.34152D-01	0.69131D 01	2.0080	0.76823D 00	0.27838D 02
1.9825	0.55381D-01	0.10210D 02	2.0090	0.79512D 00	0.25928D 02
1.9850	0.85882D-01	0.14315D 02	2.0100	0.82006D 00	0.23948D 02
1.9860	0.10111D-00	0.16150D 02	2.0110	0.84301D 00	0.21936D 02
1.9870	0.11821D-00	0.18068D 02	2.0120	0.86394D 00	0.19927D 02
1.9880	0.13726D-00	0.20047D 02	2.0130	0.88287D 00	0.17951D 02
1.9890	0.15831D-00	0.22057D 02	2.0140	0.89986D 00	0.16037D 02
1.9900	0.18138D-00	0.24068D 02	2.0150	0.91497D 00	0.14208D 02
1.9910	0.20644D-00	0.26045D 02	2.0160	0.92831D 00	0.12484D 02
1.9920	0.23344D-00	0.27949D 02	2.0175	0.94523D 00	0.10122D 02
1.9930	0.26230D-00	0.29745D 02	2.0200	0.96626D 00	0.68443D 01
1.9940	0.29288D-00	0.31392D 02	2.0225	0.98014D 00	0.43933D 01
1.9950	0.32503D-00	0.32856D 02	2.0250	0.98884D 00	0.26770D 01
1.9960	0.35852D-00	0.34103D 02	2.0275	0.99402D 00	0.15484D 01
1.9970	0.39315D-00	0.35104D 02			
1.9980	0.42864D-00	0.35834D 02			
1.9990	0.46472D-00	0.36276D 02			
2.0000	0.50109D 00	0.36418D 02			

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000070

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
			2.0010	0.53485D 00	0.33588D 02
			2.0020	0.56828D 00	0.33221D 02
			2.0030	0.60122D 00	0.32625D 02
1.9700	0.56629D-02	0.13651D 01	2.0040	0.63345D 00	0.31812D 02
1.9725	0.10138D-01	0.22796D 01	2.0050	0.66478D 00	0.30798D 02
1.9750	0.17433D-01	0.36405D 01	2.0060	0.69499D 00	0.29604D 02
1.9775	0.28807D-01	0.55600D 01	2.0070	0.72393D 00	0.28254D 02
1.9800	0.45769D-01	0.81209D 01	2.0080	0.75146D 00	0.26774D 02
1.9825	0.69965D-01	0.11343D 02	2.0090	0.77744D 00	0.25190D 02
1.9850	0.10298D-00	0.15153D 02	2.0100	0.80181D 00	0.23532D 02
1.9860	0.11895D-00	0.16802D 02	2.0110	0.82449D 00	0.21826D 02
1.9870	0.13660D-00	0.18498D 02	2.0120	0.84546D 00	0.20100D 02
1.9880	0.15596D-00	0.20221D 02	2.0130	0.86469D 00	0.18378D 02
1.9890	0.17704D-00	0.21946D 02	2.0140	0.88222D 00	0.16685D 02
1.9900	0.19984D-00	0.23650D 02	2.0150	0.89808D 00	0.15039D 02
1.9910	0.22432D-00	0.25304D 02	2.0160	0.91232D 00	0.13460D 02
1.9920	0.25042D-00	0.26881D 02	2.0175	0.93083D 00	0.11244D 02
1.9930	0.27805D-00	0.28353D 02	2.0200	0.95480D 00	0.80401D 01
1.9940	0.30709D-00	0.29693D 02	2.0225	0.97158D 00	0.54978D 01
1.9950	0.33738D-00	0.30875D 02	2.0250	0.98282D 00	0.35953D 01
1.9960	0.36877D-00	0.31876D 02	2.0275	0.99002D 00	0.22485D 01
1.9970	0.40107D-00	0.32674D 02	2.0300	0.99443D 00	0.13448D 01
1.9980	0.43405D-00	0.33255D 02			
1.9990	0.46750D-00	0.33605D 02			
2.0000	0.50118D 00	0.33716D 02			

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000080

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
1.9675	0.51415D-02	0.11719D 01
1.9700	0.89296D-02	0.19084D 01
1.9725	0.14970D-01	0.29887D 01
1.9750	0.24234D-01	0.45013D 01
1.9775	0.37899D-01	0.65198D 01
1.9800	0.57287D-01	0.90815D 01
1.9825	0.83744D-01	0.12165D 02
1.9840	0.10352D-00	0.14228D 02
1.9850	0.11847D-00	0.15672D 02
1.9860	0.13488D-00	0.17154D 02
1.9870	0.15278D-00	0.18659D 02
1.9880	0.17220D-00	0.20171D 02
1.9890	0.19312D-00	0.21668D 02
1.9900	0.21552D-00	0.23132D 02
1.9910	0.23937D-00	0.24541D 02
1.9920	0.26458D-00	0.25873D 02
1.9930	0.29108D-00	0.27108D 02
1.9940	0.31876D-00	0.28225D 02
1.9950	0.34749D-00	0.29205D 02
1.9960	0.37712D-00	0.30031D 02
1.9970	0.40749D-00	0.30687D 02
1.9980	0.43843D-00	0.31162D 02
1.9990	0.46975D-00	0.31448D 02
2.0000	0.50126D 00	0.31539D 02
2.0010	0.53276D 00	0.31432D 02
2.0020	0.56406D 00	0.31131D 02
2.0030	0.59496D 00	0.30641D 02
2.0040	0.62528D 00	0.29971D 02
2.0050	0.65485D 00	0.29132D 02
2.0060	0.68350D 00	0.28141D 02
2.0070	0.71108D 00	0.27014D 02
2.0080	0.73749D 00	0.25770D 02
2.0090	0.76259D 00	0.24431D 02
2.0100	0.78632D 00	0.23017D 02
2.0110	0.80861D 00	0.21549D 02
2.0120	0.82941D 00	0.20050D 02
2.0130	0.84870D 00	0.18539D 02
2.0140	0.86649D 00	0.17034D 02
2.0150	0.88278D 00	0.15555D 02
2.0160	0.89761D 00	0.14115D 02
2.0170	0.91103D 00	0.12729D 02
2.0185	0.92864D 00	0.10773D 02
2.0200	0.94344D 00	0.89912D 01
2.0225	0.96262D 00	0.64469D 01
2.0250	0.97612D 00	0.44455D 01
2.0275	0.98527D 00	0.29479D 01
2.0300	0.99122D 00	0.18800D 01
2.0325	0.99495D 00	0.11530D 01

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000090

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
1.9650	0.45888D-02	0.99837D 00
1.9675	0.77811D-02	0.15944D 01
1.9700	0.12785D-01	0.24593D 01
1.9725	0.20361D-01	0.36640D 01
1.9750	0.31442D-01	0.52725D 01
1.9775	0.47097D-01	0.73282D 01
1.9800	0.68462D-01	0.98378D 01
1.9810	0.78856D-01	0.10961D 02
1.9820	0.90404D-01	0.12144D 02
1.9830	0.10316D-00	0.13381D 02
1.9840	0.11718D-00	0.14662D 02
1.9850	0.13250D-00	0.15976D 02
1.9860	0.14914D-00	0.17312D 02
1.9870	0.16712D-00	0.18655D 02
1.9880	0.18645D-00	0.19992D 02
1.9890	0.20710D-00	0.21306D 02
1.9900	0.22905D-00	0.22580D 02
1.9910	0.25224D-00	0.23797D 02
1.9920	0.27662D-00	0.24942D 02
1.9930	0.30209D-00	0.25997D 02
1.9940	0.32857D-00	0.26946D 02
1.9950	0.35594D-00	0.27775D 02
1.9960	0.38408D-00	0.28471D 02
1.9970	0.41284D-00	0.29023D 02
1.9980	0.44207D-00	0.29421D 02
1.9990	0.47163D-00	0.29660D 02
2.0000	0.50134D 00	0.29735D 02
2.0010	0.53104D 00	0.29645D 02
2.0020	0.56057D 00	0.29392D 02
2.0030	0.58977D 00	0.28979D 02
2.0040	0.61848D 00	0.28414D 02
2.0050	0.64655D 00	0.27705D 02
2.0060	0.67385D 00	0.26865D 02
2.0070	0.70024D 00	0.25906D 02
2.0080	0.72562D 00	0.24842D 02
2.0090	0.74990D 00	0.23691D 02
2.0100	0.77298D 00	0.22467D 02
2.0110	0.79481D 00	0.21189D 02
2.0120	0.81535D 00	0.19872D 02
2.0130	0.83455D 00	0.18535D 02
2.0140	0.85241D 00	0.17191D 02
2.0150	0.86894D 00	0.15857D 02
2.0160	0.88413D 00	0.14545D 02
2.0170	0.89804D 00	0.13267D 02
2.0180	0.91068D 00	0.12035D 02
2.0190	0.92213D 00	0.10857D 02
2.0200	0.93242D 00	0.97400D 01
2.0210	0.94163D 00	0.86893D 01
2.0225	0.95356D 00	0.72462D 01
2.0250	0.96903D 00	0.52070D 01
2.0275	0.97997D 00	0.36139D 01
2.0300	0.98743D 00	0.24227D 01
2.0325	0.99236D 00	0.15687D 01
2.0350	0.99550D 00	0.98105D 00

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TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATICN


                                    ETA = 0.000100

     Y           PSI(Y,ETA)     DPSI(Y,ETA)/DY          Y          PSI(Y,ETA)      DPSI(Y,ETA)/DY

                                                     2.0010        0.52959D 00      0.28131D 02
                                                     2.0020        0.55763D 00      0.27914D 02
  1.9625        0.40475D-02      0.84660D 00         2.0030        0.58538D 00      0.27561D 02
  1.9650        0.67310D-02      0.13310D 01         2.0040        0.61270D 00      0.27076D 02
  1.9675        0.10880D-01      0.20283D 01         2.0050        0.63949D 00      0.26467D 02

  1.9700        0.17098D-01      0.29957D 01         2.0060        0.66560D 00      0.25742D 02
  1.9725        0.26130D-01      0.42885D 01         2.0070        0.69094D 00      0.24913D 02
  1.9750        0.38848D-01      0.59502D 01         2.0080        0.71539D 00      0.23990D 02
  1.9775        0.56207D-01      0.80018D 01         2.0090        0.73889D 00      0.22986D 02
  1.9800        0.79172D-01      0.10430D 02         2.0100        0.76134D 00      0.21914D 02


  1.9810        0.90131D-01      0.11495D 02         2.0110        0.78270D 00      0.20788D 02
  1.9820        0.10218D-00      0.12606D 02         2.0120        0.80291D 00      0.19622D 02
  1.9830        0.11536D-00      0.13755D 02         2.0130        0.82193D 00      0.18429D 02
  1.9840        0.12970D-00      0.14934D 02         2.0140        0.83976D 00      0.17221D 02
  1.9850        0.14523D-00      0.16134D 02         2.0150        0.85638D 00      0.16013D 02

  1.9860        0.16197D-00      0.17342D 02         2.0160        0.87179D 00      0.14815D 02
  1.9870        0.17991D-00      0.18549D 02         2.0170        0.88601D 00      0.13639D 02
  1.9880        0.19906D-00      0.19740D 02         2.0180        0.89908D 00      0.12493D 02
  1.9890        0.21938D-00      0.20903D 02         2.0190        0.91101D 00      0.11386D 02
  1.9900        0.24085D-00      0.22024D 02         2.0200        0.92187D 00      0.10326D 02


  1.9910        0.26341D-00      0.23090D 02         2.0210        0.93168D 00      0.93177D 01
  1.9920        0.28701D-00      0.24086D 02         2.0225        0.94459D 00      0.79123D 01
  1.9930        0.31156D-00      0.25000D 02         2.0250        0.96174D 00      0.58763D 01
  1.9940        0.33698D-00      0.25820D 02         2.0275        0.97430D 00      0.42299D 01
  1.9950        0.36316D-00      0.26533D 02         2.0300        0.98320D 00      0.29512D 01

  1.9960        0.39001D-00      0.27130D 02         2.0325        0.98932D 00      0.19956D 01
  1.9970        0.41738D-00      0.27602D 02         2.0350        0.99340D 00      0.13080D 01
  1.9980        0.44517D-00      0.27942D 02         2.0375        0.99604D 00      0.83088D 00
  1.9990        0.47322D-00      0.28146D 02
  2.0000        0.50141D 00      0.28209D 02


TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATICN


                                    ETA = 0.000200

     Y           PSI(Y,ETA)     DPSI(Y,ETA)/DY          Y          PSI(Y,ETA)      DPSI(Y,ETA)/DY

                                                     2.0020        0.54181D 00      0.19837D 02
  1.9500        0.62990D-02      0.88754D 00         2.0040        0.58121D 00      0.19532D 02
  1.9550        0.12386D-01      0.16051D 01         2.0060        0.61981D 00      0.19040D 02
  1.9600        0.23024D-01      0.27268D 01         2.0080        0.65726D 00      0.18376D 02
  1.9650        0.40496D-01      0.43519D 01         2.0100        0.69322D 00      0.17559D 02

  1.9700        0.67462D-01      0.65248D 01         2.0120        0.72741D 00      0.16611D 02
  1.9730        0.89318D-01      0.80735D 01         2.0140        0.75959D 00      0.15558D 02
  1.9760        0.11605D-00      0.97677D 01         2.0160        0.78958D 00      0.14426D 02
  1.9780        0.13676D-00      0.10953D 02         2.0180        0.81726D 00      0.13244D 02
  1.9800        0.15987D-00      0.12159D 02         2.0200        0.84255D 00      0.12038D 02


  1.9820        0.18540D-00      0.13364D 02         2.0220        0.86541D 00      0.10833D 02
  1.9840        0.21331D-00      0.14542D 02         2.0240        0.88589D 00      0.96512D 01
  1.9860        0.24353D-00      0.15667D 02         2.0260        0.90405D 00      0.85130D 01
  1.9880        0.27593D-00      0.16711D 02         2.0280        0.91998D 00      0.74342D 01
  1.9900        0.31030D-00      0.17647D 02         2.0300        0.93383D 00      0.64276D 01

  1.9920        0.34643D-00      0.18450D 02         2.0350        0.96037D 00      0.42765D 01
  1.9940        0.38400D-00      0.19097D 02         2.0400        0.97752D 00      0.26729D 01
  1.9960        0.42270D-00      0.19571D 02         2.0450        0.98793D 00      0.15694D 01
  1.9980        0.46216D-00      0.19857D 02         2.0500        0.99388D 00      0.86563D 00
  2.0000        0.50199D 00      0.19946D 02
```

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000300

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
			2.0020	0.53497D 00	0.16224D 02
			2.0040	0.56727D 00	0.16054D 02
1.9350	0.40558D-02	0.48967D-00	2.0060	0.59912D 00	0.15781D 02
1.9400	0.72774D-02	0.82326D 00	2.0080	0.63032D 00	0.15409D 02
1.9450	0.12573D-01	0.13276D 01	2.0100	0.66069D 00	0.14946D 02
1.9500	0.20923D-01	0.20536D 01	2.0120	0.69005D 00	0.14401D 02
1.9550	0.33556D-01	0.30470D 01	2.0140	0.71825D 00	0.13784D 02
1.9600	0.51889D-01	0.43365D 01	2.0160	0.74515D 00	0.13105D 02
1.9650	0.77413D-01	0.59197D 01	2.0180	0.77064D 00	0.12377D 02
1.9700	0.11150D-00	0.77512D 01	2.0200	0.79463D 00	0.11611D 02
1.9720	0.12778D-00	0.85336D 01	2.0220	0.81707D 00	0.10821D 02
1.9740	0.14565D-00	0.93325D 01	2.0240	0.83790D 00	0.10017D 02
1.9760	0.16512D-00	0.10138D 02	2.0260	0.85713D 00	0.92120D 01
1.9780	0.18620D-00	0.10941D 02	2.0280	0.87476D 00	0.84150D 01
1.9800	0.20887D-00	0.11728D 02	2.0300	0.89081D 00	0.76358D 01
1.9820	0.23309D-00	0.12489D 02	2.0320	0.90532D 00	0.68828D 01
1.9840	0.25880D-00	0.13210D 02	2.0350	0.92435D 00	0.58170D 01
1.9860	0.28590D-00	0.13880D 02	2.0400	0.94940D 00	0.42506D 01
1.9880	0.31428D-00	0.14488D 02	2.0450	0.96735D 00	0.29792D 01
1.9900	0.34380D-00	0.15021D 02	2.0500	0.97969D 00	0.20029D 01
1.9920	0.37431D-00	0.15471D 02	2.0550	0.98782D 00	0.12916D 01
1.9940	0.40562D-00	0.15828D 02	2.0600	0.99297D 00	0.79893D 00
1.9960	0.43756D-00	0.16086D 02	2.0650	0.99609D 00	0.47401D-00
1.9980	0.46990D-00	0.16240D 02			
2.0000	0.50244D 00	0.16286D 02			

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000400

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
			2.0020	0.53100D 00	0.14061D 02
			2.0040	0.55902D 00	0.13949D 02
			2.0060	0.58675D 00	0.13769D 02
1.9250	0.40913D-02	0.42738D-00	2.0080	0.61405D 00	0.13524D 02
1.9300	0.67997D-02	0.67149D 00	2.0100	0.64080D 00	0.13216D 02
1.9350	0.10984D-01	0.10226D 01	2.0120	0.66688D 00	0.12851D 02
1.9400	0.17252D-01	0.15093D 01	2.0140	0.69217D 00	0.12434D 02
1.9450	0.26350D-01	0.21592D 01	2.0160	0.71659D 00	0.11971D 02
1.9500	0.39153D-01	0.29939D 01	2.0180	0.74003D 00	0.11467D 02
1.9550	0.56615D-01	0.40236D 01	2.0200	0.76243D 00	0.10929D 02
1.9600	0.79703D-01	0.52411D 01	2.0220	0.78373D 00	0.10365D 02
1.9630	0.96628D-01	0.60505D 01	2.0240	0.80388D 00	0.97813D 01
1.9660	0.11605D-00	0.69068D 01	2.0260	0.82285D 00	0.91841D 01
1.9680	0.13046D-00	0.74970D 01	2.0280	0.84061D 00	0.85804D 01
1.9700	0.14605D-00	0.80970D 01	2.0300	0.85717D 00	0.79764D 01
1.9720	0.16285D-00	0.87014D 01	2.0320	0.87252D 00	0.73780D 01
1.9740	0.18085D-00	0.93043D 01	2.0340	0.88669D 00	0.67904D 01
1.9760	0.20006D-00	0.98994D 01	2.0360	0.89969D 00	0.62184D 01
1.9780	0.22044D-00	0.10480D 02	2.0380	0.91157D 00	0.56662D 01
1.9800	0.24196D-00	0.11039D 02	2.0400	0.92237D 00	0.51373D 01
1.9820	0.26458D-00	0.11570D 02	2.0450	0.94498D 00	0.39341D 01
1.9840	0.28822D-00	0.12067D 02	2.0500	0.96203D 00	0.29200D 01
1.9860	0.31282D-00	0.12522D 02	2.0550	0.97450D 00	0.21007D 01
1.9880	0.33828D-00	0.12929D 02	2.0600	0.98334D 00	0.14647D 01
1.9900	0.36450D-00	0.13282D 02	2.0650	0.98942D 00	0.98987D 00
1.9920	0.39137D-00	0.13578D 02	2.0700	0.99346D 00	0.64839D 00
1.9940	0.41877D-00	0.13811D 02	2.0750	0.99608D 00	0.41164D-00
1.9960	0.44657D-00	0.13977D 02			
1.9980	0.47463D-00	0.14076D 02			
2.0000	0.50282D 00	0.14104D 02			

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000500

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
1.9200	0.58386D-02	0.52479D 00	2.0020	0.52836D 00	0.12583D 02
1.9250	0.90479D-02	0.77217D 00	2.0040	0.55345D 00	0.12501D 02
1.9300	0.13708D-01	0.11081D 01	2.0060	0.57833D 00	0.12371D 02
1.9350	0.20307D-01	0.15509D 01	2.0080	0.60290D 00	0.12193D 02
1.9400	0.29423D-01	0.21172D 01	2.0100	0.62707D 00	0.11969D 02
1.9450	0.41705D-01	0.28187D 01	2.0120	0.65075D 00	0.11703D 02
1.9500	0.57844D-01	0.36601D 01	2.0140	0.67386D 00	0.11397D 02
1.9550	0.78530D-01	0.46354D 01	2.0160	0.69632D 00	0.11055D 02
1.9580	0.93390D-01	0.52775D 01	2.0180	0.71806D 00	0.10680D 02
1.9600	0.10439D-00	0.57256D 01	2.0200	0.73902D 00	0.10277D 02
1.9620	0.11630D-00	0.61869D 01	2.0220	0.75915D 00	0.98491D 01
1.9640	0.12915D-00	0.66587D 01	2.0240	0.77840D 00	0.94016D 01
1.9660	0.14294D-00	0.71379D 01	2.0260	0.79674D 00	0.89387D 01
1.9680	0.15770D-00	0.76210D 01	2.0280	0.81415D 00	0.84646D 01
1.9700	0.17342D-00	0.81043D 01	2.0300	0.83060D 00	0.79837D 01
1.9720	0.19011D-00	0.85839D 01	2.0320	0.84608D 00	0.75001D 01
1.9740	0.20776D-00	0.90556D 01	2.0340	0.86060D 00	0.70176D 01
1.9760	0.22633D-00	0.95151D 01	2.0360	0.87416D 00	0.65399D 01
1.9780	0.24580D-00	0.99580D 01	2.0380	0.88676D 00	0.60705D 01
1.9800	0.26615D-00	0.10380D 02	2.0400	0.89844D 00	0.56122D 01
1.9820	0.28731D-00	0.10776D 02	2.0420	0.90922D 00	0.51678D 01
1.9840	0.30923D-00	0.11144D 02	2.0440	0.91913D 00	0.47397D 01
1.9860	0.33186D-00	0.11477D 02	2.0470	0.93242D 00	0.41319D 01
1.9880	0.35512D-00	0.11774D 02	2.0500	0.94396D 00	0.35698D 01
1.9900	0.37893D-00	0.12029D 02	2.0550	0.95969D 00	0.27423D 01
1.9920	0.40320D-00	0.12242D 02	2.0600	0.97162D 00	0.20546D 01
1.9940	0.42786D-00	0.12408D 02	2.0650	0.98046D 00	0.15013D 01
1.9960	0.45281D-00	0.12526D 02	2.0700	0.98684D 00	0.10700D 01
1.9980	0.47794D-00	0.12596D 02	2.0750	0.99133D 00	0.74375D 00
2.0000	0.50315D 00	0.12614D 02	2.0800	0.99442D 00	0.50421D 00

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTICN OF THE LAMM EQUATICN

ETA = 0.000600

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
			2.0020	0.52647D 00	0.11490D 02
			2.0040	0.54939D 00	0.11427D 02
1.9100	0.48098D-02	0.40320D-00	2.0060	0.57215D 00	0.11327D 02
1.9150	0.72448D-02	0.57982D 00	2.0080	0.59467D 00	0.11190D 02
1.9200	0.10708D-01	0.81661D 00	2.0100	0.61689D 00	0.11018D 02
1.9250	0.15533D-01	0.11264D 01	2.0120	0.63872D 00	0.10812D 02
1.9300	0.22115D-01	0.15217D 01	2.0140	0.66011D 00	0.10575D 02
1.9350	0.30910D-01	0.20133D 01	2.0160	0.68100D 00	0.10309D 02
1.9400	0.42421D-01	0.26088D 01	2.0180	0.70133D 00	0.10016D 02
1.9450	0.57176D-01	0.33108D 01	2.0200	0.72105D 00	0.96990D 01
1.9500	0.75700D-01	0.41151D 01	2.0220	0.74011D 00	0.93608D 01
1.9530	0.88828D-01	0.46420D 01	2.0240	0.75848D 00	0.90043D 01
1.9560	0.10358D-00	0.51972D 01	2.0260	0.77612D 00	0.86326D 01
1.9580	0.11436D-00	0.55805D 01	2.0280	0.79300D 00	0.82486D 01
1.9600	0.12591D-00	0.59721D 01	2.0300	0.80911D 00	0.78556D 01
1.9620	0.13825D-00	0.63699D 01	2.0320	0.82442D 00	0.74563D 01
1.9640	0.15139D-00	0.67717D 01	2.0340	0.83893D 00	0.70538D 01
1.9660	0.16534D-00	0.71748D 01	2.0360	0.85264D 00	0.66509D 01
1.9680	0.18009D-00	0.75766D 01	2.0380	0.86554D 00	0.62501D 01
1.9700	0.19564D-00	0.79743D 01	2.0400	0.87764D 00	0.58539D 01
1.9720	0.21198D-00	0.83649D 01	2.0420	0.88896D 00	0.54645D 01
1.9740	0.22909D-00	0.87455D 01	2.0440	0.89951D 00	0.50841D 01
1.9760	0.24695D-00	0.91130D 01	2.0460	0.90930D 00	0.47145D 01
1.9780	0.26553D-00	0.94643D 01	2.0480	0.91837D 00	0.43571D 01
1.9800	0.28480D-00	0.97965D 01	2.0500	0.92674D 00	0.40135D 01
1.9820	0.30471D-00	0.10107D 02	2.0550	0.94478D 00	0.32210D 01
1.9840	0.32521D-00	0.10392D 02	2.0600	0.95912D 00	0.25317D 01
1.9860	0.34625D-00	0.10649D 02	2.0650	0.97028D 00	0.19489D 01
1.9880	0.36779D-00	0.10877D 02	2.0700	0.97878D 00	0.14693D 01
1.9900	0.38974D-00	0.11073D 02	2.0750	0.98513D 00	0.10849D 01
1.9920	0.41205D-00	0.11235D 02	2.0800	0.98977D 00	0.78458D 00
1.9940	0.43466D-00	0.11361D 02	2.0850	0.99310D 00	0.55568D 00
1.9960	0.45747D-00	0.11450D 02	2.0900	0.99543D 00	0.38545D-00
1.9980	0.48043D-00	0.11502D 02			
2.0000	0.50345D 00	0.11515D 02			

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000700

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
1.9050	0.57129D-02	0.43504D-00	2.0020	0.52504D 00	0.10640D 02
1.9100	0.82925D-02	0.60455D 00	2.0040	0.54627D 00	0.10589D 02
1.9150	0.11844D-01	0.82524D 00	2.0060	0.56738D 00	0.10509D 02
1.9200	0.16646D-01	0.11066D 01	2.0080	0.58829D 00	0.10399D 02
1.9250	0.23026D-01	0.14575D 01	2.0100	0.60895D 00	0.10261D 02
1.9300	0.31350D-01	0.18859D 01	2.0120	0.62932D 00	0.10096D 02
1.9350	0.42022D-01	0.23969D 01	2.0140	0.64932D 00	0.99054D 01
1.9400	0.55460D-01	0.29924D 01	2.0160	0.66892D 00	0.96906D 01
1.9450	0.72083D-01	0.36699D 01	2.0180	0.68807D 00	0.94534D 01
1.9500	0.92282D-01	0.44210D 01	2.0200	0.70672D 00	0.91957D 01
1.9520	0.10144D-00	0.47391D 01	2.0220	0.72484D 00	0.89196D 01
1.9540	0.11124D-00	0.50657D 01	2.0240	0.74239D 00	0.86270D 01
1.9560	0.12171D-00	0.53993D 01	2.0260	0.75934D 00	0.83202D 01
1.9580	0.13284D-00	0.57384D 01	2.0280	0.77566D 00	0.80014D 01
1.9600	0.14466D-00	0.60814D 01	2.0300	0.79134D 00	0.76729D 01
1.9620	0.15717D-00	0.64266D 01	2.0320	0.80635D 00	0.73369D 01
1.9640	0.17037D-00	0.67720D 01	2.0340	0.82068D 00	0.69956D 01
1.9660	0.18426D-00	0.71156D 01	2.0360	0.83433D 00	0.66512D 01
1.9680	0.19883D-00	0.74553D 01	2.0380	0.84729D 00	0.63057D 01
1.9700	0.21408D-00	0.77889D 01	2.0400	0.85955D 00	0.59610D 01
1.9720	0.22998D-00	0.81142D 01	2.0420	0.87113D 00	0.56192D 01
1.9740	0.24653D-00	0.84290D 01	2.0440	0.88203D 00	0.52818D 01
1.9760	0.26369D-00	0.87311D 01	2.0460	0.89226D 00	0.49505D 01
1.9780	0.28144D-00	0.90182D 01	2.0480	0.90184D 00	0.46268D 01
1.9800	0.29975D-00	0.92881D 01	2.0500	0.91078D 00	0.43119D 01
1.9820	0.31858D-00	0.95389D 01	2.0520	0.91909D 00	0.40069D 01
1.9840	0.33789D-00	0.97685D 01	2.0550	0.93045D 00	0.35703D 01
1.9860	0.35764D-00	0.99750D 01	2.0600	0.94660D 00	0.29040D 01
1.9880	0.37777D-00	0.10157D 02	2.0650	0.95963D 00	0.23202D 01
1.9900	0.39825D-00	0.10313D 02	2.0700	0.96995D 00	0.18210D 01
1.9920	0.41901D-00	0.10441D 02	2.0750	0.97798D 00	0.14039D 01
1.9940	0.43999D-00	0.10540D 02	2.0800	0.98411D 00	0.10632D 01
1.9960	0.46115D-00	0.10611D 02	2.0850	0.98872D 00	0.79089D 00
1.9980	0.48242D-00	0.10651D 02	2.0900	0.99212D 00	0.57794D 00
2.0000	0.50373D 00	0.10661D 02	2.0950	0.99458D 00	0.41485D-00

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000800

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
1.9000	0.63918D-02	0.44952D-00
1.9050	0.90210D-02	0.60884D 00
1.9100	0.12553D-01	0.81184D 00
1.9150	0.17224D-01	0.10658D 01
1.9200	0.23307D-01	0.13774D 01
1.9250	0.31104D-01	0.17526D 01
1.9300	0.40945D-01	0.21954D 01
1.9350	0.53173D-01	0.27074D 01
1.9400	0.68132D-01	0.32871D 01
1.9450	0.86149D-01	0.39291D 01
1.9480	0.98548D-01	0.43404D 01
1.9500	0.10751D-00	0.46237D 01
1.9520	0.11705D-00	0.49132D 01
1.9540	0.12717D-00	0.52079D 01
1.9560	0.13788D-00	0.55064D 01
1.9580	0.14919D-00	0.58075D 01
1.9600	0.16111D-00	0.61097D 01
1.9620	0.17363D-00	0.64117D 01
1.9640	0.18676D-00	0.67118D 01
1.9660	0.20048D-00	0.70084D 01
1.9680	0.21479D-00	0.72998D 01
1.9700	0.22967D-00	0.75844D 01
1.9720	0.24512D-00	0.78604D 01
1.9740	0.26111D-00	0.81261D 01
1.9760	0.27762D-00	0.83798D 01
1.9780	0.29462D-00	0.86198D 01
1.9800	0.31209D-00	0.88446D 01
1.9820	0.32999D-00	0.90526D 01
1.9840	0.34828D-00	0.92424D 01
1.9860	0.36694D-00	0.94126D 01
1.9880	0.38592D-00	0.95620D 01
1.9900	0.40518D-00	0.96895D 01
1.9920	0.42466D-00	0.97942D 01
1.9940	0.44434D-00	0.98753D 01
1.9960	0.46415D-00	0.99323D 01
1.9980	0.48405D-00	0.99646D 01
2.0000	0.50399D 00	0.99721D 01

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
2.0020	0.52392D 00	0.99546D 01
2.0040	0.54379D 00	0.99124D 01
2.0060	0.56355D 00	0.98458D 01
2.0080	0.58316D 00	0.97551D 01
2.0100	0.60256D 00	0.96412D 01
2.0120	0.62171D 00	0.95048D 01
2.0140	0.64056D 00	0.93470D 01
2.0160	0.65908D 00	0.91688D 01
2.0180	0.67723D 00	0.89716D 01
2.0200	0.69496D 00	0.87567D 01
2.0220	0.71224D 00	0.85256D 01
2.0240	0.72905D 00	0.82798D 01
2.0260	0.74535D 00	0.80211D 01
2.0280	0.76113D 00	0.77511D 01
2.0300	0.77635D 00	0.74715D 01
2.0320	0.79101D 00	0.71840D 01
2.0340	0.80508D 00	0.68903D 01
2.0360	0.81857D 00	0.65921D 01
2.0380	0.83145D 00	0.62911D 01
2.0400	0.84373D 00	0.59888D 01
2.0420	0.85540D 00	0.56868D 01
2.0440	0.86648D 00	0.53866D 01
2.0460	0.87695D 00	0.50895D 01
2.0480	0.88684D 00	0.47967D 01
2.0500	0.89614D 00	0.45095D 01
2.0520	0.90488D 00	0.42290D 01
2.0540	0.91306D 00	0.39559D 01
2.0570	0.92434D 00	0.35624D 01
2.0600	0.93446D 00	0.31900D 01
2.0650	0.94896D 00	0.26208D 01
2.0700	0.96078D 00	0.21198D 01
2.0750	0.97027D 00	0.16881D 01
2.0800	0.97777D 00	0.13234D 01
2.0850	0.98361D 00	0.10214D 01
2.0900	0.98808D 00	0.77611D 00
2.0950	0.99146D 00	0.58058D 00
2.1000	0.99396D 00	0.42759D-00

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.000900

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
1.8900	0.49141D-02	0.33556D-00
1.8950	0.68702D-02	0.45173D-00
1.9000	0.94845D-02	0.59974D 00
1.9050	0.12930D-01	0.78526D 00
1.9100	0.17409D-01	0.10140D 01
1.9150	0.23151D-01	0.12913D 01
1.9200	0.30411D-01	0.16217D 01
1.9250	0.39463D-01	0.20087D 01
1.9300	0.50594D-01	0.24536D 01
1.9350	0.64095D-01	0.29558D 01
1.9400	0.80242D-01	0.35117D 01
1.9450	0.99290D-01	0.41146D 01
1.9480	0.11220D-00	0.44949D 01
1.9500	0.12145D-00	0.47545D 01
1.9520	0.13122D-00	0.50179D 01
1.9540	0.14152D-00	0.52842D 01
1.9560	0.15236D-00	0.55523D 01
1.9580	0.16373D-00	0.58211D 01
1.9600	0.17564D-00	0.60893D 01
1.9620	0.18809D-00	0.63557D 01
1.9640	0.20106D-00	0.66191D 01
1.9660	0.21456D-00	0.68781D 01
1.9680	0.22857D-00	0.71313D 01
1.9700	0.24308D-00	0.73775D 01
1.9720	0.25808D-00	0.76152D 01
1.9740	0.27354D-00	0.78431D 01
1.9760	0.28944D-00	0.80600D 01
1.9780	0.30577D-00	0.82644D 01
1.9800	0.32249D-00	0.84553D 01
1.9820	0.33958D-00	0.86313D 01
1.9840	0.35701D-00	0.87915D 01
1.9860	0.37473D-00	0.89347D 01
1.9880	0.39273D-00	0.90601D 01
1.9900	0.41096D-00	0.91670D 01
1.9920	0.42939D-00	0.92544D 01
1.9940	0.44797D-00	0.93220D 01
1.9960	0.46666D-00	0.93693D 01
1.9980	0.48543D-00	0.93958D 01
2.0000	0.50423D 00	0.94016D 01

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
2.0020	0.52302D 00	0.93864D 01
2.0040	0.54176D 00	0.93505D 01
2.0060	0.56041D 00	0.92941D 01
2.0080	0.57893D 00	0.92175D 01
2.0100	0.59727D 00	0.91212D 01
2.0120	0.61540D 00	0.90060D 01
2.0140	0.63328D 00	0.88724D 01
2.0160	0.65088D 00	0.87214D 01
2.0180	0.66815D 00	0.85540D 01
2.0200	0.68508D 00	0.83712D 01
2.0220	0.70163D 00	0.81740D 01
2.0240	0.71777D 00	0.79639D 01
2.0260	0.73348D 00	0.77419D 01
2.0280	0.74873D 00	0.75094D 01
2.0300	0.76351D 00	0.72677D 01
2.0320	0.77780D 00	0.70181D 01
2.0340	0.79158D 00	0.67621D 01
2.0360	0.80484D 00	0.65010D 01
2.0380	0.81758D 00	0.62361D 01
2.0400	0.82978D 00	0.59687D 01
2.0420	0.84145D 00	0.57001D 01
2.0440	0.85258D 00	0.54315D 01
2.0460	0.86318D 00	0.51641D 01
2.0480	0.87324D 00	0.48990D 01
2.0500	0.88278D 00	0.46371D 01
2.0520	0.89179D 00	0.43795D 01
2.0540	0.90030D 00	0.41270D 01
2.0570	0.91213D 00	0.37597D 01
2.0600	0.92287D 00	0.34079D 01
2.0650	0.93852D 00	0.28613D 01
2.0700	0.95158D 00	0.23692D 01
2.0750	0.96231D 00	0.19347D 01
2.0800	0.97102D 00	0.15581D 01
2.0850	0.97799D 00	0.12375D 01
2.0900	0.98348D 00	0.96936D 00
2.0950	0.98776D 00	0.74882D 00
2.1000	0.99104D 00	0.57047D 00
2.1050	0.99353D 00	0.42861D-00
2.1100	0.99538D 00	0.31759D-00

TABLE FOR THE EVALUATION OF THE FAXEN APPROXIMATION TO THE SOLUTION OF THE LAMM EQUATION

ETA = 0.001000

Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY	Y	PSI(Y,ETA)	DPSI(Y,ETA)/DY
1.8850	0.52342D-02	0.33673D-00	2.0020	0.52229D 00	0.89056D 01
1.8900	0.71791D-02	0.44550D-00	2.0040	0.54007D 00	0.88745D 01
1.8950	0.97356D-02	0.58210D 00	2.0060	0.55777D 00	0.88258D 01
1.9000	0.13054D-01	0.75112D 00	2.0080	0.57536D 00	0.87599D 01
1.9050	0.17309D-01	0.95719D 00	2.0100	0.59280D 00	0.86771D 01
1.9100	0.22695D-01	0.12047D 01	2.0120	0.61006D 00	0.85779D 01
1.9150	0.29430D-01	0.14973D 01	2.0140	0.62710D 00	0.84629D 01
1.9200	0.37748D-01	0.18378D 01	2.0160	0.64390D 00	0.83328D 01
1.9250	0.47891D-01	0.22278D 01	2.0180	0.66043D 00	0.81882D 01
1.9300	0.60108D-01	0.26671D 01	2.0200	0.67665D 00	0.80302D 01
1.9350	0.74640D-01	0.31533D 01	2.0220	0.69254D 00	0.78594D 01
1.9400	0.91712D-01	0.36818D 01	2.0240	0.70808D 00	0.76769D 01
1.9450	0.11152D-00	0.42455D 01	2.0260	0.72324D 00	0.74837D 01
1.9480	0.12478D-00	0.45967D 01	2.0280	0.73800D 00	0.72807D 01
1.9500	0.13421D-00	0.48348D 01	2.0300	0.75235D 00	0.70691D 01
1.9520	0.14412D-00	0.50750D 01	2.0320	0.76628D 00	0.68500D 01
1.9540	0.15451D-00	0.53165D 01	2.0340	0.77975D 00	0.66244D 01
1.9560	0.16539D-00	0.55583D 01	2.0360	0.79277D 00	0.63934D 01
1.9580	0.17674D-00	0.57996D 01	2.0380	0.80532D 00	0.61581D 01
1.9600	0.18858D-00	0.60392D 01	2.0400	0.81740D 00	0.59197D 01
1.9620	0.20090D-00	0.62762D 01	2.0420	0.82900D 00	0.56791D 01
1.9640	0.21368D-00	0.65095D 01	2.0440	0.84011D 00	0.54374D 01
1.9660	0.22693D-00	0.67379D 01	2.0460	0.85075D 00	0.51956D 01
1.9680	0.24063D-00	0.69604D 01	2.0480	0.86090D 00	0.49546D 01
1.9700	0.25477D-00	0.71759D 01	2.0500	0.87057D 00	0.47154D 01
1.9720	0.26933D-00	0.73833D 01	2.0520	0.87976D 00	0.44788D 01
1.9740	0.28430D-00	0.75816D 01	2.0540	0.88848D 00	0.42455D 01
1.9760	0.29965D-00	0.77695D 01	2.0570	0.90071D 00	0.39035D 01
1.9780	0.31537D-00	0.79463D 01	2.0600	0.91192D 00	0.35730D 01
1.9800	0.33143D-00	0.81108D 01	2.0650	0.92846D 00	0.30524D 01
1.9820	0.34780D-00	0.82622D 01	2.0700	0.94251D 00	0.25753D 01
1.9840	0.36447D-00	0.83997D 01	2.0750	0.95430D 00	0.21458D 01
1.9860	0.38139D-00	0.85223D 01	2.0800	0.96406D 00	0.17657D 01
1.9880	0.39855D-00	0.86295D 01	2.0850	0.97204D 00	0.14349D 01
1.9900	0.41590D-00	0.87206D 01	2.0900	0.97848D 00	0.11516D 01
1.9920	0.43342D-00	0.87950D 01	2.0950	0.98363D 00	0.91277D 00
1.9940	0.45107D-00	0.88523D 01	2.1000	0.98768D 00	0.71447D 00
1.9960	0.46881D-00	0.88922D 01	2.1050	0.99083D 00	0.55231D 00
1.9980	0.48662D-00	0.89145D 01	2.1100	0.99325D 00	0.42165D-00
2.0000	0.50446D 00	0.89189D 01	2.1150	0.99509D 00	0.31790D-00

Thanks are due to Dr. Robert Jastrow, Director, Goddard Institute for Space Studies, for use of the Institute's computing facilities.

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(Paper 70B1–171)

JOURNAL OF RESEARCH of the National Bureau of Standards—B. Mathematics and Mathematical Physics
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Publications of the National Bureau of Standards*

Selected Abstracts

A new differential operator of the pure wave type, J. E. Lagnese, *J. Different. Eq.* **1,** *No. 2, 171–187 (Apr. 1965).*
Consider the differential operator $\mathscr{L}u = u + c(t)u$ $(= \partial_t^2 - \Sigma_{i=1}^{7} \partial_{x_i}^2)$ with $c(t)$ analytic on some open, connected interval of the real t-axis. Under this requirement, we seek to determine explicitly the form of $c(t)$ for which $\mathscr{L}$ satisfies Huygen's principle in the sense of "Hadamard's premise." (Mathisson called such operators "pure wave".) *Theorem.* $\mathscr{L}$ *is of pure waves if, and only if, it is equivalent to one of the following operators:* $\mathrm{u}, \mathrm{u} - \frac{2}{\mathrm{t}^2}\mathrm{u}, \mathrm{u} - \frac{6}{\mathrm{t}^2}\mathrm{u}, \mathrm{u} - \frac{6\mathrm{t}(2+\mathrm{t}^3)}{(1-\mathrm{t}^3)^2}\mathrm{u}$.
This theorem extends earlier results along this line and presents a new, and substantially more complicated, counterexample to "Hadamard's conjecture," namely the operator $u - 6t(2+t^3)/(1-t^3)^2\, u$.

Aggregation in matrix models of resource flows, D. Rosenblatt, *Am. Stat.* **19,** *No. 3, 36–39 (June 1965).*
The aggregation of finite substochastic systems of the form $x(I-A) = w$, A a square and substochastic matrix and w a nonnegative vector, is considered from normative and descriptive standpoints in connection with models of resource flows. Certain of the fundamental functional equations of the theory of aggregation are derived and are given a graph theoretic interpretation.

An application of the inverse Z-transform theory to the synthesis of linear antenna arrays, M. T. Ma, *IEEE Trans. Ant. Prop.* **AP–12,** *No. 6, 798–799 (Nov. 1964).*
It has been known that the Z-transform theory can be applied as a new technique for analyzing linear array problems. The reverse problem, synthesizing linear arrays by applying the inverse Z-transform theory, has not yet been reported in the literature.
This communication demonstrates that the job of synthesizing an antenna array, when certain conditions are satisfied by the given radiation pattern, can be accomplished particularly as a result of applying the inverse Z-transform theory originally developed for sampled-data systems, and that the error occurring between the synthesized and specified patterns can be estimated.

Spacetime coordinate systems, G. E. Hudson, *Proc. Intern. Conf. Chronometry, pp. 197-221 (Lausanne, Switzerland, June 1964).*
The principle of covariance is sometimes said to preclude the necessity for specifying a set of coordinates operationally. A simple example illustrates that this is not the case. This leads to the basic problem of specifying coordinate systems of physical use and interest over the vast reaches of spacetime. Examples of two operational definitions for spacetime networks associated with the surface of a spinning sphere serve to make definite some of the requirements, and show the importance and use of the general Doppler effect. For space navigational purposes, the gravitational fields, medium refraction and dispersion, and instrument uncertainty are discussed.
The point of view we have adopted here stems from, but is not limited to, a consideration of general relativistic effects and uses much of the formalism of relativity theory. It suggests moreover, a new general approach to time synchronization, space communication, and tracking problems, which is reminiscent of the concept of "homologue" space introduced by various authors to eliminate major refraction effects in a medium, or of Fock's concept of harmonic coordinates. Of more importance is the demonstration that a generalized range and range-rate coordinate system introduced here can be identified with a class of "null" coordinate systems previously mentioned by Synge.

Correlated walk and diffusion equations in a driving force, J. R. Manning, *Phys. Rev.* **139,** *No. 1A, A126–A135 (July 5, 1965).*
The correlation factor for diffusion by a vacancy mechanism arises because an atom can exchange with a given vacancy more than once. This results in a series of correlated exchanges between the atom and vacancy. In order to include correlation effects in the diffusion equations, one must allow the atom sufficient time to complete any corrrlated series of jumps. With this in mind, the basic diffusion equations are derived in terms of the number N of correlated series. A complete description of planar diffusion then can be presented in terms of effective jump frequencies, where each jump is independent of previous jumps. The resulting equations are correct to first order in small quantities. This is shown to be true even where there are driving forces and a diffusion coefficient gradient. Final expressions for the diffusion coefficient, correlation factor, drift velocity, and diffusion flux are valid for diffusion in any direction in cubic crystals and along particular directions in noncubic crystals. As an example, effects from a chemical concentration gradient are discussed.

Generalized master equation for quantum mechanical systems to all orders in the density, J. Weinstock, *Phys. Rev.* **136,** *2d series, No. 4A, A879–A888 (Nov. 1964).*
An exact generalized master equation is derived for a large quantum mechanical system in the form of a power series in the density. This derivation is a quantum mechanical generalization of a previous work by the author for classical systems. The quantum equation can be viewed as a time-dependent analog of the virial expansion of the quantum mechanical partition function for both degenerate systems (B.E. or F.D. statistics) and non-degenerate systems. The coefficients of the series, in the quantum equation, are explicitly given in terms of operators (Green functions) which are determined by the dynamics of isolated groups of particles and are convergent functions of the interaction potential. Equations are obtained for the off-diagonal elements of the density matrix as well as for the diagonal elements. The equation for the diagonal elements is shown to reduce to a Markoffian master equation for asymptotically long times, and an explicit expression is obtained for the "scattering" operator of this asymptotic equation.

Master equations and Markov processes, I. Oppenheim and K. E. Shuler, *Phys. Rev.* **138,** *No. 4B, B117–B1011 (May 24, 1965).*
The processes described by generalized master equations (GME), derived from the Liouville equation on the basis of various physical and dynamic arguments, have been termed Markovian or non-Markovian depending upon whether the GME did not or did involve an explicit time integration. We have shown here that these designations are not in accord with the (very specific) mathematical definition of a Markov and a non-Markovian process. We suggest that the much more appropriate terms Pauli process (or equation) and non-Paulian process (or equation) be used instead to designate processes described by the GME.

Analogies between theories of antenna arrays and passive networks, M. T. Ma., *IEEE Intern. Conv. Record* **13,** *Pt. 5, 150–154 (Mar. 1965).*
This paper demonstrates the analogy between two different fields, antenna arrays and passive networks, which are generally not known to each other. Successful application, either directly or with modification, of various known techniques for synthesizing a passive network, when an impulse response is specified, to the synthesis of linear antenna arrays with amplitude excitations, phase distributions and element spacings as the controlling parameters, when a desired radiation pattern is given, is presented with many interesting examples.

Approximations to the distribution of quadratic forms, M. M. Siddiqui, *Ann. Math. Stat.* **36,** *No. 2, 677–682 (Apr. 1965).*

Let $Q=1/2\ \Sigma_{j=1}^{2k}\ a_j X_j^2$, where $0 < a_1 \leqslant a_2 \leqslant . . . \leqslant a_{2k}$ are constants and $X_1, . . . , X_{2k}$ are independent $N(0, 1)$ variates. If a_j's are equal within groups of even sizes the distribution of Q can be evaluated exactly: otherwise some approximations to this distribution are needed. In the present paper an approximation to $F(x)=Pr(Q > x)$ is obtained by bounding Q by Q_1 and Q_2, where Q_1 and Q_2 are quadratic forms whose exact distributions can be evaluated. Let $F_i(x) = Pr(Q_i > x)$, $i=1, 2$, and let $\hat{F}(x)=(1-0)\ F_i(x)+0F_2(x)$. The approximation to $F(x)$ is obtained by minimizing $d(F, F)$ for variations of 0 where $d(. . .)$ is the distance function of the metric space L^2 $(0, \infty)$.

Estimation for a one-parameter exponential model, J. A. Speckman and R. G. Cornell, *J. Amer. Stat. Assoc.* **60,** *560–572 (1965).*

The partial totals estimation procedure is presented, illustrated and evaluated for the model $y=\exp(-pt)+e$ when the values of t are equally spaced. Tables of estimates using this estimation procedure are given for the case where the smallest value of t is zero. The evaluation consists of an analytical investigation of the large sample properties of the partial totals estimator and a comparative study of its small sample properties relative to three other estimators based on Monte Carlo results where it is assumed either that y is a binomial proportion or that y is a proportion with variance proportional to a binomial variance.

Inequalities for permanents and permanental minors, R. A. Brualdi and M. Newman, *Proc. Cambridge Phil. Soc.* **61,** *pt. 3, 741–746 (Jan. 26, 1965).*

The principal result of this paper is that for all non-negative doubly-stochastic matrices A and all α such that $0 \leqslant \alpha \leqslant 1$, $\operatorname{per}(\alpha I+(1-\alpha)A) \leqslant \alpha+(1-\alpha)\operatorname{per}(A)$, where per (A) denotes the permanent of A.

On the binary collision expansion of the classical *N*-body Green's function, J. Weinstock, *Phys. Rev.* **126,** *No. 1, 341–344 (Apr. 1, 1962).*

The explicit time integrations in the formal Binary Collision Expansion of the classical N-body Green's function are performed to obtain a product of binary collision operators which bears a strong resemblance to the Mayer product of f_{ij}'s. These integrations are exact for hard sphere interactions and are expected to be a good approximation for finite but short range pair interactions. The resulting expansion can be averaged over configuration space to obtain a transport equation for a dense gas in analogy with the cluster expansion of the classical partition function.

On matching problems, J. Edmonds, A. J. Goldman, C. Witzgall, C. T. Zahn, Jr., *Proc. ARO Working Group on Computer, ARO–D Report 65–1, pp. 46–50 (Office Chief Res. and Develop., Feb. 1964).*

Combinatorial optimization problems, although finite, remain intracable in practice so long as all known solution methods involve an amount of labor which increases exponentially with problem size. The present paper reports the recent development, by members of the Combinatorial Mathematics Project at the National Bureau of Standards, of efficient solution and checking algorithms for one class of problems. The prototype of this class is the problem of finding in a linear graph a set of pairwise disjoint edges (a "matching") with as many edges as possible; several generalizations are also discussed.

Paths, trees, and flowers, J. Edmonds, *Can. J. Math.* **17,** *449–467 (1965).*

A matching in a graph is a subset of its edges such that no two meet the same vertex. The theory of matchings is treated. In particular, an efficient algorithm is described for finding in a given graph a matching of maximum cardinality. The Konig theorem is generalized to arbitrary (non-bipartite) graphs.

Realization of semi-multipliers as multipliers, H. Fell and A. J. Goldman, *Am. Math. Mo.* **72,** *No. 6, 641 (June–July 1965).*

The semi-multipliers of a linear associative algebra A are linear transformations obeying a generalization of the formula imposed on the multipliers of A by the associative law. Buck showed that A could be imbedded as an ideal in a very large algebra B so that each semi-multiplier of A was realized as a multiplier in B, and asked how to construct a smaller algebra B with the same property. This note presents such a construction.

Some remarks on certain generalized Dedekind sums, H. Rademacher, *Acta Arithmetica* **9,** *Sec. 1, 97–105 (1964).*

Some years ago the German mathematician C. Meyer introduced a certain generalization of the Dedekind sums. This paper has as its aim to formulate the "true" generalization, which lies behind all the previous attempts. In this new formulation the theorems become not only general but also really transparent. A reciprocity theorem is to be expected in this theory and is indeed fully established. The paper closes with a hint at a useful Euclidean algorithm.

The paper is dedicated to L. J. Mordell (who himself has made contributions to the theory of Dedekind sums). It is an invited paper for an anniversary volume.

Stochastic theory of diffusion in a plasma across a magnetic field, C. M. Tchen, *Proc. Intern. Symp. Diffusion, Feldafing, Germany, June 29–July 3, 1964, pp. 118–123 (1964).*

A stochastic theory is proposed to investigate the diffusion across a constant magnetic field for the cases of collision and collective oscillations. A general formula is obtained, which shows the two cases separately, and the underlying assumptions permitting such a separation are clarified. It is found that the diffusion by collective oscillations is determined by the wave energy, while the collisional diffusion is determined by the thermal energy.

Electromagnetic properties of a quantized relativistic electron-positron gas, L. A. Steinert, *Il Nuovo Cimento, Serie X* **36,** *935–953 (Apr. 1965).*

A relativistic quantum statistical description is given of electromagnetic wave propagation in a uniformly magnetized electron-positron gas, with specific attention devoted to long wavelength propagation as determined by the "collective" approximation. Collisionless absorption effects derived from relativity theory are compared with those obtained from the corresponding nonrelativistic treatment, showing that the two theories predict substantially different effects even for "nonrelativistic" temperatures. Contrasts appear in the predicted characteristics of the cyclotron resonance absorption effect, including the fact that Landau damping is completely nonexistent in the relativistic gas for waves propagating at phase velocities exceeding the velocity of light.

Wave functions for anharmonic oscillators by perturbation methods, A. M. Shorb, R. Schroeder, and E. R. Lippincott, *J. Chem. Phys.* **37,** *1043 (Sept. 1, 1962).*

Approximate wave functions and the corresponding energies are given in tabular form for anharmonic potentials which can be expanded in polynomial series up to the sixth power in the displacement, x.

Localized-induction concept on a curved vortex and motion of an elliptic vortex ring, R. J. Arms and F. R. Hama, *Phys. Fluids* **8,** *No. 4, 553–559 (Apr. 1965).*

The localized-induction concept for the induction effect of a smooth curved vortex on itself is derived. This concept is applicable to the limiting case of a vortex filament of infinitesimal core size and of negligible long-distance effect, and was already successfully utilized in the investigations of the motion and deformation of a curved vortex filament given various initial configurations. Two theorems obtained under this concept are that the arc length of a vortex filament and the projected area of a closed vortex filament are both invariant with respect to time. These theoretical predictions are examined by a numerical analysis of the motion of an initially plane elliptic vortex ring of various eccentricities.

Random-walk model of chain-polymer adsorption at a surface, R. J. Rubin, *J. Chem. Phys.* **43,** *No. 7, 2392–2407 (Oct. 1, 1965).*

A random walk lattice model of adsorption of an isolated polymer chain at a solution surface is investigated. On neglecting the self-excluded volume, a number of one-dimensional characteristics of the monomer unit distribution are determined analytically in the limit of long polymer chains. On assuming that one end of the poly-

mer chain lies in the surface layer, the mean number of monomer units adsorbed in the surface layer $\nu(\theta, N)$ and the mean distance of the other end of the chain from the surface layer $z(\theta, N)$ are determined, where N is the number of monomer units in the chain and θ is the adsorption energy of each monomer unit in the surface layer measured in units of kT. The lattice models considered include the simple cubic, hexagonal, close-packed, face-centered cubic, and body-centered cubic lattices. In the limit in which $N\rightarrow\infty$, both $\nu(\theta, N)$ and $z(\theta, N)$ exhibit a very interesting discontinuity at a lattice-dependent adsorption energy θ_c. For example for $\theta>\theta_c$, $\nu(\theta, N)$ (which is also proportional to the average adsorption energy of a polymer chain) is proportional to N. *For* $\theta<\theta_c$, $\nu(\theta, N)$ is proportional to a constant of order unity; and for $\theta=\theta_c$, $\nu(\theta, N)$ is proportional to $N^{1/2}$. It is shown that the probability distribution of the end of the chain decreases exponentially with increasing distance from the surface layer for $\theta>\theta_c$.
In addition, the mean number of monomer units in the kth layer from the surface is determined for $N>>1$ and $\theta>\theta_c$ and is found to decrease exponentially with increasing k. In effect, for $\theta>\theta_c$ the polymer chain exists in an adsorbed state. An improvement in the model, which includes short range correlation between successive steps in the random walk description, is also considered.

Interaction between configurations with several open shells, U. Fano, *Phys. Rev.* **140,** *No. 1A, A67–A75 (Oct. 4, 1965).*
Antisymmetrized product wave functions are written for atomic configurations with an arbitrary number of partially or entirely filled shells. Interaction matrix elements between such configurations are calculated and a numerical evaluation is given for the autoionization of an inner excitation level of neon. A suitable notation keeps the analytical complexities within reasonable bounds.

Other NBS Publications

J. Res. NBS 69A (Phys. and Chem.), No. 6 (Nov.-Dec. 1965), 75 cents.

Arc measurement of some argon transition probabilities. C. H. Popenoe and J. B. Shumaker, Jr.
Theoretical interpretation of the third spectrum of gold (Au III). Y. Shadmi.
Photopolarographic behavior of inorganic depolarizers. R. A. Durst and J. K. Taylor.
Spectral structure of critical opalescence: binary mixture. R. D. Mountain.
Irregularities in the NBS (1955) provisional temperature scale. H. M. Roder.
Isotherms determined by the National Bureau of Standards acoustical thermometer in the liquid helium temperature range. G. Cataland and H. Plumb.
Synthesis of D-glucose-3-^{14}C and related compounds. H. L. Frush, L. T. Sniegoski, N. B. Holt, and H. S. Isbell.
Correlation of large longitudinal deformations with different histories. L. J. Zapas and T. Craft.
Crystallography of tetracalcium phosphate. W. E. Brown and E. F. Epstein.
Electrode potentials in fused systems XII. Measurement of cation concentration in molten salts using glass membrane electrodes. K. H. Stern and S. E. Meador.

Radio Sci. J. Res. NBS/USNC-URSI 69D, No. 12 (December 1965), $1.00

Symposium on Planetary Atmospheres and Surfaces, May 1965:
I Session: Jupiter, as observed at long radio waves.
II Session: Jupiter, as observed at short radio waves.
III Session: Passive radio observations of Venus, Saturn, Mercury, Mars, and Uranus.
IV Session: Passive radio observations of the Moon.
V Session: Radar observations of the planets.
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