Title
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Publication Date
1970-08-01

7th International Conference on
High Energy Accelerators,
Yerevan, Armenia, USSR
August 27-September 2, 1969

UCRL-19313
Preprint

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AEC Contract No. W-7405-eng-48

LAWRENCE RADIATION LABORATORY
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THIN LENS OPTICS WITH SPACE CHARGE*

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1. Introduction

In this paper the beam-envelope theory of Kapchinskij and Vladimirskij[1] is applied to the case of a drifting relativistic beam of circular cross section focussed by thin lenses. Numerical integration of the envelope equation in dimensionless form produces a single family of envelope curves that represent all possible beam envelopes for any particular choice of momentum, emittance, and intensity. From these curves the minimum possible beam radius for any particular lens spacing may be determined, as well as the corresponding lens strength.

2. Review of Envelope Equations

For completeness a derivation of the envelope equations, slightly different but equivalent to that of Ref. 1, follows.

The authors of Ref. 1 consider beams in which the distribution of particles among the transverse degrees of freedom is such as to

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*Work done under the auspices of the U. S. Atomic Energy Commission.

[1] I. M. Kapchinskij and V. V. Vladimirskij, Limitations of Proton Beam Current in a Strong Focussing Linear Accelerator Associated with the Beam Space Charge, in Proceedings of the International Conference on High-Energy Accelerators and Instrumentation, CERN, 1959, p. 274.

produce spatially uniform density on any transverse section of the beam, though this density may vary (slowly) in the longitudinal direction. Discussion of this distribution will be given later, but it is now relevant to note that uniform density produces linear space charge forces on the particles.

One considers a beam with total particle flux J, longitudinal velocity $\beta_p c$, and uniform charge density

$$\rho = \frac{e\, J/\beta_p c}{\pi r_x r_y} \tag{1}$$

in the interior of the upright ellipse with semi-axes r_x and r_y. The beam is taken to be unneutralized. In the rest-frame the density is $\rho_0 = \rho/\gamma_p$, $\gamma_p = 1/\sqrt{1-\beta_p^2}$, and the electrostatic potential is (cf. Ref. 1)

$$V_0(x, z) = -\frac{2\pi\rho_0}{r_x + r_y}\left(r_y x^2 + r_x y^2\right). \tag{2}$$

The transverse equation of motion is $m d^2\vec{x}/d\tau^2 = -e\nabla V_0(\vec{x}) + \vec{F}_{ext}$ where τ is the proper time. If the external force $\vec{F}_{ext}$ is linear and without x-y coupling, the x, y equations of motion for the particles, in terms of the path length in the lab frame $s = \beta_p\gamma_p c\tau$, become

$$\frac{d^2x}{ds^2} + \left[K_x - \frac{g}{r_x(r_x + r_y)}\right] x = 0 \tag{3}$$

$$\frac{d^2y}{ds^2} + \left[K_y - \frac{g}{r_y(r_x + r_y)}\right] y = 0.$$

Here $K_x \cdot x$ and $K_y \cdot y$ are proportional to the external forces and*

*If the beam is partly neutralized, so that for each beam particle there are f ions of opposite sign at rest, also with uniform transverse density, then the factor g is multiplied by $(1 - f\gamma^2)$. Also for electrons, $4r_0J/c = 0.23467$ I(kiloamperes).

$$g = 4\, r_0 J/cp^3, \qquad p = \beta_p \gamma_p, \qquad r_0 = e^2/mc^2. \tag{4}$$

While r_x and r_y are not yet known, they are functions of s only, so that each of Eqs. (3) has the form

$$\frac{d^2u}{ds^2} + \bar{K}(s)u = 0. \tag{5}$$

The displacement vector $U = \binom{u}{u'}$, where $u' = du/ds$, can be expressed in terms of phase-amplitude variables[2] Φ, A by

$$U = \begin{bmatrix} A\, w \cos\psi \\ A[w' \cos\Psi - (1/w)](\sin\Psi) \end{bmatrix}, \quad \Psi(s) = \psi(s) + \Phi, \tag{6}$$

where A and Φ are constants, different for each particle. The variables ψ, w are taken to be the same for each particle and must satisfy

$$\psi' = 1/w^2 \tag{7a}$$

$$w'' + \bar{K}\, w + 1/w^3 = 0 \tag{7b}$$

in order that (6) be a solution of (5).

Of the many solutions of Eqs. (7), defined by the initial values of w and w', just one provides a clear view of the evolution of a particular beam distribution that initially, when $s = s_0$, fills the interior of a particular ellipse in the u, u' plane:

$$\epsilon_u = \gamma_0 u^2 + 2\alpha_0\, u\, u' + \beta_0 u'^2, \quad \gamma_0 = (1+\alpha_0{}^2)/\beta_0. \tag{8}$$

By proper choice of the constants ϵ_u, α_0, and β_0, any ellipse can be represented in the form (8).

On the other hand, using (6) to express $\cos\Psi$ and $\sin\Psi$ in terms

[2] See E. D. Courant and H. S. Snyder, Theory of the Alternating Gradient Synchrotron, Annals of Physics, Vol. 3, No. 1, Jan. 1958.

of u, u' and writing $\cos^2 \Psi + \sin^2 \Psi = 1$, it is found that all particles with the same A but any Φ lie on the ellipse

$$A^2 = \gamma u^2 + 2 \alpha u u' + \beta u'^2 \tag{9a}$$

where β, α, γ are functions of s related to w(s), w'(s) by

$$\beta = w^2, \quad \alpha = - w w', \quad \gamma = (1+\alpha^2)/\beta. \tag{9b}$$

If now at $s = s_0$ the initial values w(0), w'(0) are chosen so that (9b) gives $\beta(0) = \beta_0$, $\alpha(0) = \alpha_0$, then the ellipses (9a) will be similar to and nested in the interior of the initial beam ellipse (8), provided that the amplitudes A are in the range $0 \leq A \leq \sqrt{\epsilon_u}$. Furthermore, for any s, the beam which was bounded by the ellipse (8) at s_0 will be bounded by the ellipse (9a) with $A = \sqrt{\epsilon_u}$. The u-u' area of the beam, or emittance, is $\pi \epsilon_u$ and the maximum u displacement, r_u, which occurs when $\Psi = 0$, is

$$r_u(s) = \sqrt{\epsilon_u}\, w(s). \tag{10}$$

Combination of (7b) and (10) yields the u-envelope equation:

$$r_u'' + \overline{K}(s)\, r_u - \epsilon_u^2/r_u^3 = 0, \tag{11}$$

and by comparison of (11) with Eqs. (3) and (5) it is seen that the self-consistent x and y envelope equations are

$$\begin{aligned} r_x'' + K_x r_x - g/(r_x + r_y) - \epsilon_x^2/r_x^3 &= 0 \\ r_y'' + K_y r_y - g/(r_x + r_y) - \epsilon_y^2/r_y^3 &= 0, \end{aligned} \tag{12}$$

where $\pi\epsilon_x$ and $\pi\epsilon_y$ are the beam emittances in the x - x' and y - y' planes respectively.

3. The Micro-Canonical Distribution

Kapchinskij and Vladimirskij have shown that the four dimensional distribution in x, x', y, y' formed from the set of points for which the amplitudes A_x, A_y of Eqs. (6) or (9a) satisfy

$$\epsilon = A_x^2 + h A_y^2 \tag{13}$$

where h is a constant of arbitrary value, has uniform density in the x-y plane. To be more precise, the number of particles with A_x, Φ_x, A_y, Φ_y [see Eq. (6)] is taken to be

$$dN = N_0 \delta(\epsilon - A_x^2 - h A_y^2)\, dA_x^2\, d\Phi_x\, dA_y^2\, d\Phi_y \tag{14}$$

with Φ_x and Φ_y uniform from zero to 2π. To verify that the density is uniform, transform to the variables ξ, P_ξ, η, P_η:

$$\begin{aligned} \xi &= x/w_x = A_x \cos\psi_x & P_\xi &= w_x x' - w_x' x = - A_x \sin\psi_x \\ \eta &= y/w_y = A_y \cos\psi_y & P_\eta &= w_y y' - w_y' y = - A_y \sin\psi_y \end{aligned} \tag{15}$$

in terms of which

$$dN = 4\, N_0 \delta[\epsilon - (P_\xi^2 + \xi^2) - h(P_\eta^2 + \eta^2)]\, dP_\xi\, dP_\eta\, d\xi\, d\eta. \tag{16}$$

To get the density at ξ, η one integrates over $P_\xi P_\eta$, using polar coordinates:

$$P_\xi = P \cos\Phi, \qquad \sqrt{h}\, P_\eta = P \sin\Phi,$$

$$dN = \frac{4N_0}{\sqrt{h}}\, d\xi\, d\eta \iint \delta(\epsilon - \xi^2 - h\eta^2 - P^2)\, P\, dP\, d\Phi$$

$$= \begin{cases} \dfrac{4\pi N_0}{\sqrt{h}\, w_x w_y}\, dx\, dy \\ 0 \end{cases}, \quad \text{for } (\xi^2 + h\eta^2) \lessgtr \epsilon. \tag{17}$$

Thus the density is spatially uniform. The projections of this distribution on the xx' and yy' planes fill the ellipse of Eq. (13), with $\epsilon_x = \epsilon$,

$\epsilon_y = \epsilon/h$, while on the xy plane it fills the ellipse

$$(x/r_x)^2 + (y/r_y)^2 = 1, \qquad r_x = w_x\sqrt{\epsilon_x}, \qquad r_y = w_y\sqrt{\epsilon_y} .$$

It was shown in the previous section that if the density is uniform, then the amplitudes A_x and A_y are constants of the motion for each particle. Then the distribution (14) will be conserved in time, and likewise the uniform density. Consequently the theory culminating in the envelope equations (12) is self-consistent for distributions of type (14).

4. Specialization to Circular Beams with Thin Lenses

This paper now concerns itself with cases for which it is reasonable to integrate the envelope equations in the drift spaces taking account of space charge and emittance, but in the region of strong short focussing lenses to ignore these terms, so that the effects of the lenses on the envelope vectors $\begin{pmatrix} r_x \\ r'_x \end{pmatrix}$ and $\begin{pmatrix} r_y \\ r'_y \end{pmatrix}$ may be given by matrices. We assume that the lenses, even if composite, have the same overall transfer matrix in both transverse planes. It is further assumed that the projection of the beam on the two transverse planes are identical so that $\epsilon_x = \epsilon_y = \epsilon$, $w_x = w_y = w$, and the constant h of Eq. (13) is unity. With these assumptions the beam is circular: $r_x = r_y = r$, and each of Eqs. (12) may be written

$$\frac{d^2r}{ds^2} + K(s)\, r - \frac{g}{2r} - \frac{\epsilon^2}{r^3} = 0. \tag{18}$$

It is possible to reduce (18) to dimensionless form in the drift spaces by the following substitutions:*

*The parameter t is not to be confused with the time.

$$r = \sqrt{\epsilon}\, w, \qquad w = W/\sqrt{G}, \qquad s = t/G$$
$$K(s) = G^2 \kappa(t), \qquad G = g/\epsilon\,, \qquad g = 4 r_0 J/c(\beta\gamma)^3 \tag{19}$$

that change the envelope equation to

$$\frac{d^2W}{dt^2} + \kappa(t)\, W - \frac{1}{2W} - \frac{1}{W^3} = 0. \tag{20}$$

This may be compared to Eq. (7b) when space charge is ignored: $w'' + Kw - 1/W^3 = 0$. Hence, whether or not we include space charge forces, there is only one essential physical parameter to consider in determining the evolution of the beam envelope, the external force coefficient κ or K respectively.

In a drift space, $\kappa(t) = 0$, and all possible solutions can be obtained by integrating Eq. (20) starting at a waist with the initial conditions

$$W = W_0,\ \ W' = 0 \ \text{ at } \ t = 0, \tag{21}$$

for various values of W_0. Thus from a single one-parameter family of curves one obtains all drifting circular beam envelopes, regardless of intensity, emittance, or energy.

<u>Universal Envelope Curves</u>

Equation (20) with $\kappa = 0$ and initial conditions (21) has been integrated numerically using a CDC-6600 computer at LRL. The computed values of $W(t, W_0)$ are shown in Fig. 1.* The lower envelope of these curves gives the smallest possible beam radius at a distance t from the waist, and the solid circles mark the point where the plotted W-curves touch that envelope.

When $W < \sqrt{2}$, the emittance term $1/W^3$ in Eq. (20) is larger than the space-charge term $1/(2W)$, while the reverse is true for $W > \sqrt{2}$.

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*Figures 1 through 5 are repeated three times with different ranges of t.

In the emittance-dominated region, $W < \sqrt{2}$, ignoring the space charge term gives $W'' - W^{-3} = 0$, which has the solution $W^2 = W_0^{\,2} + t^2/W_0^{\,2}$. The smallest W for given t, obtained by solving $\partial W^2/\partial W_0^{\,2} = 0$ for $W_0^{\,2}$, is $W_0^{\,2} = t$, $W^2 = 2t$. Correspondingly $\beta_{min}(s) = w^2 = 2s$. Hence in a beam line with thin lenses a distance L apart, focussed to give minimum β at the lenses, we have $\beta_{lens} = L$, $r = \sqrt{\epsilon L}$. The use of these familiar formulas should be restricted to those cases where $W < \sqrt{2}$ for the entire envelope between lenses, which implies $|t_{lens}| < 1$.

On the other hand if $W > \sqrt{2}$, space charge dominates emittance and the lower boundary of the beam envelopes is approximately a straight line, $W_{min}(t) \approx t$, and correspondingly the minimum beam radius at the lenses is $r \approx \sqrt{g}\, L/2$.

In Fig. 3 a curve of β/s is shown corresponding to the minimum beam size. We see that as $t \to 0$, this ratio goes to 2, as it must when space charge is unimportant.

Lens Strength for Periodic Envelopes

If a periodic system of thin lenses is to produce a periodic envelope, then the envelope vector $\binom{W}{W'}$ must be changed to $\binom{W}{-W'}$ by the lenses. The thin-lens matrix for a lens has the form $\begin{pmatrix} 1 & 0 \\ -k & 1 \end{pmatrix}$ so the required strength is $k = 2W'/W$. Curves of k vs t are shown in Fig. 2 corresponding to each of the envelope curves of Fig. 1. The diamonds correspond to the lower boundary of the envelopes, so they give the proper lens strength for a periodic beam line with minimum beam size. The focal length is related to k by $f = (Gk)^{-1}$.

The curves of Fig. 2 can also be used to calculate lens strength if the spacings are not equal. If the waists before and after the lens are at distances t_1 and t_2 from the lens, the proper lens strength is $k = (1/2)(k_1 + k_2)$, where k_1 and k_2 are taken from the k(t) curves at t_1 and t_2 that correspond to two different W curves W_a and W_b such that $W_a(t_1) = W_b(t_2)$.

In Fig. 3 a curve of f/s is shown, as a function of t. As $t \rightarrow 0$ (low space charge) the ratio $f/s \rightarrow 1$. This limiting value can also be derived by calculating the one-period transfer matrix, evaluating the amplitude function β, and minimizing β with respect to f.

Phase Advance

The phase advance of particles in the beam is given by $\psi = \int dt/W^2$, and was integrated simultaneously with W by the computer. The resulting curves are shown in Fig. 4. For one period of a periodic system the total phase advance is $\mu = 2\psi(T)$ where the lenses are at $t = \pm T$.

The center of mass of beam will "see" only the lenses and empty drift spaces so its phase advance μ_0 can be evaluated from the transfer matrix. Curves of μ and μ_0 for minimum radius envelopes are shown in Fig. 5.

5. Neutralized Beams

As noted in the footnote on page 2, when the beam is partly neutralized by particles of opposite sign, the factor g should be multiplied by $1-f\gamma^2$, where f is the fractional neutralization. If $f > \gamma^{-2}$ the resulting g factor will be negative, and the dimensicnless equation for the beam envelope in a drift space becomes

$$W''(t) + (2W)^{-1} - W^{-3} = 0 \qquad (20)'$$

rather than Eq. (20). Again all possible solutions can be obtained by interpreting this equation for various W_0 with the initial conditions

$$W = W_0, \; W' = 0 \text{ at } t = 0.$$

A few such neutralized beam envelopes are shown in Fig. 6.

6. Beams in Solenoidal Fields

Consider a beam moving in the z direction confined by a solenoidal magnetic field $B_z(r, z)$, $B_r(r, z)$. If $\vec{B}$ is expanded in powers of r, and one writes the equations of motion in terms of x-y axes that rotate about the z axis with speed

$$\omega(z) = d\theta/dz = - e\, B(z)/(2mc^2\beta\gamma) \qquad (22)$$

then the linearized equations of motion may be shown to be

$$d^2x/dz^2 + \omega^2 x = 0$$
$$d^2y/dz^2 + \omega^2 y = 0 \qquad (23)$$

in the absence of space charge. The latter will add the same terms as are in Eq. (3) so that the envelope equations are the same. For circular beams the envelope obeys

$$\frac{d^2r}{dz^2} + \omega^2(z)\, r - \frac{g}{2r} - \frac{\epsilon^2}{r^3} = 0. \qquad (24)$$

If the magnetic field is constant, there is a solution of (24) for which the beam radius is constant. This radius is easily seen to be

$$R = \rho_0 \left(g + \sqrt{g^2 + \delta^2} \right)^{1/2}$$

$$\rho_0 = (2\omega)^{-1} = \text{radius of curvature in field B}$$

$$= (B\rho)/(B_{sol}$$

$$\delta = 2\epsilon/\rho_0, \; g = 4r_0 J/cp^3.$$

7. Tables

For more accurate beam design the attached tables may be useful. Table I gives values of W, dW/dt, $k = 2W'/W$, μ and μ_0 versus t for envelope curves defined by various initial values W_0. Table II gives values of the above quantities which the envelope curves attain at their intersection with the lower boundary of the envelopes (see Fig. 1).

The use of these tables is illustrated by the following examples.

Example (a) We want to transport a beam of electrons focussed by a set of equally spaced solenoid lenses. Suppose the electrons have energy of 1.25 MeV ($\gamma = 3.4463$, $\beta = 0.95698$, $B\rho = 5.6213$ kG-cm) emittance $\pi\epsilon = 0.15\pi$ cm-rad, and current I = 1000 A. The solenoids have separation 2L = 92 and effective length $\ell_{sol} = 10$ cm. What is the minimum beam radius and corresponding lens strength? From Eq. (4) we have

$$g = \frac{4r_0 J}{c(\beta\gamma)^3} = 0.23467 \frac{I_{kA}}{(\beta\gamma)^3} = \frac{0.23467\times(1)}{(3.298)^3} = 6.5416\times 10^{-3}$$

and from (19), $G = g/\epsilon = 6.5416\times 10^{-3}/0.14 = 0.04673\ \text{cm}^{-1}$.

The distance from a beam waist to a lens is, from (19),

$$T = GL = 0.04673\times 46 = 2.1496.$$

We interpolate in Table II and find:

$W_0 = 1.5753$, $T = 2.1496$, $W = 2.6789$, $k = 0.6680$, $\mu = 68.95$ deg, $\mu_0 = 115.43$ deg.

The beam radius is connected to W by $r = \sqrt{\epsilon/G}\, W$, from (19). Here $\sqrt{\epsilon/G} = \sqrt{0.15/0.04673} = 1.792$ cm, so the beam radius at the waists is $r_0 = 1.792\, W_0 = 2.82$ cm, and at the lenses is $r_{max} = 1.792\, W = 4.80$ cm.

The focal length of the lenses is $f = (Gk)^{-1} = 32$ cm. To obtain the solenoid field require we use

$$f^{-1} = B^2 \ell_{sol}/[4(B\rho)^2], \quad B = 2(B\rho)/\sqrt{f\ell_{sol}} = 0.628 \text{ kG}.$$

To see more detail of the beam envelope, we can look in Table I. The nearest trajectory tabulated there corresponds to $W_0 = 1.5$.

Example (b) After the beam leaves the transport line (a), we want the last lens to focus the beam down to a 1-cm radius spot. How far is this from the last lens and how strong should that lens be?

The new focus has $W_0 = r_0/1.792 = 0.558$. The closest tabulated envelope, Table I, has $W_0 = 0.50$. We must follow this envelope to $W = 2.6789$, the value corresponding to the beam radius in the last solenoid. We find $W = 2.7661$ at $t = 1.20$ where $k = 1.7079$.

The distance from the last lens to the 1-cm focus then is $\ell = t/G = 1.2/0.0467 = 26$ cm. The strength of the last lens is the average of the two k values:

$$k_f = (0.6680 + 1.7079)/2 = 1.188 = 1.78\, k_0,$$

where $k_0 = 0.6680$ is the strength obtained in example (a). Hence $B_f = 1.78\, B_0 = 0.840$ kG.

TABLE I

Tabulation of envelope curves for various W_0.*

t = normalized path length from waist,

W = normalized radius,

k = $2(dW/dt)/W$ ~ lens strength for periodic envelope,

μ = $2\times$phase advance of beam particles from $t=0$ to t,

i.e., one period phase advance in periodic system with lens spacing $2t$.

μ_0 = phase advance of beam center of mass for one period.

Lines marked with asterisks represent the intersection of the particular envelope curve with the lower boundary of all envelope curves. Such intersections are also tabulated in Table II.

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*To aid conversion to ordinary units, we repeat Eq. (19):

$$r = \sqrt{\epsilon}\, w \,, \qquad w = W/\sqrt{G}, \qquad s = t/G \,,$$

$$K(s) = G^2 \kappa(t) \,, \qquad G = g/\epsilon \,, \qquad g = 4r_0 J/c(\beta\gamma)^3$$

WO = .1

	T	W	DW/DT	K	MU(DEG)	MUO(DEG)	
	0.00	.1000	0.0000				
**	.0100	.1416	7.1035	100.3452	89.88	90.16	**
	.02	.2242	8.9956	80.2310	126.63	127.20	
	.04	.4142	9.7772	47.2063	151.51	152.65	
	.06	.6119	9.9569	32.5446	160.56	162.30	
	.08	.8118	10.0288	24.7064	165.17	167.56	
	.10	1.0128	10.0668	19.8786	167.96	171.06	
	.12	1.2144	10.0905	16.6179	169.82	173.80	
	.14	1.4164	10.1070	14.2714	171.16	176.37	
	.16	1.6187	10.1194	12.5033	172.16		
	.18	1.8212	10.1292	11.1239	172.93		
	.20	2.0238	10.1372	10.0179	173.56	UNSTABLE	
	.22	2.2266	10.1440	9.1115	174.06	FOR BEAM	
	.24	2.4296	10.1499	8.3553	174.49	CENTER OF	
	.26	2.6326	10.1551	7.7148	174.85	MASS IN	
	.28	2.8358	10.1598	7.1654	175.15	PERIODIC	
	.30	3.0390	10.1640	6.6890	175.42	SYSTEM	
	.32	3.2423	10.1678	6.2719	175.65		
	.34	3.4457	10.1713	5.9037	175.86		
	.36	3.6492	10.1746	5.5763	176.04		
	.38	3.8527	10.1776	5.2834	176.20		
	.40	4.0563	10.1805	5.0196	176.35		
	.42	4.2599	10.1832	4.7809	176.48		
	.44	4.4636	10.1857	4.5639	176.60		
	.46	4.6674	10.1881	4.3657	176.71		
	.48	4.8711	10.1904	4.1840	176.81		
	.50	5.0750	10.1926	4.0168	176.91		
	.52	5.2788	10.1946	3.8624	176.99		
	.54	5.4828	10.1966	3.7195	177.07		
	.56	5.6867	10.1985	3.5868	177.14		
	.58	5.8907	10.2004	3.4632	177.21		
	.60	6.0947	10.2021	3.3479	177.28		
	.62	6.2988	10.2038	3.2399	177.34		
	.64	6.5029	10.2055	3.1388	177.39		
	.66	6.7070	10.2070	3.0437	177.44		
	.68	6.9112	10.2086	2.9542	177.49		
	.70	7.1153	10.2101	2.8699	177.54		
	.72	7.3196	10.2115	2.7902	177.58		
	.74	7.5238	10.2129	2.7148	177.63		
	.76	7.7281	10.2142	2.6434	177.67		
	.78	7.9324	10.2156	2.5757	177.70		
	.80	8.1367	10.2168	2.5113	177.74		
	.82	8.3410	10.2181	2.4501	177.77		
	.84	8.5454	10.2193	2.3918	177.80		
	.86	8.7498	10.2205	2.3362	177.84		
	.88	8.9542	10.2217	2.2831	177.86		
	.90	9.1587	10.2228	2.2324	177.89		
	.92	9.3632	10.2239	2.1839	177.92		
	.94	9.5676	10.2250	2.1374	177.94		
	.96	9.7722	10.2260	2.0929	177.97		
	.98	9.9767	10.2271	2.0502	177.99		
	1.00	10.1812	10.2281	2.0092	178.02		

WO = .2

T	W	DW/DT	K	MU(DEG)	MUO(DEG)
0.00	.2000	0.0000			
.04	.2845	3.6047	25.3443	89.65	90.79
** .0399	.2841	3.6002	25.3437	89.51	90.65 **
.08	.4523	4.5747	20.2288	125.92	128.19
.12	.6422	4.8726	15.1749	141.75	145.18
.16	.8400	5.0018	11.9094	150.26	154.89
.20	1.0416	5.0723	9.7397	155.50	161.43
.24	1.2454	5.1171	8.2174	159.04	166.45
.28	1.4508	5.1484	7.0976	161.58	170.87
.32	1.6572	5.1721	6.2420	163.48	175.90
.36	1.8645	5.1908	5.5682	164.97	
.40	2.0724	5.2063	5.0244	166.15	
.44	2.2809	5.2194	4.5765	167.12	UNSTABLE
.48	2.4899	5.2307	4.2015	167.93	FOR BEAM
.52	2.6994	5.2407	3.8829	168.61	CENTER OF
.56	2.9092	5.2497	3.6090	169.19	MASS IN
.60	3.1193	5.2578	3.3711	169.70	PERIODIC
.64	3.3298	5.2652	3.1625	170.14	SYSTEM
.68	3.5405	5.2720	2.9781	170.53	
.72	3.7516	5.2783	2.8139	170.88	
.76	3.9628	5.2842	2.6669	171.18	
.80	4.1743	5.2897	2.5344	171.46	
.84	4.3860	5.2949	2.4145	171.71	
.88	4.5979	5.2998	2.3053	171.94	
.92	4.8100	5.3044	2.2056	172.15	
.96	5.0222	5.3088	2.1141	172.34	
1.00	5.2347	5.3130	2.0299	172.51	
1.04	5.4473	5.3170	1.9522	172.67	
1.08	5.6600	5.3209	1.8802	172.82	
1.12	5.8729	5.3245	1.8133	172.96	
1.16	6.0860	5.3281	1.7509	173.09	
1.20	6.2992	5.3315	1.6928	173.20	
1.24	6.5125	5.3348	1.6383	173.32	
1.28	6.7260	5.3379	1.5873	173.42	
1.32	6.9395	5.3410	1.5393	173.52	
1.36	7.1532	5.3439	1.4941	173.61	
1.40	7.3670	5.3468	1.4515	173.70	
1.44	7.5810	5.3496	1.4113	173.78	
1.48	7.7950	5.3522	1.3732	173.86	
1.52	8.0091	5.3549	1.3372	173.93	
1.56	8.2234	5.3574	1.3030	174.00	
1.60	8.4377	5.3599	1.2705	174.07	
1.64	8.6522	5.3623	1.2395	174.13	
1.68	8.8667	5.3646	1.2101	174.19	
1.72	9.0814	5.3669	1.1820	174.25	
1.76	9.2961	5.3691	1.1551	174.30	
1.80	9.5109	5.3713	1.1295	174.35	
1.84	9.7258	5.3734	1.1050	174.40	
1.88	9.9408	5.3755	1.0815	174.45	
1.92	10.1558	5.3775	1.0590	174.50	
1.96	10.3710	5.3795	1.0374	174.54	
2.00	10.5862	5.3815	1.0167	174.58	

WO = .3

T	W	DW/DT	K	MU(DEG)	MUO(DEG)
0.00	.3000	0.0000			
.05	.3451	1.6894	9.7912	57.89	59.31
** .0895	.4285	2.4538	11.4516	88.91	91.43 **
.10	.4550	2.5878	11.3756	95.08	97.91
.15	.5958	2.9968	10.0589	116.36	120.59
.20	.7514	3.2028	8.5254	129.19	134.84
.25	.9147	3.3213	7.2620	137.53	144.64
.30	1.0828	3.3973	6.2751	143.32	151.95
.35	1.2540	3.4504	5.5029	147.54	157.82
.40	1.4276	3.4900	4.8894	150.75	162.89
.45	1.6029	3.5210	4.3933	153.25	167.68
.50	1.7796	3.5462	3.9854	155.26	173.07
.55	1.9575	3.5673	3.6448	156.90	
.60	2.1363	3.5854	3.3566	158.27	
.65	2.3160	3.6012	3.1099	159.43	UNSTABLE
.70	2.4964	3.6152	2.8963	160.42	FOR BEAM
.75	2.6775	3.6277	2.7098	161.28	CENTER OF
.80	2.8591	3.6391	2.5456	162.03	MASS IN
.85	3.0414	3.6496	2.4000	162.69	PERIODIC
.90	3.2241	3.6592	2.2699	163.27	SYSTEM
.95	3.4073	3.6681	2.1531	163.79	
1.00	3.5909	3.6764	2.0476	164.26	
1.05	3.7749	3.6842	1.9519	164.68	
1.10	3.9593	3.6915	1.8647	165.07	
1.15	4.1440	3.6985	1.7849	165.42	
1.20	4.3291	3.7050	1.7117	165.74	
1.25	4.5145	3.7112	1.6441	166.03	
1.30	4.7002	3.7172	1.5817	166.30	
1.35	4.8862	3.7229	1.5238	166.55	
1.40	5.0725	3.7283	1.4700	166.78	
1.45	5.2591	3.7335	1.4198	167.00	
1.50	5.4459	3.7385	1.3730	167.20	
1.55	5.6329	3.7433	1.3291	167.38	
1.60	5.8202	3.7479	1.2879	167.56	
1.65	6.0077	3.7524	1.2492	167.72	
1.70	6.1954	3.7567	1.2127	167.87	
1.75	6.3834	3.7609	1.1783	168.02	
1.80	6.5715	3.7649	1.1458	168.16	
1.85	6.7599	3.7688	1.1151	168.28	
1.90	6.9484	3.7727	1.0859	168.41	
1.95	7.1371	3.7763	1.0582	168.52	
2.00	7.3260	3.7799	1.0319	168.63	
2.05	7.5151	3.7834	1.0069	168.74	
2.10	7.7044	3.7868	.9830	168.84	
2.15	7.8938	3.7901	.9603	168.93	
2.20	8.0834	3.7934	.9386	169.02	
2.25	8.2731	3.7965	.9178	169.10	
2.30	8.4630	3.7996	.8979	169.19	
2.35	8.6531	3.8026	.8789	169.26	
2.40	8.8433	3.8055	.8607	169.34	
2.45	9.0336	3.8084	.8432	169.41	
2.50	9.2241	3.8112	.8264	169.48	
2.55	9.4148	3.8139	.8102	169.55	
2.60	9.6055	3.8166	.7947	169.61	

WO = .4

	T	W	DW/DT	K	MU(DEG)	MUO(DEG)	
	0.00	.4000	0.0000				
	.10	.4773	1.4274	5.9809	63.50	66.30	
**	.1584	.5756	1.8962	6.5888	88.09	92.52	**
	.20	.6591	2.1089	6.3993	100.67	106.25	
	.30	.8865	2.4028	5.4207	120.41	128.77	
	.40	1.1350	2.5528	4.4982	131.82	143.06	
	.50	1.3951	2.6430	3.7889	139.07	153.44	
	.60	1.6627	2.7043	3.2529	144.01	162.13	
	.70	1.9355	2.7495	2.8412	147.57	171.42	
	.80	2.2123	2.7850	2.5178	150.25		
	.90	2.4922	2.8140	2.2582	152.33		
	1.00	2.7749	2.8385	2.0458	153.99	UNSTABLE	
	1.10	3.0598	2.8597	1.8692	155.34	FOR BEAM	
	1.20	3.3468	2.8784	1.7201	156.46	CENTER OF	
	1.30	3.6354	2.8951	1.5927	157.40	MASS IN	
	1.40	3.9257	2.9101	1.4826	158.20	PERIODIC	
	1.50	4.2174	2.9239	1.3866	158.89	SYSTEM	
	1.60	4.5105	2.9366	1.3021	159.50		
	1.70	4.8047	2.9483	1.2273	160.03		
	1.80	5.1001	2.9592	1.1605	160.49		
	1.90	5.3965	2.9695	1.1005	160.91		
	2.00	5.6940	2.9791	1.0464	161.28		
	2.10	5.9923	2.9881	.9973	161.62		
	2.20	6.2916	2.9967	.9526	161.92		
	2.30	6.5917	3.0048	.9117	162.20		
	2.40	6.8925	3.0126	.8742	162.45		
	2.50	7.1942	3.0200	.8396	162.68		
	2.60	7.4965	3.0270	.8076	162.89		
	2.70	7.7996	3.0338	.7779	163.09		
	2.80	8.1033	3.0403	.7504	163.27		
	2.90	8.4076	3.0465	.7247	163.44		
	3.00	8.7126	3.0525	.7007	163.60		
	3.10	9.0181	3.0583	.6783	163.74		
	3.20	9.3242	3.0639	.6572	163.88		
	3.30	9.6309	3.0693	.6374	164.01		
	3.40	9.9381	3.0745	.6187	164.13		
	3.50	10.2458	3.0796	.6011	164.24		
	3.60	10.5540	3.0844	.5845	164.34		
	3.70	10.8627	3.0892	.5688	164.44		
	3.80	11.1718	3.0938	.5539	164.54		
	3.90	11.4814	3.0983	.5397	164.63		
	4.00	11.7915	3.1027	.5263	164.71		
	4.10	12.1019	3.1069	.5135	164.79		
	4.20	12.4128	3.1110	.5013	164.87		
	4.30	12.7241	3.1151	.4896	164.94		
	4.40	13.0359	3.1190	.4785	165.01		
	4.50	13.3479	3.1228	.4679	165.08		
	4.60	13.6604	3.1266	.4578	165.14		
	4.70	13.9733	3.1302	.4480	165.20		
	4.80	14.2865	3.1338	.4387	165.26		
	4.90	14.6000	3.1373	.4298	165.31		
	5.00	14.9139	3.1407	.4212	165.36		

WO = .5

T	W	DW/DT	K	MU(DEG)	MUO(DEG)
0.00	.5000	0.0000			
.10	.5433	.8336	3.0687	43.35	46.12
.20	.6574	1.3998	4.2589	75.95	81.48
** .2462	.7262	1.5739	4.3330	87.06	93.83 **
.30	.8152	1.7275	4.2380	97.49	105.75
.40	.9984	1.9205	3.8471	111.62	122.60
.50	1.1970	2.0433	3.4139	121.22	134.99
.60	1.4058	2.1279	3.0272	128.04	144.72
.70	1.6219	2.1901	2.7007	133.07	152.93
.80	1.8434	2.2384	2.4286	136.90	160.54
.90	2.0693	2.2775	2.2012	139.91	168.84
1.00	2.2987	2.3100	2.0099	142.32	
1.10	2.5311	2.3379	1.8473	144.29	
1.20	2.7661	2.3622	1.7079	145.93	UNSTABLE
1.30	3.0035	2.3837	1.5873	147.30	FOR BEAM
1.40	3.2428	2.4030	1.4821	148.48	CENTER OF
1.50	3.4840	2.4205	1.3895	149.50	MASS IN
1.60	3.7269	2.4365	1.3076	150.38	PERIODIC
1.70	3.9713	2.4513	1.2345	151.15	SYSTEM
1.80	4.2171	2.4650	1.1690	151.84	
1.90	4.4642	2.4777	1.1100	152.45	
2.00	4.7126	2.4897	1.0566	152.99	
2.10	4.9621	2.5009	1.0080	153.48	
2.20	5.2128	2.5115	.9636	153.92	
2.30	5.4644	2.5215	.9229	154.33	
2.40	5.7170	2.5310	.8854	154.69	
2.50	5.9706	2.5401	.8509	155.03	
2.60	6.2250	2.5487	.8189	155.34	
2.70	6.4803	2.5570	.7892	155.62	
2.80	6.7364	2.5649	.7615	155.88	
2.90	6.9933	2.5725	.7357	156.13	
3.00	7.2509	2.5798	.7116	156.35	
3.10	7.5092	2.5868	.6890	156.56	
3.20	7.7683	2.5936	.6677	156.76	
3.30	8.0279	2.6001	.6478	156.94	
3.40	8.2883	2.6064	.6289	157.12	
3.50	8.5492	2.6125	.6112	157.28	
3.60	8.8108	2.6184	.5944	157.43	
3.70	9.0729	2.6242	.5785	157.57	
3.80	9.3356	2.6297	.5634	157.71	
3.90	9.5988	2.6351	.5491	157.84	
4.00	9.8626	2.6404	.5354	157.96	
4.10	10.1269	2.6455	.5225	158.07	
4.20	10.3917	2.6505	.5101	158.18	
4.30	10.6570	2.6553	.4983	158.28	
4.40	10.9228	2.6600	.4871	158.38	
4.50	11.1890	2.6646	.4763	158.48	
4.60	11.4557	2.6691	.4660	158.57	
4.70	11.7228	2.6735	.4561	158.65	
4.80	11.9904	2.6777	.4466	158.73	
4.90	12.2584	2.6819	.4376	158.81	
5.00	12.5268	2.6860	.4288	158.89	

WO = .6

T	W	DW/DT	K	MU(DEG)	MUO(DEG)
0.00	.6000	0.0000			
.10	.6268	.5253	1.6762	30.91	33.66
.20	.7016	.9501	2.7084	57.25	62.72
.30	.8126	1.2518	3.0807	77.49	85.65
** .3522	.8811	1.3689	3.1077	85.84	95.42 **
.40	.9488	1.4578	3.0730	92.41	103.25
.50	1.1021	1.6008	2.9050	103.39	116.90
.60	1.2676	1.7039	2.6884	111.61	127.81
.70	1.4421	1.7815	2.4708	117.88	136.85
.80	1.6233	1.8422	2.2696	122.78	144.65
.90	1.8101	1.8912	2.0896	126.68	151.72
1.00	2.0013	1.9320	1.9308	129.84	158.55
1.10	2.1963	1.9667	1.7910	132.45	165.94
1.20	2.3945	1.9968	1.6678	134.63	
1.30	2.5956	2.0234	1.5591	136.48	
1.40	2.7991	2.0470	1.4626	138.05	UNSTABLE
1.50	3.0049	2.0684	1.3767	139.42	FOR BEAM
1.60	3.2127	2.0878	1.2997	140.60	CENTER OF
1.70	3.4224	2.1056	1.2305	141.65	MASS IN
1.80	3.6338	2.1221	1.1680	142.57	PERIODIC
1.90	3.8468	2.1373	1.1112	143.39	SYSTEM
2.00	4.0612	2.1516	1.0596	144.12	
2.10	4.2771	2.1650	1.0124	144.78	
2.20	4.4942	2.1776	.9691	145.38	
2.30	4.7125	2.1895	.9292	145.92	
2.40	4.9321	2.2007	.8924	146.41	
2.50	5.1527	2.2114	.8584	146.86	
2.60	5.3743	2.2216	.8268	147.27	
2.70	5.5970	2.2313	.7973	147.66	
2.80	5.8206	2.2406	.7699	148.01	
2.90	6.0451	2.2496	.7443	148.33	
3.00	6.2705	2.2581	.7202	148.64	
3.10	6.4967	2.2663	.6977	148.92	
3.20	6.7237	2.2742	.6765	149.18	
3.30	6.9515	2.2819	.6565	149.42	
3.40	7.1801	2.2892	.6377	149.65	
3.50	7.4094	2.2963	.6198	149.87	
3.60	7.6394	2.3032	.6030	150.07	
3.70	7.8700	2.3099	.5870	150.26	
3.80	8.1013	2.3163	.5718	150.44	
3.90	8.3333	2.3226	.5574	150.61	
4.00	8.5658	2.3287	.5437	150.77	
4.10	8.7990	2.3346	.5306	150.92	
4.20	9.0328	2.3403	.5182	151.07	
4.30	9.2671	2.3459	.5063	151.21	
4.40	9.5019	2.3514	.4949	151.34	
4.50	9.7373	2.3567	.4841	151.46	
4.60	9.9733	2.3619	.4736	151.58	
4.70	10.2097	2.3669	.4637	151.69	
4.80	10.4467	2.3719	.4541	151.80	
4.90	10.6841	2.3767	.4449	151.90	
5.00	10.9220	2.3814	.4361	152.00	

WO = .8

	T	W	DW/DT	K	MU(DEG)	MUO(DEG)	
	0.00	.8000	0.0000				
	.20	.8502	.4900	1.1527	34.38	39.69	
	.40	.9881	.8657	1.7522	62.03	72.60	
	.60	1.1882	1.1179	1.8817	81.71	97.41	
**	.6155	1.2057	1.1335	1.8803	82.95	99.05	**
	.80	1.4297	1.2860	1.7990	95.26	116.05	
	1.00	1.6993	1.4034	1.6518	104.71	130.68	
	1.20	1.9890	1.4901	1.4984	111.51	142.94	
	1.40	2.2940	1.5575	1.3579	116.53	154.30	
	1.60	2.6112	1.6121	1.2347	120.36	167.32	
	1.80	2.9383	1.6576	1.1283	123.35		
	2.00	3.2738	1.6966	1.0364	125.73		
	2.20	3.6166	1.7305	.9570	127.67	UNSTABLE	
	2.40	3.9657	1.7606	.8879	129.27	FOR BEAM	
	2.60	4.3206	1.7876	.8275	130.61	CENTER OF	
	2.80	4.6806	1.8120	.7743	131.74	MASS IN	
	3.00	5.0453	1.8343	.7272	132.71	PERIODIC	
	3.20	5.4142	1.8549	.6852	133.55	SYSTEM	
	3.40	5.7871	1.8739	.6476	134.28		
	3.60	6.1637	1.8916	.6138	134.92		
	3.80	6.5437	1.9081	.5832	135.49		
	4.00	6.9268	1.9236	.5554	136.00		
	4.20	7.3130	1.9382	.5301	136.45		
	4.40	7.7021	1.9520	.5069	136.86		
	4.60	8.0938	1.9651	.4856	137.23		
	4.80	8.4880	1.9775	.4659	137.56		
	5.00	8.8847	1.9893	.4478	137.86		
	5.20	9.2837	2.0006	.4310	138.14		
	5.40	9.6849	2.0114	.4154	138.40		
	5.60	10.0882	2.0217	.4008	138.63		
	5.80	10.4936	2.0316	.3872	138.85		
	6.00	10.9008	2.0411	.3745	139.05		
	6.20	11.3100	2.0502	.3626	139.23		
	6.40	11.7209	2.0591	.3513	139.41		
	6.60	12.1336	2.0676	.3408	139.57		
	6.80	12.5479	2.0758	.3309	139.72		
	7.00	12.9639	2.0837	.3215	139.86		
	7.20	13.3814	2.0914	.3126	139.99		
	7.40	13.8004	2.0988	.3042	140.11		
	7.60	14.2209	2.1060	.2962	140.23		
	7.80	14.6428	2.1130	.2886	140.34		
	8.00	15.0661	2.1198	.2814	140.45		
	8.20	15.4908	2.1264	.2745	140.54		
	8.40	15.9167	2.1329	.2680	140.64		
	8.60	16.3439	2.1391	.2618	140.72		
	8.80	16.7723	2.1452	.2558	140.81		
	9.00	17.2019	2.1511	.2501	140.89		
	9.20	17.6327	2.1569	.2446	140.96		
	9.40	18.0647	2.1625	.2394	141.04		
	9.60	18.4978	2.1680	.2344	141.10		
	9.80	18.9319	2.1734	.2296	141.17		
	10.00	19.3671	2.1787	.2250	141.23		

WO = 1.0

T	W	DW/DT	K	MU(DEG)	MUO(DEG)
0.00	1.0000	0.0000			
.20	1.0297	.2933	.5696	22.47	27.62
.40	1.1149	.5517	.9896	42.60	52.83
.60	1.2469	.7600	1.2189	59.18	74.42
.80	1.4158	.9213	1.3015	72.22	92.36
** .9412	1.5525	1.0124	1.3044	79.59	103.16 **
1.00	1.6130	1.0458	1.2967	82.28	107.26
1.20	1.8323	1.1436	1.2482	90.05	119.86
1.40	2.0692	1.2221	1.1813	96.10	130.83
1.60	2.3203	1.2868	1.1092	100.88	140.78
1.80	2.5832	1.3413	1.0385	104.71	150.38
2.00	2.8563	1.3881	.9720	107.82	160.73
2.20	3.1381	1.4290	.9108	110.37	
2.40	3.4276	1.4652	.8549	112.51	
2.60	3.7239	1.4976	.8043	114.30	UNSTABLE
2.80	4.0264	1.5268	.7584	115.83	FOR BEAM
3.00	4.3344	1.5535	.7168	117.14	CENTER OF
3.20	4.6476	1.5780	.6791	118.28	MASS IN
3.40	4.9655	1.6006	.6447	119.28	PERIODIC
3.60	5.2878	1.6216	.6133	120.15	SYSTEM
3.80	5.6141	1.6412	.5847	120.92	
4.00	5.9442	1.6596	.5584	121.61	
4.20	6.2778	1.6768	.5342	122.22	
4.40	6.6148	1.6931	.5119	122.77	
4.60	6.9550	1.7084	.4913	123.27	
4.80	7.2981	1.7230	.4722	123.72	
5.00	7.6442	1.7369	.4544	124.13	
5.20	7.9929	1.7501	.4379	124.51	
5.40	8.3442	1.7627	.4225	124.85	
5.60	8.6979	1.7748	.4081	125.17	
5.80	9.0540	1.7863	.3946	125.46	
6.00	9.4124	1.7974	.3819	125.73	
6.20	9.7730	1.8081	.3700	125.98	
6.40	10.1356	1.8183	.3588	126.21	
6.60	10.5003	1.8282	.3482	126.42	
6.80	10.8669	1.8377	.3382	126.63	
7.00	11.2354	1.8469	.3288	126.81	
7.20	11.6056	1.8558	.3198	126.99	
7.40	11.9777	1.8644	.3113	127.15	
7.60	12.3514	1.8728	.3032	127.31	
7.80	12.7268	1.8808	.2956	127.45	
8.00	13.1037	1.8887	.2883	127.59	
8.20	13.4822	1.8963	.2813	127.72	
8.40	13.8622	1.9037	.2747	127.84	
8.60	14.2437	1.9109	.2683	127.96	
8.80	14.6265	1.9179	.2622	128.07	
9.00	15.0108	1.9247	.2564	128.17	
9.20	15.3964	1.9313	.2509	128.27	
9.40	15.7833	1.9378	.2455	128.37	
9.60	16.1715	1.9441	.2404	128.46	
9.80	16.5609	1.9502	.2355	128.54	
10.00	16.9516	1.9562	.2308	128.63	

W0 = 1.2

T	W	DW/DT	K	MU(DEG)	MUO(DEG)
0.00	1.2000	0.0000			
.20	1.2198	.1967	.3226	15.74	20.69
.40	1.2778	.3806	.5957	30.52	40.38
.60	1.3706	.5432	.7926	43.66	58.37
.80	1.4935	.6818	.9131	54.89	74.36
1.00	1.6418	.7981	.9722	64.26	88.41
1.20	1.8115	.8953	.9885	71.98	100.73
** 1.3208	1.9228	.9463	.9844	75.96	107.47 **
1.40	1.9989	.9770	.9775	78.32	111.62
1.60	2.2014	1.0464	.9506	83.53	121.40
1.80	2.4168	1.1061	.9153	87.84	130.36
2.00	2.6433	1.1580	.8762	91.43	138.80
2.20	2.8796	1.2038	.8361	94.45	147.08
2.40	3.1245	1.2446	.7966	97.00	155.78
2.60	3.3772	1.2812	.7587	99.17	166.59
2.80	3.6368	1.3144	.7228	101.03	
3.00	3.9027	1.3447	.6891	102.65	
3.20	4.1745	1.3725	.6576	104.06	UNSTABLE
3.40	4.4516	1.3982	.6282	105.29	FOR BEAM
3.60	4.7336	1.4220	.6008	106.38	CENTER OF
3.80	5.0203	1.4443	.5754	107.34	MASS IN
4.00	5.3113	1.4651	.5517	108.20	PERIODIC
4.20	5.6063	1.4847	.5296	108.97	SYSTEM
4.40	5.9050	1.5031	.5091	109.66	
4.60	6.2074	1.5205	.4899	110.29	
4.80	6.5132	1.5370	.4720	110.86	
5.00	6.8222	1.5527	.4552	111.37	
5.20	7.1342	1.5676	.4395	111.84	
5.40	7.4492	1.5818	.4247	112.27	
5.60	7.7669	1.5954	.4108	112.67	
5.80	8.0873	1.6085	.3978	113.04	
6.00	8.4102	1.6209	.3855	113.37	
6.20	8.7356	1.6329	.3739	113.68	
6.40	9.0634	1.6444	.3629	113.97	
6.60	9.3934	1.6555	.3525	114.24	
6.80	9.7256	1.6662	.3426	114.49	
7.00	10.0599	1.6765	.3333	114.73	
7.20	10.3962	1.6865	.3244	114.95	
7.40	10.7344	1.6961	.3160	115.15	
7.60	11.0746	1.7055	.3080	115.35	
7.80	11.4166	1.7145	.3004	115.53	
8.00	11.7604	1.7233	.2931	115.70	
8.20	12.1059	1.7318	.2861	115.86	
8.40	12.4531	1.7400	.2795	116.01	
8.60	12.8019	1.7480	.2731	116.15	
8.80	13.1523	1.7558	.2670	116.29	
9.00	13.5042	1.7634	.2612	116.42	
9.20	13.8576	1.7708	.2556	116.54	
9.40	14.2125	1.7780	.2502	116.66	
9.60	14.5688	1.7850	.2450	116.77	
9.80	14.9265	1.7919	.2401	116.87	
10.00	15.2855	1.7985	.2353	116.98	

WO = 1.4

T	W	DW/DT	K	MU(DEG)	MUO(DEG)
0.00	1.4000	0.0000			
.20	1.4144	.1433	.2027	11.61	16.37
.40	1.4570	.2810	.3858	22.77	32.26
.60	1.5261	.4088	.5357	33.11	47.27
.80	1.6196	.5241	.6472	42.40	61.17
1.00	1.7349	.6265	.7222	50.58	73.87
1.20	1.8694	.7164	.7664	57.65	85.39
1.40	2.0207	.7952	.7870	63.73	95.84
1.60	2.1868	.8643	.7905	68.92	105.35
** 1.7455	2.3159	.9094	.7854	72.21	111.77 **
1.80	2.3659	.9253	.7822	73.35	114.08
2.00	2.5565	.9795	.7663	77.15	122.18
2.20	2.7573	1.0278	.7455	80.40	129.81
2.40	2.9673	1.0714	.7221	83.20	137.14
2.60	3.1856	1.1108	.6974	85.63	144.41
2.80	3.4114	1.1467	.6723	87.74	151.93
3.00	3.6441	1.1796	.6474	89.58	160.44
3.20	3.8831	1.2100	.6232	91.20	173.85
3.40	4.1279	1.2381	.5999	92.63	
3.60	4.3782	1.2642	.5775	93.90	
3.80	4.6335	1.2886	.5562	95.03	UNSTABLE
4.00	4.8935	1.3114	.5360	96.04	FOR BEAM
4.20	5.1580	1.3329	.5168	96.95	CENTER CF
4.40	5.4266	1.3532	.4987	97.77	MASS IN
4.60	5.6992	1.3723	.4816	98.51	PERIODIC
4.80	5.9755	1.3905	.4654	99.18	SYSTEM
5.00	6.2553	1.4077	.4501	99.80	
5.20	6.5385	1.4241	.4356	100.36	
5.40	6.8249	1.4397	.4219	100.87	
5.60	7.1143	1.4547	.4089	101.34	
5.80	7.4067	1.4690	.3967	101.78	
6.00	7.7019	1.4827	.3850	102.18	
6.20	7.9997	1.4958	.3740	102.55	
6.40	8.3002	1.5085	.3635	102.90	
6.60	8.6031	1.5206	.3535	103.22	
6.80	8.9084	1.5324	.3440	103.52	
7.00	9.2160	1.5437	.3350	103.79	
7.20	9.5258	1.5546	.3264	104.06	
7.40	9.8378	1.5651	.3182	104.30	
7.60	10.1519	1.5753	.3104	104.53	
7.80	10.4679	1.5852	.3029	104.75	
8.00	10.7859	1.5948	.2957	104.95	
8.20	11.1058	1.6041	.2889	105.14	
8.40	11.4276	1.6131	.2823	105.32	
8.60	11.7511	1.6219	.2760	105.49	
8.80	12.0763	1.6304	.2700	105.65	
9.00	12.4032	1.6387	.2642	105.81	
9.20	12.7317	1.6467	.2587	105.95	
9.40	13.0619	1.6546	.2533	106.09	
9.60	13.3935	1.6622	.2482	106.22	
9.80	13.7267	1.6697	.2433	106.34	
10.00	14.0614	1.6769	.2385	106.46	

WO = 1.6

T	W	DW/DT	K	MU(DEG)	MUO(DEG)
0.00	1.6000	0.0000			
.20	1.6111	.1108	.1376	8.91	13.47
.40	1.6442	.2189	.2663	17.58	26.69
.60	1.6983	.3218	.3790	25.81	39.41
.80	1.7724	.4179	.4716	33.43	51.48
1.00	1.8650	.5063	.5430	40.38	62.80
1.20	1.9744	.5868	.5944	46.61	73.34
1.40	2.0992	.6597	.6286	52.15	83.11
1.60	2.2378	.7256	.6485	57.03	92.15
1.80	2.3890	.7850	.6572	61.32	100.54
2.00	2.5515	.8389	.6575	65.08	108.37
2.20	2.7242	.8877	.6517	68.38	115.71
** 2.2066	2.7301	.8893	.6515	68.49	115.95 **
2.40	2.9063	.9323	.6415	71.28	122.66
2.60	3.0969	.9730	.6284	73.83	129.33
2.80	3.2953	1.0105	.6133	76.07	135.82
3.00	3.5009	1.0450	.5970	78.06	142.28
3.20	3.7131	1.0770	.5801	79.83	148.91
3.40	3.9315	1.1068	.5630	81.40	156.11
3.60	4.1557	1.1345	.5460	82.80	164.95
3.80	4.3852	1.1605	.5293	84.06	
4.00	4.6198	1.1850	.5130	85.19	
4.20	4.8591	1.2079	.4972	86.21	UNSTABLE
4.40	5.1029	1.2296	.4819	87.13	FOR BEAM
4.60	5.3509	1.2502	.4673	87.97	CENTER OF
4.80	5.6029	1.2697	.4532	88.74	MASS IN
5.00	5.8587	1.2882	.4398	89.44	PERIODIC
5.20	6.1181	1.3058	.4269	90.08	SYSTEM
5.40	6.3809	1.3226	.4146	90.66	
5.60	6.6471	1.3387	.4028	91.20	
5.80	6.9164	1.3541	.3916	91.70	
6.00	7.1887	1.3689	.3808	92.16	
6.20	7.4639	1.3830	.3706	92.59	
6.40	7.7419	1.3966	.3608	92.99	
6.60	8.0225	1.4097	.3514	93.36	
6.80	8.3057	1.4223	.3425	93.70	
7.00	8.5914	1.4345	.3339	94.02	
7.20	8.8795	1.4463	.3258	94.32	
7.40	9.1699	1.4576	.3179	94.60	
7.60	9.4625	1.4686	.3104	94.87	
7.80	9.7573	1.4792	.3032	95.11	
8.00	10.0542	1.4895	.2963	95.35	
8.20	10.3531	1.4995	.2897	95.57	
8.40	10.6540	1.5092	.2833	95.78	
8.60	10.9568	1.5186	.2772	95.97	
8.80	11.2614	1.5278	.2713	96.16	
9.00	11.5679	1.5367	.2657	96.33	
9.20	11.8761	1.5453	.2602	96.50	
9.40	12.1860	1.5538	.2550	96.66	
9.60	12.4976	1.5620	.2500	96.81	
9.80	12.8108	1.5700	.2451	96.95	
10.00	13.1256	1.5778	.2404	97.09	

WO = 1.8

T	W	DW/DT	K	MU(DEG)	MUO(DEG)
0.00	1.8000	0.0000			
.20	1.8090	.0896	.0990	7.05	11.42
.40	1.8357	.1776	.1935	13.96	22.69
.60	1.8798	.2628	.2796	20.61	33.67
.80	1.9406	.3439	.3545	26.91	44.24
1.00	2.0171	.4204	.4168	32.77	54.33
1.20	2.1084	.4918	.4665	38.16	63.88
1.40	2.2135	.5579	.5041	43.08	72.89
1.60	2.3312	.6191	.5311	47.52	81.36
1.80	2.4608	.6754	.5489	51.52	89.32
2.00	2.6011	.7273	.5592	55.11	96.80
2.20	2.7514	.7752	.5635	58.31	103.86
2.40	2.9109	.8193	.5629	61.17	110.55
2.60	3.0789	.8602	.5588	63.73	116.92
** 2.6963	3.1627	.8788	.5557	64.86	119.90 **
2.80	3.2548	.8981	.5519	66.02	123.04
3.00	3.4380	.9333	.5430	68.07	128.97
3.20	3.6280	.9662	.5326	69.91	134.79
3.40	3.8243	.9969	.5214	71.56	140.59
3.60	4.0266	1.0257	.5095	73.05	146.52
3.80	4.2345	1.0528	.4972	74.39	152.81
4.00	4.4476	1.0783	.4849	75.61	159.97
4.20	4.6657	1.1023	.4725	76.71	169.94
4.40	4.8885	1.1251	.4603	77.72	
4.60	5.1157	1.1467	.4483	78.63	
4.80	5.3471	1.1672	.4366	79.47	UNSTABLE
5.00	5.5825	1.1868	.4252	80.24	FOR BEAM
5.20	5.8218	1.2054	.4141	80.95	CENTER OF
5.40	6.0646	1.2232	.4034	81.60	MASS IN
5.60	6.3110	1.2402	.3930	82.19	PERIODIC
5.80	6.5606	1.2565	.3830	82.75	SYSTEM
6.00	6.8135	1.2721	.3734	83.26	
6.20	7.0694	1.2871	.3641	83.74	
6.40	7.3283	1.3015	.3552	84.18	
6.60	7.5900	1.3154	.3466	84.59	
6.80	7.8544	1.3288	.3384	84.97	
7.00	8.1215	1.3417	.3304	85.33	
7.20	8.3911	1.3542	.3228	85.67	
7.40	8.6632	1.3662	.3154	85.99	
7.60	8.9376	1.3779	.3083	86.28	
7.80	9.2143	1.3892	.3015	86.56	
8.00	9.4932	1.4001	.2950	86.82	
8.20	9.7743	1.4107	.2887	87.07	
8.40	10.0575	1.4210	.2826	87.30	
8.60	10.3427	1.4310	.2767	87.52	
8.80	10.6299	1.4407	.2711	87.73	
9.00	10.9190	1.4502	.2656	87.93	
9.20	11.2099	1.4593	.2604	88.12	
9.40	11.5027	1.4683	.2553	88.29	
9.60	11.7972	1.4770	.2504	88.46	
9.80	12.0935	1.4855	.2457	88.62	
10.00	12.3914	1.4938	.2411	88.78	

WO = 2.0

	T	W	DW/DT	K	MU(DEG)	MUO(DEG)	
	0.00	2.0000	0.0000				
	.20	2.0075	.0748	.0746	5.72	9.91	
	.40	2.0299	.1488	.1466	11.35	19.72	
	.60	2.0669	.2209	.2138	16.82	29.34	
	.80	2.1181	.2906	.2744	22.06	38.70	
	1.00	2.1829	.3573	.3274	27.02	47.73	
	1.20	2.2608	.4206	.3721	31.67	56.39	
	1.40	2.3509	.4803	.4086	35.98	64.67	
	1.60	2.4527	.5365	.4375	39.96	72.54	
	1.80	2.5653	.5890	.4592	43.61	80.02	
	2.00	2.6881	.6382	.4748	46.93	87.11	
	2.20	2.8203	.6841	.4851	49.96	93.86	
	2.40	2.9615	.7270	.4910	52.70	100.27	
	2.60	3.1110	.7671	.4932	55.19	106.39	
	2.80	3.2682	.8046	.4924	57.44	112.26	
	3.00	3.4327	.8398	.4893	59.49	117.90	
	3.20	3.6040	.8729	.4844	61.34	123.37	
**	3.2077	3.6107	.8741	.4842	61.41	123.58	**
	3.40	3.7817	.9039	.4781	63.02	128.71	
	3.60	3.9654	.9332	.4707	64.55	133.98	
	3.80	4.1549	.9608	.4625	65.94	139.25	
	4.00	4.3497	.9870	.4538	67.21	144.61	
	4.20	4.5495	1.0117	.4448	68.37	150.22	
	4.40	4.7543	1.0352	.4355	69.43	156.37	
	4.60	4.9636	1.0575	.4261	70.40	163.77	
	4.80	5.1772	1.0788	.4168	71.29		
	5.00	5.3950	1.0991	.4074	72.11		
	5.20	5.6168	1.1184	.3983	72.87	UNSTABLE	
	5.40	5.8423	1.1370	.3892	73.57	FOR BEAM	
	5.60	6.0715	1.1547	.3804	74.21	CENTER OF	
	5.80	6.3042	1.1717	.3717	74.81	MASS IN	
	6.00	6.5401	1.1880	.3633	75.37	PERIODIC	
	6.20	6.7793	1.2037	.3551	75.89	SYSTEM	
	6.40	7.0216	1.2188	.3472	76.37		
	6.60	7.2668	1.2334	.3395	76.82		
	6.80	7.5149	1.2474	.3320	77.24		
	7.00	7.7658	1.2610	.3247	77.63		
	7.20	8.0193	1.2740	.3177	78.00		
	7.40	8.2753	1.2867	.3110	78.34		
	7.60	8.5339	1.2989	.3044	78.67		
	7.80	8.7949	1.3108	.2981	78.97		
	8.00	9.0582	1.3222	.2919	79.26		
	8.20	9.3238	1.3334	.2860	79.53		
	8.40	9.5915	1.3442	.2803	79.79		
	8.60	9.8614	1.3547	.2747	80.03		
	8.80	10.1334	1.3649	.2694	80.26		
	9.00	10.4074	1.3748	.2642	80.48		
	9.20	10.6833	1.3845	.2592	80.68		
	9.40	10.9611	1.3939	.2543	80.88		
	9.60	11.2408	1.4030	.2496	81.07		
	9.80	11.5223	1.4120	.2451	81.24		
	10.00	11.8056	1.4207	.2407	81.41		

WO = 2.5

T	W	DW/DT	K	MU(DEG)	MUO(DEG)
0.00	2.5000	0.0000			
.20	2.5053	.0527	.0421	3.66	7.44
.40	2.5211	.1052	.0834	7.29	14.84
.60	2.5473	.1569	.1232	10.86	22.17
.80	2.5838	.2078	.1608	14.35	29.39
1.00	2.6303	.2575	.1958	17.72	36.46
1.20	2.6867	.3057	.2276	20.97	43.37
1.40	2.7525	.3525	.2561	24.07	50.10
1.60	2.8276	.3976	.2812	27.02	56.63
1.80	2.9114	.4409	.3029	29.80	62.95
2.00	3.0038	.4824	.3212	32.42	69.05
2.20	3.1043	.5222	.3365	34.88	74.94
2.40	3.2126	.5603	.3488	37.18	80.62
2.60	3.3283	.5966	.3585	39.32	86.10
2.80	3.4511	.6312	.3658	41.32	91.39
3.00	3.5807	.6643	.3710	43.18	96.49
3.20	3.7167	.6958	.3744	44.90	101.43
3.40	3.8589	.7259	.3762	46.50	106.21
3.60	4.0070	.7546	.3767	47.98	110.85
3.80	4.1607	.7821	.3759	49.35	115.37
4.00	4.3197	.8083	.3742	50.63	119.80
4.20	4.4839	.8333	.3717	51.81	124.14
4.40	4.6530	.8573	.3685	52.91	128.42
4.60	4.8268	.8803	.3648	53.93	132.68
** 4.5465	4.7798	.8743	.3658	53.67	131.55 **
4.80	5.0050	.9023	.3606	54.88	136.95
5.00	5.1876	.9235	.3560	55.76	141.28
5.20	5.3744	.9438	.3512	56.59	145.72
5.40	5.5651	.9633	.3462	57.35	150.39
5.60	5.7596	.9821	.3410	58.07	155.46
5.80	5.9579	1.0001	.3357	58.74	161.31
6.00	6.1597	1.0175	.3304	59.36	169.21
6.20	6.3648	1.0343	.3250	59.94	
6.40	6.5733	1.0505	.3196	60.49	
6.60	6.7850	1.0662	.3143	61.01	UNSTABLE
6.80	6.9998	1.0813	.3089	61.49	FOR BEAM
7.00	7.2175	1.0959	.3037	61.94	CENTER OF
7.20	7.4381	1.1101	.2985	62.37	MASS IN
7.40	7.6615	1.1238	.2934	62.77	PERIODIC
7.60	7.8876	1.1371	.2883	63.15	SYSTEM
7.80	8.1163	1.1500	.2834	63.51	
8.00	8.3475	1.1625	.2785	63.85	
8.20	8.5813	1.1746	.2738	64.17	
8.40	8.8174	1.1864	.2691	64.47	
8.60	9.0558	1.1979	.2646	64.76	
8.80	9.2965	1.2090	.2601	65.03	
9.00	9.5394	1.2199	.2558	65.29	
9.20	9.7844	1.2305	.2515	65.53	
9.40	10.0316	1.2408	.2474	65.77	
9.60	10.2807	1.2508	.2433	65.99	
9.80	10.5319	1.2606	.2394	66.20	
10.00	10.7849	1.2701	.2355	66.40	

WO = 3.0

	T	W	DW/DT	K	MU(DEG)	MUO(DEG)	
	0.00	3.0000	0.0000				
	.20	3.0041	.0407	.0271	2.54	5.97	
	.40	3.0163	.0813	.0539	5.07	11.92	
	.60	3.0366	.1216	.0801	7.58	17.83	
	.80	3.0649	.1614	.1053	10.04	23.69	
	1.00	3.1011	.2007	.1294	12.45	29.47	
	1.20	3.1451	.2393	.1521	14.80	35.17	
	1.40	3.1967	.2771	.1734	17.09	40.77	
	1.60	3.2559	.3140	.1929	19.29	46.26	
	1.80	3.3223	.3501	.2107	21.41	51.64	
	2.00	3.3958	.3851	.2268	23.44	56.88	
	2.20	3.4763	.4192	.2412	25.38	62.00	
	2.40	3.5634	.4522	.2538	27.23	66.99	
	2.60	3.6571	.4841	.2648	28.99	71.84	
	2.80	3.7570	.5151	.2742	30.66	76.57	
	3.00	3.8630	.5449	.2821	32.24	81.16	
	3.20	3.9749	.5738	.2887	33.73	85.63	
	3.40	4.0925	.6016	.2940	35.14	89.98	
	3.60	4.2155	.6285	.2982	36.47	94.21	
	3.80	4.3438	.6544	.3013	37.72	98.34	
	4.00	4.4772	.6794	.3035	38.90	102.36	
	4.20	4.6155	.7035	.3049	40.01	106.29	
	4.40	4.7586	.7268	.3055	41.05	110.13	
	4.60	4.9062	.7493	.3055	42.04	113.90	
	4.80	5.0582	.7710	.3048	42.96	117.60	
	5.00	5.2145	.7919	.3037	43.83	121.25	
	5.20	5.3750	.8122	.3022	44.65	124.85	
	5.40	5.5394	.8317	.3003	45.42	128.43	
	5.60	5.7076	.8506	.2981	46.14	132.01	
	5.80	5.8796	.8689	.2956	46.82	135.59	
	6.00	6.0551	.8866	.2929	47.47	139.21	
**	5.9273	5.9909	.8803	.2939	47.24	137.89	**
	6.20	6.2342	.9038	.2899	48.07	142.91	
	6.40	6.4166	.9204	.2869	48.65	146.72	
	6.60	6.6023	.9365	.2837	49.19	150.73	
	6.80	6.7912	.9521	.2804	49.70	155.04	
	7.00	6.9831	.9672	.2770	50.18	159.90	
	7.20	7.1780	.9819	.2736	50.64	165.88	
	7.40	7.3758	.9962	.2701	51.07	177.24	
	7.60	7.5765	1.0100	.2666	51.48		
	7.80	7.7798	1.0235	.2631	51.87		
	8.00	7.9858	1.0366	.2596	52.24	UNSTABLE	
	8.20	8.1944	1.0493	.2561	52.59	FOR BEAM	
	8.40	8.4055	1.0617	.2526	52.92	CENTER OF	
	8.60	8.6191	1.0738	.2492	53.24	MASS IN	
	8.80	8.8350	1.0855	.2457	53.54	PERIODIC	
	9.00	9.0533	1.0970	.2423	53.83	SYSTEM	
	9.20	9.2738	1.1082	.2390	54.10		
	9.40	9.4965	1.1191	.2357	54.36		
	9.60	9.7214	1.1297	.2324	54.61		
	9.80	9.9484	1.1401	.2292	54.85		
	10.00	10.1774	1.1502	.2260	55.07		

WO = 3.5

	T	W	DW/DT	K	MU(DEG)	MUO(DEG)	
	0.00	3.5000	0.0000				
	.20	3.5033	.0332	.0190	1.87	4.99	
	.40	3.5133	.0664	.0378	3.73	9.97	
	.60	3.5299	.0993	.0563	5.58	14.93	
	.80	3.5530	.1321	.0744	7.41	19.86	
	1.00	3.5827	.1645	.0918	9.21	24.75	
	1.20	3.6188	.1966	.1087	10.98	29.59	
	1.40	3.6613	.2282	.1247	12.71	34.36	
	1.60	3.7101	.2594	.1398	14.40	39.08	
	1.80	3.7650	.2899	.1540	16.04	43.72	
	2.00	3.8260	.3200	.1673	17.63	48.28	
	2.20	3.8929	.3494	.1795	19.17	52.76	
	2.40	3.9657	.3781	.1907	20.65	57.16	
	2.60	4.0441	.4062	.2009	22.08	61.46	
	2.80	4.1281	.4336	.2101	23.46	65.68	
	3.00	4.2175	.4603	.2183	24.77	69.81	
	3.20	4.3122	.4864	.2256	26.03	73.85	
	3.40	4.4120	.5117	.2320	27.24	77.80	
	3.60	4.5168	.5363	.2375	28.39	81.66	
	3.80	4.6265	.5603	.2422	29.48	85.44	
	4.00	4.7409	.5836	.2462	30.53	89.13	
	4.20	4.8599	.6063	.2495	31.52	92.74	
	4.40	4.9834	.6283	.2521	32.47	96.28	
	4.60	5.1112	.6496	.2542	33.37	99.75	
	4.80	5.2432	.6704	.2557	34.23	103.15	
	5.00	5.3793	.6906	.2567	35.04	106.48	
	5.20	5.5194	.7101	.2573	35.81	109.76	
	5.40	5.6633	.7292	.2575	36.54	112.99	
	5.60	5.8110	.7477	.2573	37.24	116.17	
	5.80	5.9623	.7656	.2568	37.90	119.31	
	6.00	6.1172	.7831	.2560	38.53	122.43	
	6.20	6.2756	.8001	.2550	39.13	125.51	
	6.40	6.4372	.8166	.2537	39.69	128.59	
	6.60	6.6022	.8327	.2522	40.23	131.67	
	6.80	6.7703	.8483	.2506	40.75	134.75	
	7.00	6.9415	.8635	.2488	41.23	137.86	
	7.20	7.1156	.8783	.2469	41.70	141.03	
	7.40	7.2928	.8927	.2448	42.14	144.26	
**	7.3191	7.2207	.8869	.2457	41.96	142.94	**
	7.60	7.4727	.9068	.2427	42.56	147.61	
	7.80	7.6554	.9204	.2405	42.96	151.12	
	8.00	7.8409	.9338	.2382	43.34	154.89	
	8.20	8.0289	.9468	.2358	43.71	159.05	
	8.40	8.2196	.9595	.2335	44.05	163.96	
	8.60	8.4127	.9718	.2310	44.39	170.74	
	8.80	8.6083	.9839	.2286	44.70		
	9.00	8.8062	.9957	.2261	45.00		
	9.20	9.0065	1.0072	.2237	45.29	UNSTABLE	
	9.40	9.2091	1.0185	.2212	45.57	FOR BEAM	
	9.60	9.4139	1.0295	.2187	45.83	CENTER OF	
	9.80	9.6209	1.0402	.2162	46.09	MASS IN	
	10.00	9.8300	1.0507	.2138	46.33	PERIODIC	

WO = 4.0

	T	W	DW/DT	K	MU(DEG)	MUO(DEG)	
	0.00	4.0000	0.0000				
	.25	4.0044	.0351	.0176	1.79	5.37	
	.50	4.0176	.0702	.0349	3.57	10.73	
	.75	4.0395	.1050	.0520	5.34	16.06	
	1.00	4.0701	.1396	.0686	7.08	21.35	
	1.25	4.1093	.1739	.0846	8.79	26.59	
	1.50	4.1570	.2077	.0999	10.47	31.77	
	1.75	4.2130	.2409	.1144	12.11	36.89	
	2.00	4.2774	.2737	.1280	13.70	41.92	
	2.25	4.3498	.3058	.1406	15.24	46.87	
	2.50	4.4302	.3372	.1522	16.72	51.73	
	2.75	4.5184	.3679	.1629	18.16	56.49	
	3.00	4.6141	.3979	.1725	19.53	61.15	
	3.25	4.7173	.4272	.1811	20.85	65.71	
	3.50	4.8276	.4557	.1888	22.11	70.17	
	3.75	4.9450	.4834	.1955	23.31	74.53	
	4.00	5.0693	.5104	.2014	24.45	78.78	
	4.25	5.2002	.5366	.2064	25.54	82.94	
	4.50	5.3375	.5620	.2106	26.57	87.00	
	4.75	5.4811	.5867	.2141	27.55	90.97	
	5.00	5.6308	.6107	.2169	28.48	94.85	
	5.25	5.7864	.6339	.2191	29.36	98.64	
	5.50	5.9477	.6565	.2207	30.19	102.36	
	5.75	6.1146	.6783	.2219	30.98	106.01	
	6.00	6.2868	.6995	.2225	31.72	109.59	
	6.25	6.4643	.7201	.2228	32.43	113.11	
	6.50	6.6468	.7401	.2227	33.09	116.58	
	6.75	6.8343	.7594	.2222	33.72	120.01	
	7.00	7.0265	.7782	.2215	34.32	123.41	
	7.25	7.2234	.7965	.2205	34.88	126.78	
	7.50	7.4247	.8142	.2193	35.42	130.16	
	7.75	7.6304	.8314	.2179	35.92	133.53	
	8.00	7.8403	.8481	.2163	36.40	136.94	
	8.25	8.0544	.8643	.2146	36.86	140.41	
	8.50	8.2724	.8801	.2128	37.29	143.96	
	8.75	8.4944	.8954	.2108	37.69	147.64	
**	8.7076	8.4564	.8928	.2112	37.63	147.00	**
	9.00	8.7201	.9103	.2088	38.08	151.53	
	9.25	8.9495	.9248	.2067	38.45	155.75	
	9.50	9.1825	.9390	.2045	38.80	160.54	
	9.75	9.4190	.9527	.2023	39.13	166.50	
	10.00	9.6588	.9661	.2000	39.44		
	10.25	9.9020	.9792	.1978	39.74		
	10.50	10.1484	.9919	.1955	40.03	UNSTABLE	
	10.75	10.3979	1.0043	.1932	40.30	FOR BEAM	
	11.00	10.6505	1.0164	.1909	40.56	CENTER OF	
	11.25	10.9061	1.0282	.1885	40.81	MASS IN	
	11.50	11.1645	1.0397	.1862	41.04	PERIODIC	
	11.75	11.4259	1.0509	.1840	41.26	SYSTEM	
	12.00	11.6900	1.0619	.1817	41.48		
	12.25	11.9568	1.0726	.1794	41.68		
	12.50	12.2263	1.0831	.1772	41.88		
	12.75	12.4983	1.0933	.1750	42.07		
	13.00	12.7729	1.1034	.1728	42.25		

WO = 4.5

T	W	DW/DT	K	MU(DEG)	MUO(DEG)	
0.00	4.5000	0.0000				
.25	4.5038	.0305	.0135	1.41	4.72	
.50	4.5153	.0610	.0270	2.82	9.43	
.75	4.5343	.0913	.0403	4.22	14.12	
1.00	4.5609	.1214	.0533	5.61	18.78	
1.25	4.5950	.1514	.0659	6.98	23.41	
1.50	4.6365	.1810	.0781	8.32	28.01	
1.75	4.6855	.2103	.0898	9.64	32.55	
2.00	4.7416	.2392	.1009	10.93	37.04	
2.25	4.8050	.2677	.1114	12.19	41.47	
2.50	4.8754	.2957	.1213	13.41	45.83	
2.75	4.9528	.3233	.1305	14.60	50.13	
3.00	5.0370	.3503	.1391	15.75	54.36	
3.25	5.1279	.3768	.1470	16.86	58.51	
3.50	5.2254	.4028	.1542	17.92	62.58	
3.75	5.3293	.4281	.1607	18.95	66.58	
4.00	5.4394	.4530	.1665	19.94	70.50	
4.25	5.5557	.4772	.1718	20.89	74.34	
4.50	5.6780	.5009	.1764	21.80	78.11	
4.75	5.8061	.5240	.1805	22.67	81.80	
5.00	5.9399	.5465	.1840	23.50	85.41	
5.25	6.0793	.5684	.1870	24.29	88.96	
5.50	6.2241	.5898	.1895	25.05	92.43	
5.75	6.3742	.6107	.1916	25.77	95.84	
6.00	6.5294	.6310	.1933	26.46	99.19	
6.25	6.6896	.6508	.1946	27.12	102.48	
6.50	6.8547	.6700	.1955	27.74	105.71	
6.75	7.0246	.6888	.1961	28.34	108.89	
7.00	7.1991	.7071	.1964	28.90	112.03	
7.25	7.3781	.7249	.1965	29.44	115.12	
7.50	7.5615	.7422	.1963	29.95	118.19	
7.75	7.7492	.7591	.1959	30.44	121.22	
8.00	7.9410	.7756	.1953	30.91	124.24	
8.25	8.1369	.7916	.1946	31.35	127.24	
8.50	8.3368	.8072	.1937	31.78	130.24	
8.75	8.5405	.8224	.1926	32.18	133.25	
9.00	8.7480	.8373	.1914	32.56	136.29	
9.25	8.9591	.8518	.1901	32.93	139.36	
9.50	9.1738	.8659	.1888	33.28	142.50	
9.75	9.3920	.8797	.1873	33.61	145.73	
10.00	9.6136	.8931	.1858	33.92	149.10	
10.25	9.8386	.9062	.1842	34.23	152.66	
** 10.0871	9.6916	.8977	.1853	34.03	150.31	**
10.50	10.0667	.9191	.1826	34.52	156.53	
10.75	10.2981	.9316	.1809	34.79	160.89	
11.00	10.5325	.9438	.1792	35.06	166.26	
11.25	10.7699	.9557	.1775	35.31	175.33	
11.50	11.0103	.9674	.1757	35.55		
11.75	11.2536	.9788	.1740	35.78		
12.00	11.4997	.9900	.1722	36.00	UNSTABLE	
12.25	11.7486	1.0009	.1704	36.22	FOR BEAM	
12.50	12.0002	1.0116	.1686	36.42	CENTER OF	
12.75	12.2544	1.0220	.1668	36.61	MASS IN	
13.00	12.5112	1.0322	.1650	36.80	PERIODIC	

WO = 5.0

T	W	DW/DT	K	MU(DEG)	MUO(DEG)
0.00	5.0000	0.0000			
.50	5.0135	.0539	.0215	2.29	8.41
1.00	5.0539	.1076	.0426	4.55	16.78
1.50	5.1209	.1605	.0627	6.77	25.05
2.00	5.2143	.2126	.0815	8.91	33.18
2.50	5.3333	.2634	.0988	10.98	41.14
3.00	5.4774	.3128	.1142	12.94	48.90
3.50	5.6459	.3607	.1278	14.79	56.44
4.00	5.8378	.4069	.1394	16.53	63.74
4.50	6.0525	.4514	.1492	18.16	70.80
5.00	6.2889	.4940	.1571	19.66	77.62
5.50	6.5462	.5349	.1634	21.05	84.19
6.00	6.8235	.5740	.1682	22.34	90.54
6.50	7.1199	.6113	.1717	23.52	96.67
7.00	7.4346	.6470	.1741	24.60	102.61
7.50	7.7667	.6810	.1754	25.59	108.38
8.00	8.1154	.7135	.1758	26.50	114.00
8.50	8.4799	.7446	.1756	27.33	119.51
9.00	8.8597	.7742	.1748	28.10	124.95
9.50	9.2539	.8025	.1734	28.80	130.36
10.00	9.6619	.8295	.1717	29.44	135.81
10.50	10.0832	.8553	.1697	30.03	141.39
11.00	10.5171	.8801	.1674	30.57	147.24
11.50	10.9631	.9038	.1649	31.06	153.64
** 11.4561	10.9234	.9017	.1651	31.02	153.05 **
12.00	11.4207	.9265	.1622	31.52	161.25
12.50	11.8894	.9482	.1595	31.94	173.64
13.00	12.3687	.9691	.1567	32.33	
13.50	12.8584	.9892	.1539	32.69	
14.00	13.3578	1.0085	.1510	33.03	UNSTABLE
14.50	13.8667	1.0271	.1481	33.34	FOR BEAM
15.00	14.3848	1.0449	.1453	33.62	CENTER OF
15.50	14.9116	1.0622	.1425	33.89	MASS IN
16.00	15.4468	1.0788	.1397	34.14	PERIODIC
16.50	15.9902	1.0948	.1369	34.37	SYSTEM
17.00	16.5415	1.1103	.1342	34.59	
17.50	17.1005	1.1253	.1316	34.79	
18.00	17.6667	1.1398	.1290	34.98	
18.50	18.2401	1.1538	.1265	35.16	
19.00	18.8204	1.1673	.1241	35.32	
19.50	19.4074	1.1805	.1217	35.48	
20.00	20.0009	1.1932	.1193	35.63	
20.50	20.6006	1.2056	.1170	35.77	
21.00	21.2064	1.2176	.1148	35.90	
21.50	21.8182	1.2293	.1127	36.02	
22.00	22.4357	1.2407	.1106	36.14	
22.50	23.0588	1.2517	.1086	36.25	
23.00	23.6873	1.2624	.1066	36.36	
23.50	24.3212	1.2729	.1047	36.46	
24.00	24.9602	1.2831	.1028	36.55	
24.50	25.6042	1.2930	.1010	36.64	
25.00	26.2531	1.3026	.0992	36.72	
25.50	26.9068	1.3121	.0975	36.81	
26.00	27.5651	1.3213	.0959	36.88	

WO = 6.0

T	W	DW/DT	K	MU(DEG)	MU0(DEG)
0.00	6.0000	0.0000			
.50	6.0110	.0440	.0146	1.59	6.93
1.00	6.0439	.0877	.0290	3.17	13.84
1.50	6.0987	.1312	.0430	4.72	20.69
2.00	6.1750	.1741	.0564	6.25	27.47
2.50	6.2726	.2163	.0690	7.73	34.15
3.00	6.3912	.2578	.0807	9.16	40.71
3.50	6.5303	.2984	.0914	10.53	47.14
4.00	6.6894	.3379	.1010	11.84	53.43
4.50	6.8680	.3764	.1096	13.09	59.55
5.00	7.0656	.4138	.1171	14.27	65.52
5.50	7.2816	.4500	.1236	15.38	71.33
6.00	7.5154	.4850	.1291	16.43	76.97
6.50	7.7665	.5189	.1336	17.41	82.45
7.00	8.0341	.5516	.1373	18.33	87.77
7.50	8.3178	.5831	.1402	19.19	92.95
8.00	8.6170	.6134	.1424	19.99	97.99
8.50	8.9311	.6427	.1439	20.73	102.90
9.00	9.2595	.6708	.1449	21.43	107.70
9.50	9.6017	.6979	.1454	22.07	112.40
10.00	9.9572	.7240	.1454	22.67	117.02
10.50	10.3256	.7492	.1451	23.23	121.58
11.00	10.7063	.7734	.1445	23.75	126.10
11.50	11.0988	.7967	.1436	24.23	130.62
12.00	11.5028	.8192	.1424	24.68	135.17
12.50	11.9179	.8408	.1411	25.10	139.80
13.00	12.3435	.8617	.1396	25.49	144.60
13.50	12.7795	.8819	.1380	25.85	149.68
14.00	13.2253	.9014	.1363	26.19	155.27
14.50	13.6807	.9201	.1345	26.50	161.90
** 14.1636	13.3732	.9076	.1357	26.29	157.28 **
15.00	14.1454	.9383	.1327	26.80	171.88
15.50	14.6189	.9559	.1308	27.08	
16.00	15.1011	.9728	.1288	27.34	
16.50	15.5917	.9893	.1269	27.58	UNSTABLE
17.00	16.0903	1.0052	.1249	27.81	FOR BEAM
17.50	16.5967	1.0206	.1230	28.02	CENTER CF
18.00	17.1108	1.0355	.1210	28.23	MASS IN
18.50	17.6322	1.0500	.1191	28.42	PERIODIC
19.00	18.1607	1.0641	.1172	28.59	SYSTEM
19.50	18.6962	1.0777	.1153	28.76	
20.00	19.2384	1.0910	.1134	28.92	
20.50	19.7871	1.1039	.1116	29.07	
21.00	20.3422	1.1164	.1098	29.22	
21.50	20.9034	1.1286	.1080	29.35	
22.00	21.4707	1.1404	.1062	29.48	
22.50	22.0438	1.1520	.1045	29.60	
23.00	22.6226	1.1632	.1028	29.71	
23.50	23.2069	1.1741	.1012	29.82	
24.00	23.7967	1.1848	.0996	29.93	
24.50	24.3917	1.1952	.0980	30.03	
25.00	24.9919	1.2054	.0965	30.12	
25.50	25.5971	1.2153	.0950	30.21	
26.00	26.2071	1.2250	.0935	30.29	

WO = 7.0

T	W	DW/DT	K	MU(DEG)	MUO(DEG)
0.00	7.0000	0.0000			
.50	7.0093	.0372	.0106	1.17	5.90
1.00	7.0371	.0742	.0211	2.33	11.79
1.50	7.0835	.1110	.0314	3.48	17.64
2.00	7.1481	.1476	.0413	4.61	23.45
2.50	7.2310	.1837	.0508	5.72	29.19
3.00	7.3317	.2193	.0598	6.80	34.86
3.50	7.4502	.2544	.0683	7.85	40.45
4.00	7.5860	.2888	.0762	8.87	45.94
4.50	7.7389	.3226	.0834	9.84	51.33
5.00	7.9085	.3556	.0899	10.78	56.61
5.50	8.0944	.3878	.0958	11.67	61.77
6.00	8.2962	.4192	.1011	12.53	66.82
6.50	8.5135	.4498	.1057	13.34	71.75
7.00	8.7459	.4796	.1097	14.11	76.57
7.50	8.9930	.5085	.1131	14.84	81.27
8.00	9.2543	.5366	.1160	15.53	85.85
8.50	9.5294	.5638	.1183	16.18	90.33
9.00	9.8179	.5902	.1202	16.79	94.71
9.50	10.1195	.6158	.1217	17.37	98.99
10.00	10.4336	.6406	.1228	17.91	103.17
10.50	10.7599	.6646	.1235	18.42	107.28
11.00	11.0980	.6879	.1240	18.90	111.32
11.50	11.4476	.7104	.1241	19.35	115.29
12.00	11.8083	.7322	.1240	19.77	119.22
12.50	12.1797	.7533	.1237	20.17	123.11
13.00	12.5616	.7738	.1232	20.55	126.99
13.50	12.9534	.7937	.1225	20.90	130.87
14.00	13.3551	.8129	.1217	21.23	134.77
14.50	13.7662	.8315	.1208	21.54	138.74
15.00	14.1865	.8496	.1198	21.83	142.81
15.50	14.6158	.8671	.1187	22.11	147.05
16.00	15.0536	.8841	.1175	22.37	151.58
16.50	15.4998	.9006	.1162	22.62	156.57
17.00	15.9542	.9167	.1149	22.85	162.46
** 16.8370	15.8051	.9115	.1153	22.77	160.40 **
17.50	16.4164	.9322	.1136	23.07	170.95
18.00	16.8863	.9474	.1122	23.27	
18.50	17.3637	.9621	.1108	23.47	
19.00	17.8483	.9764	.1094	23.65	UNSTABLE
19.50	18.3400	.9903	.1080	23.83	FOR BEAM
20.00	18.8385	1.0038	.1066	24.00	CENTER OF
20.50	19.3437	1.0170	.1051	24.15	MASS IN
21.00	19.8554	1.0298	.1037	24.30	PERIODIC
21.50	20.3734	1.0423	.1023	24.44	SYSTEM
22.00	20.8976	1.0544	.1009	24.58	
22.50	21.4278	1.0663	.0995	24.71	
23.00	21.9639	1.0779	.0982	24.83	
23.50	22.5056	1.0892	.0968	24.94	
24.00	23.0530	1.1002	.0954	25.05	
24.50	23.6058	1.1109	.0941	25.16	
25.00	24.1639	1.1214	.0928	25.26	
25.50	24.7272	1.1317	.0915	25.36	
26.00	25.2956	1.1417	.0903	25.45	

WO = 8.0

T	W	DW/DT	K	MU(DEG)	MUO(DEG)
0.00	8.0000	0.0000			
.50	8.0081	.0322	.0080	.89	5.14
1.00	8.0322	.0644	.0160	1.79	10.27
1.50	8.0724	.0964	.0239	2.67	15.38
2.00	8.1285	.1282	.0315	3.54	20.46
2.50	8.2005	.1597	.0390	4.40	25.50
3.00	8.2882	.1909	.0461	5.25	30.48
3.50	8.3914	.2218	.0529	6.07	35.41
4.00	8.5099	.2522	.0593	6.87	40.28
4.50	8.6435	.2822	.0653	7.65	45.07
5.00	8.7920	.3116	.0709	8.41	49.79
5.50	8.9550	.3405	.0760	9.13	54.43
6.00	9.1324	.3688	.0808	9.83	58.98
6.50	9.3238	.3965	.0851	10.51	63.44
7.00	9.5288	.4237	.0889	11.15	67.82
7.50	9.7473	.4502	.0924	11.77	72.11
8.00	9.9789	.4760	.0954	12.36	76.31
8.50	10.2233	.5013	.0981	12.92	80.42
9.00	10.4801	.5259	.1004	13.46	84.45
9.50	10.7490	.5499	.1023	13.96	88.39
10.00	11.0298	.5732	.1039	14.45	92.26
10.50	11.3221	.5959	.1053	14.91	96.05
11.00	11.6257	.6181	.1063	15.34	99.76
11.50	11.9401	.6396	.1071	15.75	103.42
12.00	12.2652	.6605	.1077	16.15	107.01
12.50	12.6005	.6809	.1081	16.52	110.54
13.00	12.9460	.7007	.1083	16.87	114.03
13.50	13.3012	.7200	.1083	17.20	117.48
14.00	13.6659	.7387	.1081	17.52	120.90
14.50	14.0398	.7570	.1078	17.81	124.30
15.00	14.4227	.7747	.1074	18.10	127.69
15.50	14.8144	.7920	.1069	18.37	131.09
16.00	15.2146	.8088	.1063	18.62	134.51
16.50	15.6231	.8251	.1056	18.86	137.98
17.00	16.0397	.8410	.1049	19.09	141.52
17.50	16.4641	.8565	.1041	19.31	145.17
18.00	16.8962	.8716	.1032	19.51	149.00
18.50	17.3357	.8864	.1023	19.71	153.10
19.00	17.7825	.9007	.1013	19.89	157.62
19.50	18.2363	.9147	.1003	20.07	162.95
** 19.4843	18.2219	.9142	.1003	20.07	162.77 **
20.00	18.6971	.9283	.0993	20.24	170.37
20.50	19.1645	.9416	.0983	20.40	
21.00	19.6386	.9545	.0972	20.55	
21.50	20.1190	.9671	.0961	20.70	UNSTABLE
22.00	20.6057	.9795	.0951	20.83	FOR BEAM
22.50	21.0984	.9915	.0940	20.97	CENTER OF
23.00	21.5972	1.0033	.0929	21.09	MASS IN
23.50	22.1017	1.0148	.0918	21.21	PERIODIC
24.00	22.6119	1.0260	.0907	21.33	SYSTEM
24.50	23.1277	1.0370	.0897	21.44	
25.00	23.6488	1.0477	.0886	21.54	
25.50	24.1753	1.0582	.0875	21.64	
26.00	24.7070	1.0685	.0865	21.74	

WO = 9.0

T	W	DW/DT	K	MU(DEG)	MUO(DEG)
0.00	9.0000	0.0000			
.50	9.0071	.0285	.0063	.71	4.56
1.00	9.0284	.0569	.0126	1.41	9.10
1.50	9.0640	.0852	.0188	2.11	13.64
2.00	9.1136	.1134	.0249	2.81	18.15
2.50	9.1773	.1413	.0308	3.49	22.63
3.00	9.2549	.1691	.0365	4.17	27.08
3.50	9.3464	.1966	.0421	4.83	31.49
4.00	9.4515	.2238	.0474	5.48	35.85
4.50	9.5701	.2507	.0524	6.11	40.16
5.00	9.7021	.2772	.0571	6.73	44.42
5.50	9.8473	.3033	.0616	7.33	48.61
6.00	10.0054	.3290	.0658	7.91	52.74
6.50	10.1762	.3543	.0696	8.47	56.81
7.00	10.3596	.3791	.0732	9.02	60.81
7.50	10.5552	.4034	.0764	9.54	64.74
8.00	10.7630	.4273	.0794	10.04	68.61
8.50	10.9825	.4507	.0821	10.53	72.40
9.00	11.2136	.4736	.0845	10.99	76.13
9.50	11.4560	.4960	.0866	11.44	79.78
10.00	11.7095	.5179	.0885	11.87	83.37
10.50	11.9738	.5393	.0901	12.28	86.90
11.00	12.2487	.5602	.0915	12.67	90.36
11.50	12.5340	.5807	.0927	13.04	93.76
12.00	12.8293	.6007	.0936	13.40	97.10
12.50	13.1346	.6201	.0944	13.74	100.39
13.00	13.4494	.6392	.0950	14.06	103.63
13.50	13.7736	.6577	.0955	14.37	106.82
14.00	14.1071	.6758	.0958	14.67	109.96
14.50	14.4494	.6935	.0960	14.95	113.07
15.00	14.8005	.7108	.0960	15.21	116.15
15.50	15.1601	.7276	.0960	15.47	119.20
16.00	15.5281	.7441	.0958	15.71	122.23
16.50	15.9041	.7601	.0956	15.95	125.25
17.00	16.2881	.7757	.0953	16.17	128.27
17.50	16.6798	.7910	.0948	16.38	131.29
18.00	17.0791	.8059	.0944	16.58	134.33
18.50	17.4857	.8205	.0938	16.77	137.41
19.00	17.8995	.8347	.0933	16.95	140.54
19.50	18.3204	.8486	.0926	17.13	143.76
20.00	18.7481	.8622	.0920	17.30	147.09
20.50	19.1825	.8754	.0913	17.45	150.59
21.00	19.6235	.8884	.0905	17.61	154.35
21.50	20.0709	.9011	.0898	17.75	158.50
22.00	20.5245	.9134	.0890	17.89	163.38
22.50	20.9843	.9255	.0882	18.02	169.99
** 22.1118	20.6268	.9162	.0888	17.92	164.63 **
23.00	21.4500	.9374	.0874	18.15	
23.50	21.9216	.9490	.0866	18.27	
24.00	22.3989	.9603	.0857	18.39	UNSTABLE
24.50	22.8818	.9714	.0849	18.50	FOR BEAM
25.00	23.3702	.9822	.0841	18.61	CENTER CF
25.50	23.8640	.9928	.0832	18.71	MASS IN
26.00	24.3630	1.0032	.0824	18.81	PERIODIC

WO = 10.0

T	W	DW/DT	K	MU(DEG)	MUO(DEG)
0.00	10.0000	0.0000			
.50	10.0064	.0255	.0051	.57	4.09
1.00	10.0255	.0510	.0102	1.14	8.18
1.50	10.0573	.0763	.0152	1.71	12.25
2.00	10.1018	.1016	.0201	2.28	16.31
2.50	10.1589	.1268	.0250	2.83	20.35
3.00	10.2286	.1518	.0297	3.39	24.36
3.50	10.3107	.1766	.0343	3.93	28.35
4.00	10.4052	.2012	.0387	4.46	32.30
4.50	10.5119	.2255	.0429	4.99	36.21
5.00	10.6307	.2496	.0470	5.50	40.08
5.50	10.7614	.2734	.0508	6.00	43.90
6.00	10.9040	.2969	.0545	6.49	47.68
6.50	11.0583	.3200	.0579	6.97	51.41
7.00	11.2240	.3428	.0611	7.43	55.08
7.50	11.4010	.3653	.0641	7.87	58.71
8.00	11.5892	.3874	.0668	8.31	62.28
8.50	11.7883	.4091	.0694	8.73	65.79
9.00	11.9982	.4304	.0717	9.13	69.25
9.50	12.2186	.4513	.0739	9.52	72.65
10.00	12.4494	.4718	.0758	9.90	76.00
10.50	12.6904	.4920	.0775	10.26	79.29
11.00	12.9414	.5117	.0791	10.61	82.53
11.50	13.2021	.5311	.0805	10.95	85.71
12.00	13.4724	.5500	.0817	11.27	88.85
12.50	13.7521	.5686	.0827	11.58	91.93
13.00	14.0409	.5868	.0836	11.88	94.97
13.50	14.3388	.6046	.0843	12.16	97.96
14.00	14.6454	.6220	.0849	12.43	100.90
14.50	14.9607	.6390	.0854	12.69	103.81
15.00	15.2844	.6557	.0858	12.95	106.68
15.50	15.6164	.6720	.0861	13.19	109.52
16.00	15.9564	.6880	.0862	13.42	112.32
16.50	16.3043	.7036	.0863	13.64	115.10
17.00	16.6600	.7189	.0863	13.85	117.85
17.50	17.0232	.7339	.0862	14.05	120.59
18.00	17.3938	.7485	.0861	14.24	123.31
18.50	17.7716	.7628	.0858	14.43	126.02
19.00	18.1565	.7768	.0856	14.61	128.74
19.50	18.5483	.7905	.0852	14.78	131.46
20.00	18.9470	.8039	.0849	14.94	134.20
20.50	19.3522	.8170	.0844	15.09	136.97
21.00	19.7640	.8299	.0840	15.24	139.78
21.50	20.1821	.8425	.0835	15.39	142.65
22.00	20.6064	.8548	.0830	15.53	145.61
22.50	21.0368	.8668	.0824	15.66	148.68
23.00	21.4732	.8787	.0818	15.78	151.92
23.50	21.9154	.8902	.0812	15.91	155.40
24.00	22.3634	.9016	.0806	16.02	159.25
24.50	22.8170	.9127	.0800	16.14	163.74
25.00	23.2760	.9236	.0794	16.24	169.73
** 24.7245	23.0224	.9176	.0797	16.18	166.14 **
25.50	23.7405	.9343	.0787	16.35	
26.00	24.2103	.9447	.0780	16.45	

TABLE II

Tabulation of envelope curves at lower boundary points. The W values are minimum for corresponding path lengths t.

WO	T	W	DW/DT	K	MU(DEG)	MUO(DEG)
.1	.0100	.1416	7.1034	100.3275	89.9	90.2
.2	.0399	.2841	3.6002	25.3397	89.5	90.6
.3	.0895	.4285	2.4538	11.4516	88.9	91.4
.4	.1584	.5756	1.8962	6.5888	88.1	92.5
.5	.2462	.7262	1.5739	4.3330	87.1	93.8
.6	.3522	.8811	1.3689	3.1077	85.8	95.4
.7	.4756	1.0407	1.2305	2.3647	84.5	97.2
.8	.6155	1.2057	1.1335	1.8803	82.9	99.1
.9	.7711	1.3762	1.0636	1.5467	81.3	101.1
1.0	.9412	1.5525	1.0124	1.3044	79.6	103.2
1.1	1.1248	1.7347	.9745	1.1235	77.8	105.3
1.2	1.3208	1.9228	.9463	.9844	76.0	107.5
1.3	1.5281	2.1166	.9252	.8743	74.1	109.6
1.4	1.7455	2.3159	.9094	.7854	72.2	111.8
1.5	1.9720	2.5205	.8978	.7124	70.3	113.9
1.6	2.2066	2.7301	.8893	.6515	68.5	115.9
1.7	2.4484	2.9443	.8831	.5999	66.7	118.0
1.8	2.6963	3.1627	.8788	.5557	64.9	119.9
1.9	2.9497	3.3849	.8759	.5176	63.1	121.8
2.0	3.2077	3.6107	.8741	.4842	61.4	123.6
2.1	3.4697	3.8395	.8731	.4548	59.8	125.3
2.2	3.7351	4.0712	.8728	.4288	58.2	127.0
2.3	4.0033	4.3053	.8729	.4055	56.6	128.6
2.4	4.2739	4.5416	.8735	.3847	55.1	130.1
2.5	4.5465	4.7798	.8743	.3658	53.7	131.6
2.6	4.8206	5.0196	.8753	.3487	52.3	132.9
2.7	5.0960	5.2608	.8764	.3332	50.9	134.3
2.8	5.3724	5.5032	.8776	.3190	49.7	135.5
2.9	5.6496	5.7466	.8789	.3059	48.4	136.7
3.0	5.9273	5.9909	.8803	.2939	47.2	137.9
3.1	6.2054	6.2359	.8816	.2828	46.1	139.0
3.2	6.4838	6.4815	.8830	.2725	45.0	140.0
3.3	6.7622	6.7276	.8843	.2629	43.9	141.1
3.4	7.0407	6.9740	.8856	.2540	42.9	142.0
3.5	7.3191	7.2207	.8869	.2457	42.0	142.9
3.6	7.5973	7.4677	.8882	.2379	41.0	143.8
3.7	7.8753	7.7148	.8894	.2306	40.1	144.7
3.8	8.1530	7.9620	.8906	.2237	39.3	145.5
3.9	8.4305	8.2092	.8917	.2173	38.4	146.3
4.0	8.7076	8.4564	.8928	.2112	37.6	147.0
4.1	8.9843	8.7036	.8939	.2054	36.9	147.7
4.2	9.2606	8.9508	.8949	.2000	36.1	148.4
4.3	9.5365	9.1978	.8959	.1948	35.4	149.1
4.4	9.8120	9.4448	.8968	.1899	34.7	149.7
4.5	10.0871	9.6916	.8977	.1853	34.0	150.3
4.6	10.3618	9.9383	.8986	.1808	33.4	150.9
4.7	10.6360	10.1848	.8994	.1766	32.8	151.5
4.8	10.9098	10.4312	.9002	.1726	32.2	152.0
4.9	11.1831	10.6774	.9010	.1688	31.6	152.5
5.0	11.4561	10.9234	.9017	.1651	31.0	153.0
5.1	11.7286	11.1692	.9024	.1616	30.5	153.5
5.2	12.0007	11.4149	.9031	.1582	30.0	154.0
5.3	12.2724	11.6604	.9037	.1550	29.4	154.5
5.4	12.5437	11.9056	.9044	.1519	29.0	154.9
5.5	12.8146	12.1507	.9049	.1490	28.5	155.3

WO	T	W	DW/DT	K	MU(DEG)	MUO(DEG)
5.6	13.0851	12.3956	.9055	.1461	28.0	155.8
5.7	13.3553	12.6403	.9061	.1434	27.6	156.2
5.8	13.6251	12.8848	.9066	.1407	27.1	156.5
5.9	13.8945	13.1291	.9071	.1382	26.7	156.9
6.0	14.1636	13.3733	.9076	.1357	26.3	157.3
6.1	14.4323	13.6172	.9080	.1334	25.9	157.6
6.2	14.7007	13.8610	.9085	.1311	25.5	158.0
6.3	14.9688	14.1046	.9089	.1289	25.1	158.3
6.4	15.2365	14.3480	.9093	.1268	24.8	158.6
6.5	15.5040	14.5913	.9097	.1247	24.4	158.9
6.6	15.7712	14.8344	.9101	.1227	24.1	159.3
6.7	16.0380	15.0773	.9105	.1208	23.7	159.5
6.8	16.3046	15.3201	.9108	.1189	23.4	159.8
6.9	16.5709	15.5627	.9112	.1171	23.1	160.1
7.0	16.8370	15.8051	.9115	.1153	22.8	160.4
7.1	17.1027	16.0474	.9118	.1136	22.5	160.7
7.2	17.3683	16.2896	.9121	.1120	22.2	160.9
7.3	17.6336	16.5316	.9124	.1104	21.9	161.2
7.4	17.8986	16.7735	.9127	.1088	21.6	161.4
7.5	18.1634	17.0152	.9130	.1073	21.3	161.7
7.6	18.4280	17.2568	.9132	.1058	21.1	161.9
7.7	18.6924	17.4983	.9135	.1044	20.8	162.1
7.8	18.9565	17.7396	.9137	.1030	20.6	162.3
7.9	19.2205	17.9808	.9140	.1017	20.3	162.6
8.0	19.4842	18.2219	.9142	.1003	20.1	162.8
8.1	19.7478	18.4629	.9144	.0991	19.8	163.0
8.2	20.0112	18.7038	.9147	.0978	19.6	163.2
8.3	20.2743	18.9445	.9149	.0966	19.4	163.4
8.4	20.5373	19.1851	.9151	.0954	19.2	163.6
8.5	20.8002	19.4257	.9153	.0942	18.9	163.8
8.6	21.0628	19.6661	.9155	.0931	18.7	163.9
8.7	21.3253	19.9064	.9156	.0920	18.5	164.1
8.8	21.5876	20.1467	.9158	.0909	18.3	164.3
8.9	21.8498	20.3868	.9160	.0899	18.1	164.5
9.0	22.1118	20.6268	.9162	.0888	17.9	164.6
9.1	22.3737	20.8667	.9163	.0878	17.7	164.8
9.2	22.6354	21.1066	.9165	.0868	17.5	165.0
9.3	22.8970	21.3464	.9166	.0859	17.4	165.1
9.4	23.1585	21.5860	.9168	.0849	17.2	165.3
9.5	23.4198	21.8256	.9169	.0840	17.0	165.4
9.6	23.6810	22.0651	.9171	.0831	16.8	165.6
9.7	23.9420	22.3046	.9172	.0822	16.7	165.7
9.8	24.2030	22.5439	.9173	.0814	16.5	165.9
9.9	24.4638	22.7832	.9175	.0805	16.3	166.0
10.0	24.7245	23.0224	.9176	.0797	16.2	166.1
10.1	24.9850	23.2615	.9177	.0789	16.0	166.3
10.2	25.2455	23.5006	.9178	.0781	15.9	166.4
10.3	25.5059	23.7395	.9180	.0773	15.7	166.5
10.4	25.7661	23.9785	.9181	.0766	15.6	166.7
10.5	26.0263	24.2173	.9182	.0758	15.4	166.8
10.6	26.2863	24.4561	.9183	.0751	15.3	166.9
10.7	26.5463	24.6948	.9184	.0744	15.2	167.0
10.8	26.8061	24.9335	.9185	.0737	15.0	167.1
10.9	27.0659	25.1721	.9186	.0730	14.9	167.3
11.0	27.3256	25.4106	.9187	.0723	14.8	167.4

8. Acknowledgments

It is a pleasure to thank Mrs. Ardith S. Kenney for carrying out the numerical computations.

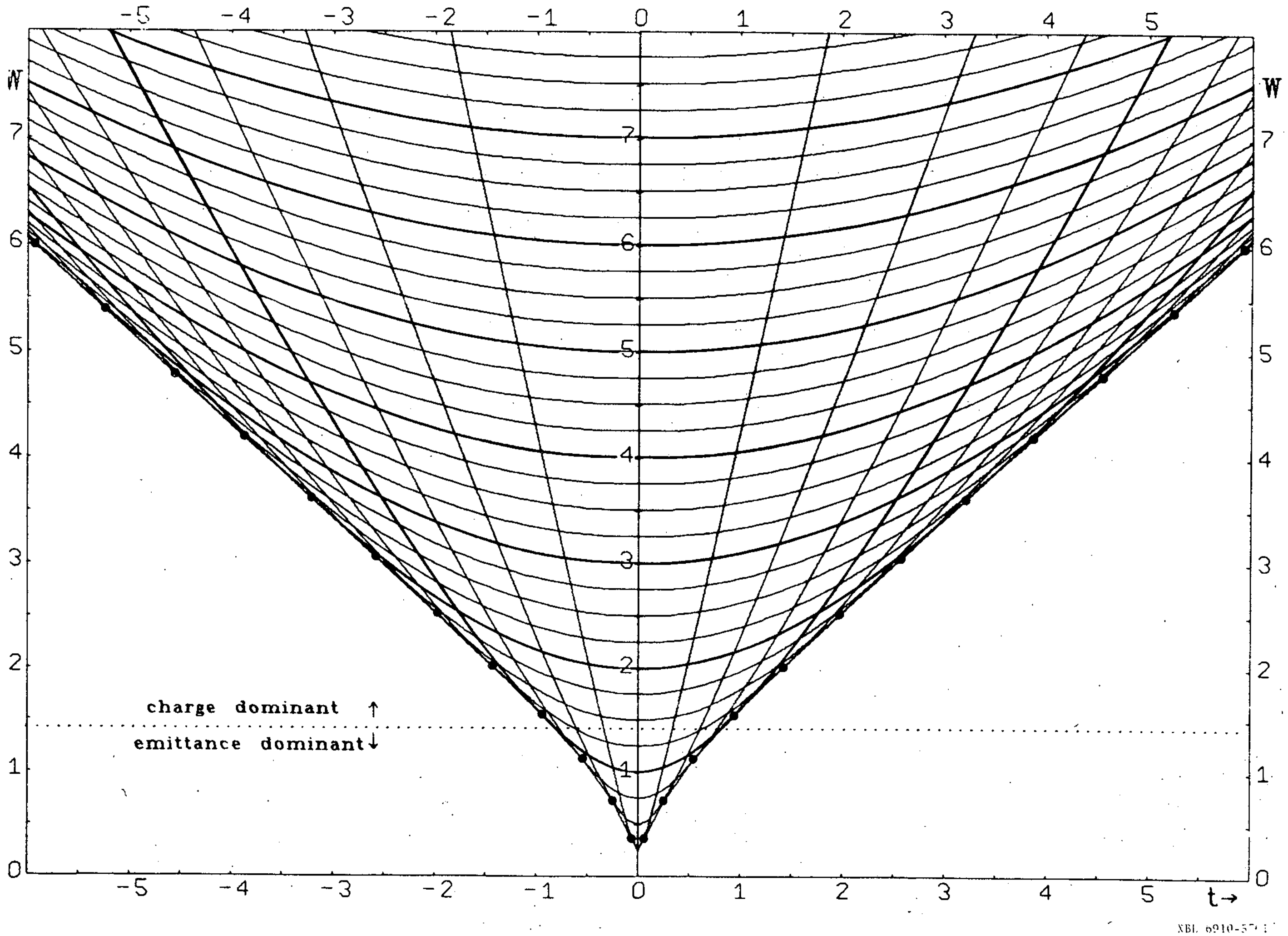


Fig. 1(a). Radius r of envelopes of drifting beams vs. path length from waist s. The plotted parameters are $W = (\sqrt{g}/\epsilon)\ r$ and $t = (g/\epsilon)\ s$, where ϵ is the two-dimensional emittance and g, defined in Eq. (19), depends on beam intensity and momentum.

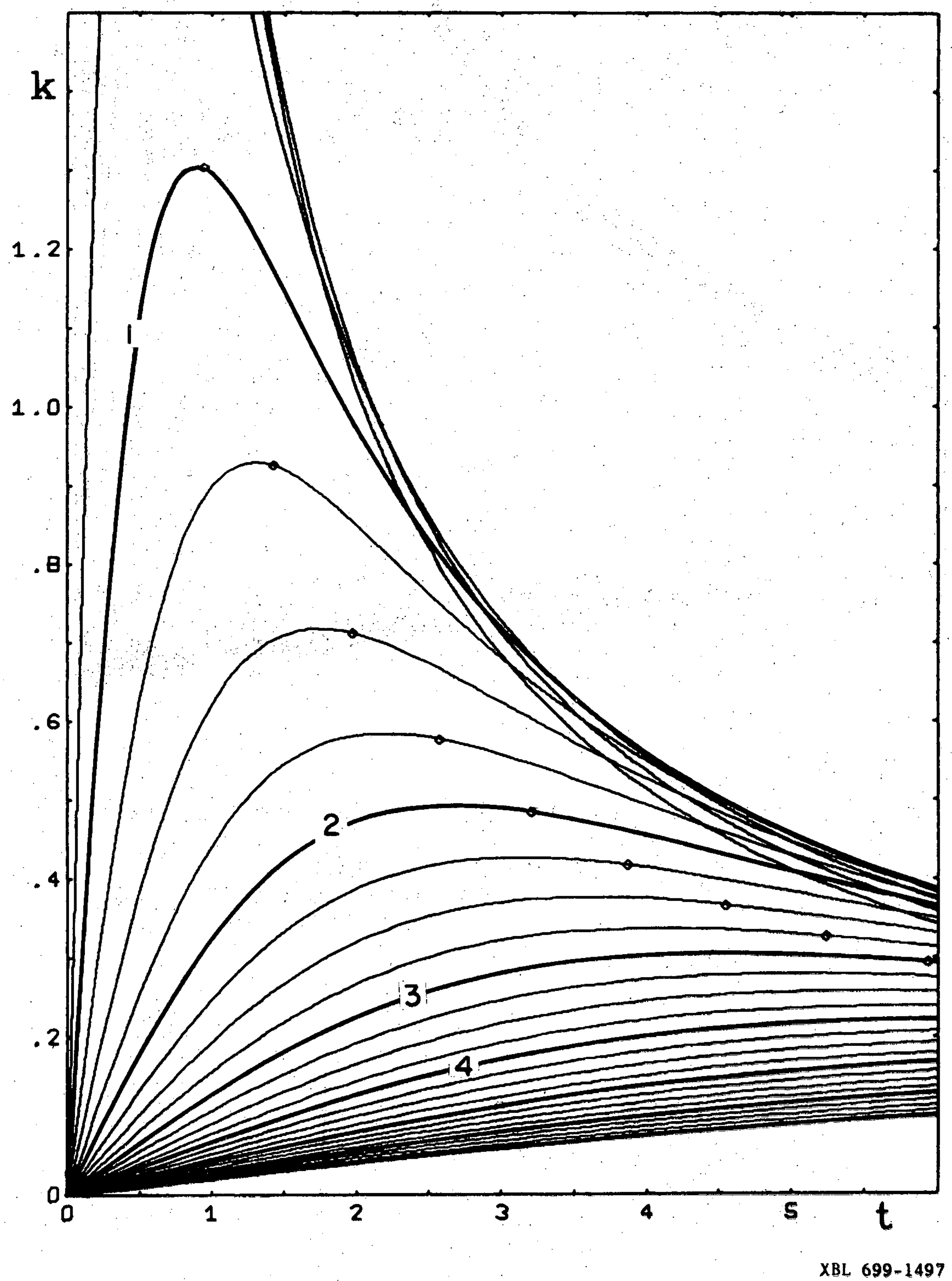
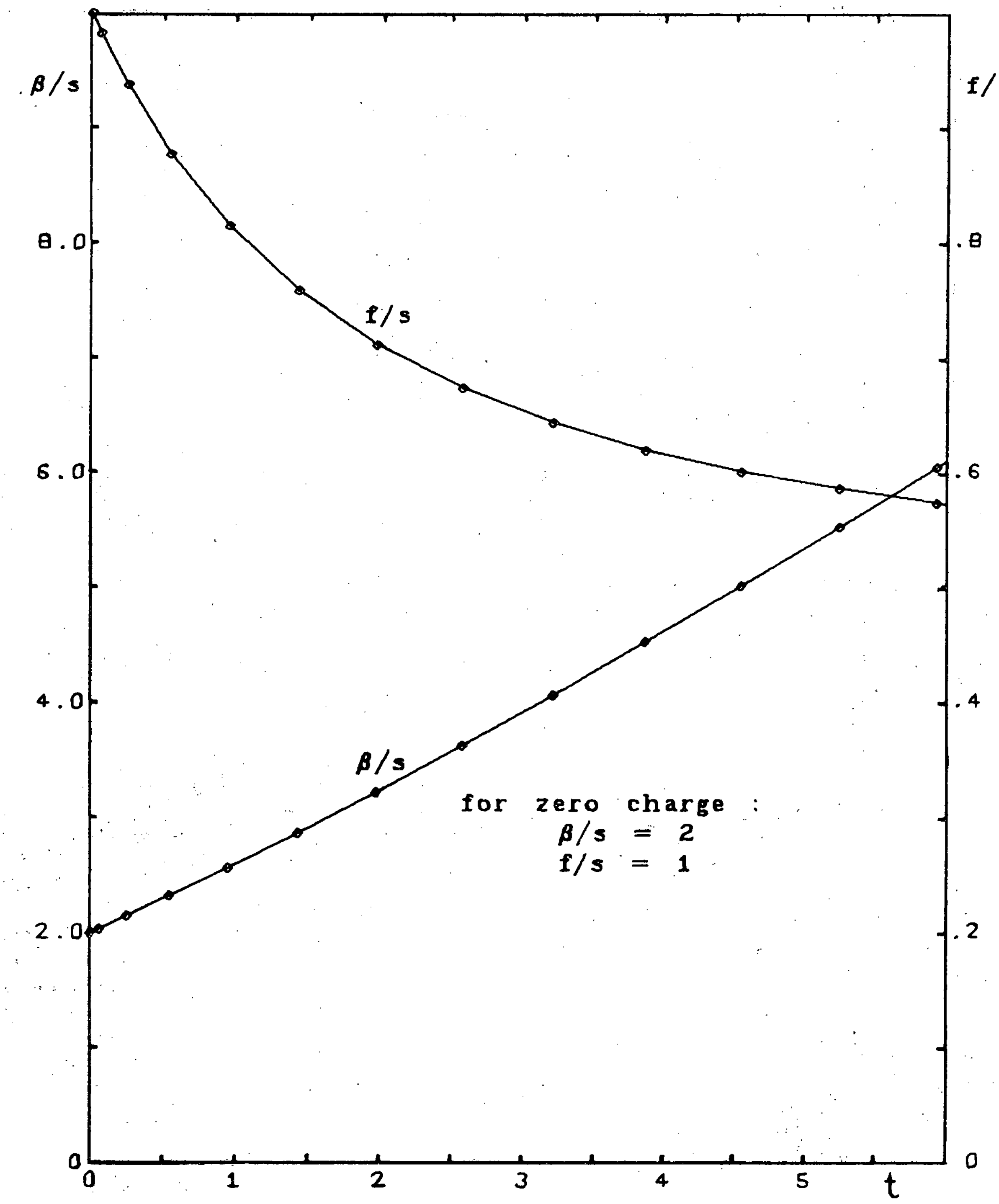
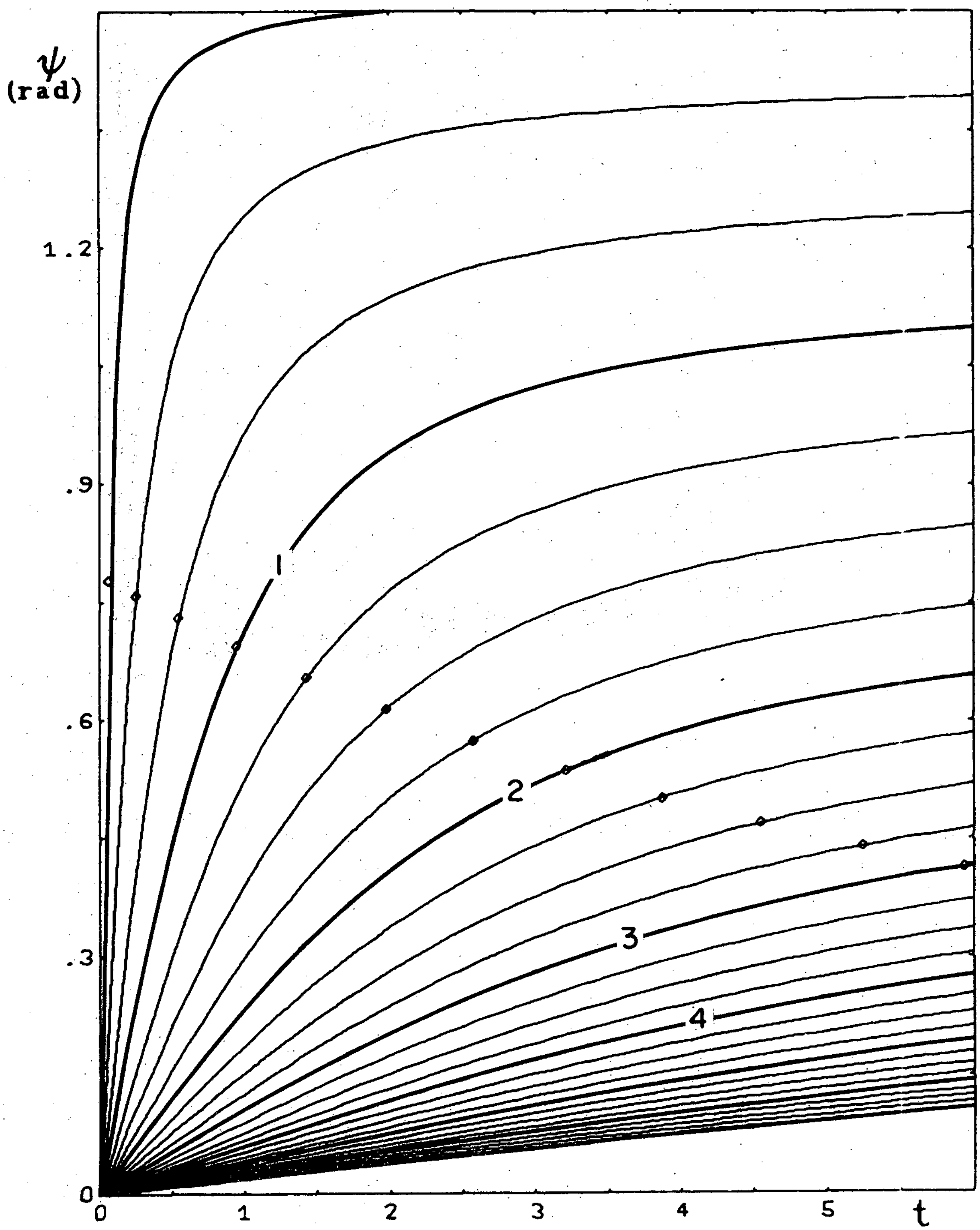


Fig. 2(a). Lens strength $k = (Gf)^{-1}$ required to produce periodic envelopes, i.e., to reverse the slope of the envelope curves of Fig. 1: $k = 2W'/W$. Diamonds give k values for minimum radius beams. Numbers on curves are values of W at t = 0.



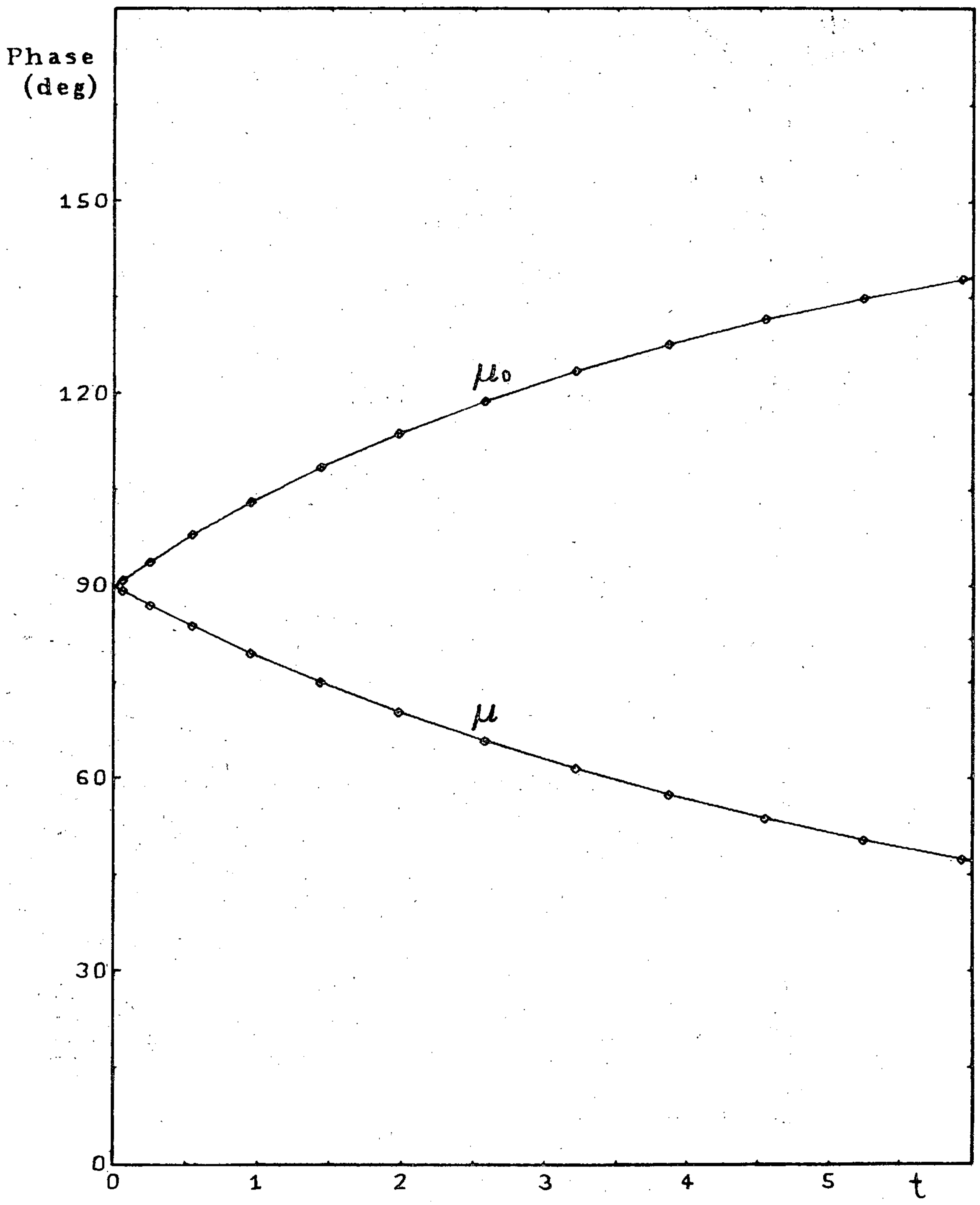
XBL 699-1498

Fig. 3(a). Ratios β/s and f/s for envelopes that have minimum radius at t = Gs, where β is the amplitude function and f the required focal length for a periodic beam line.



XBL 699-1496

Fig. 4(a). Particle phase advance ψ in the beams corresponding to the envelopes of Fig. 1(a).



XBL 699-1499

Fig. 5(a). Particle phase advance μ for a complete period of a system with lenses located at -t, +t, 3t, ... and beam center of mass phase advance μ_0, with lenses adjusted for minimum beam radius.

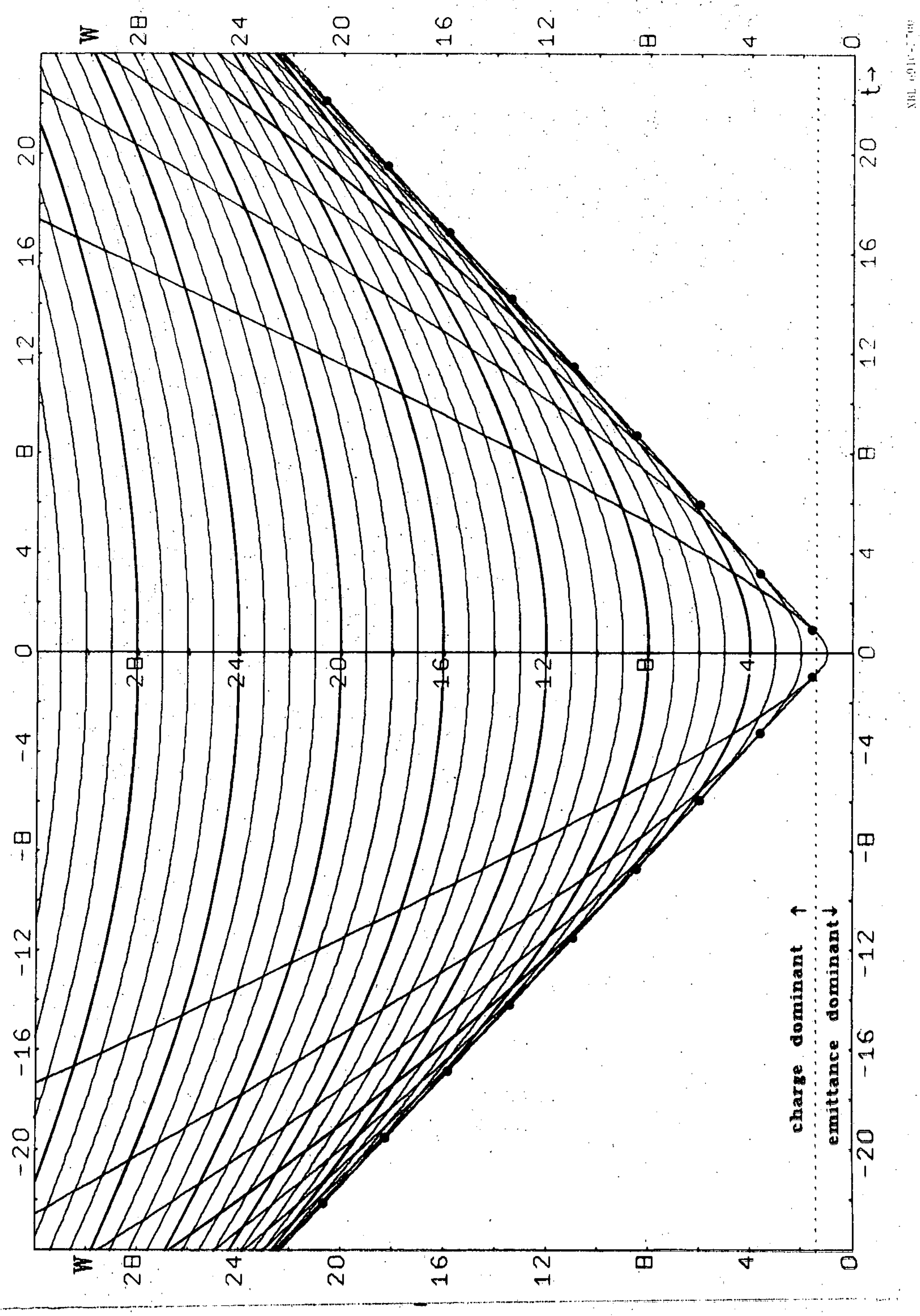
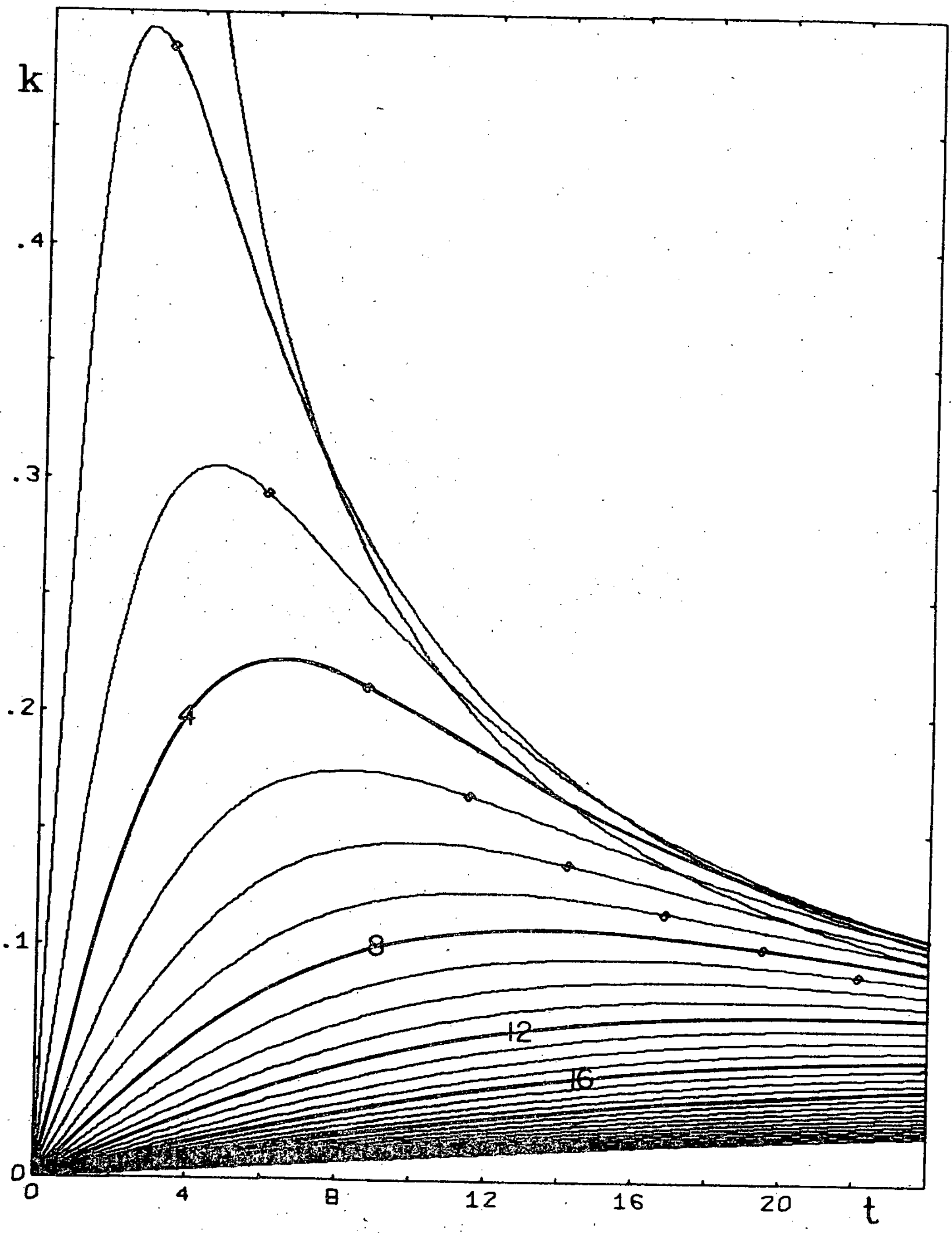
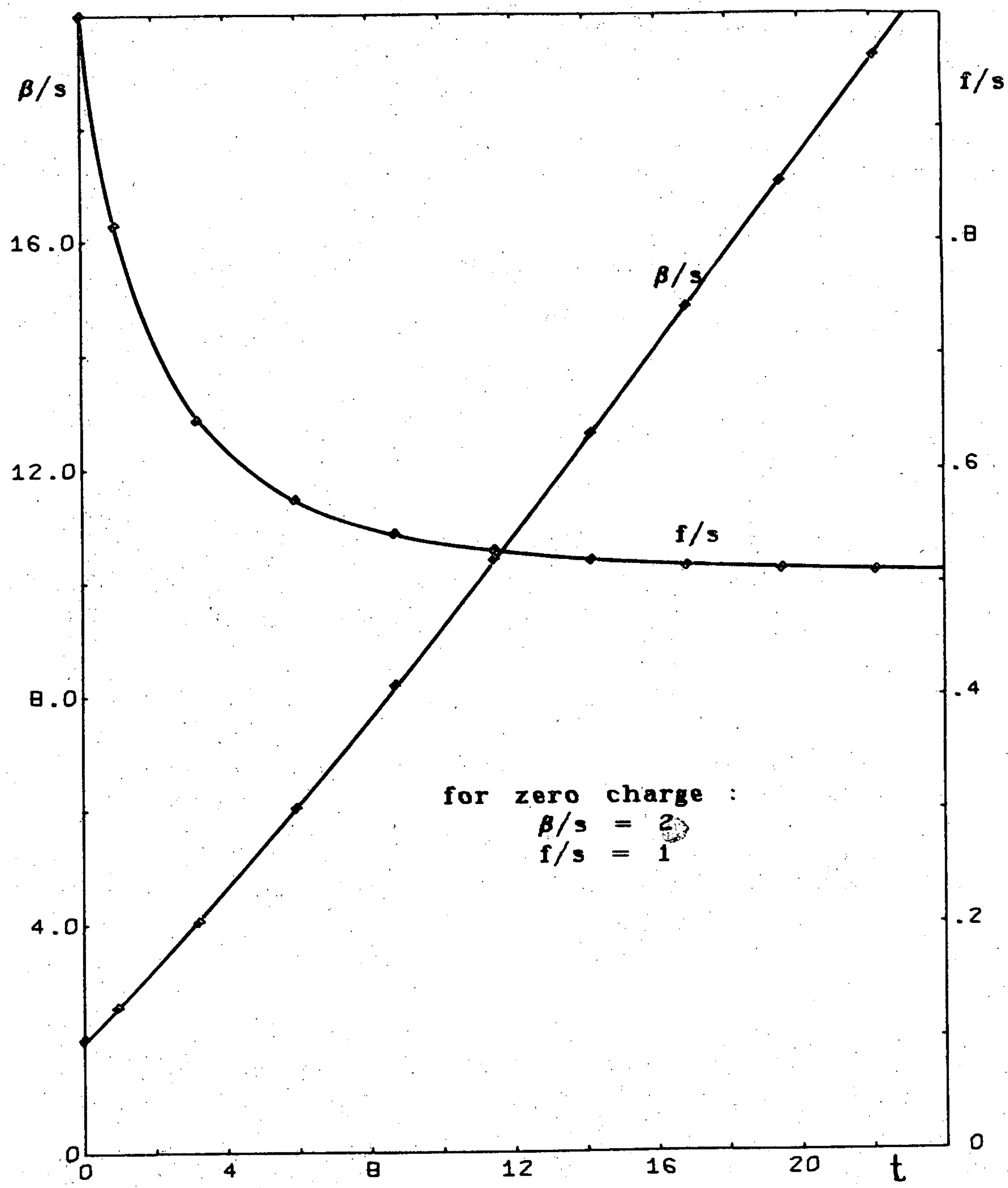


Fig. 1(b). Same as for 1(a) but for a different range of the normalized path length t.



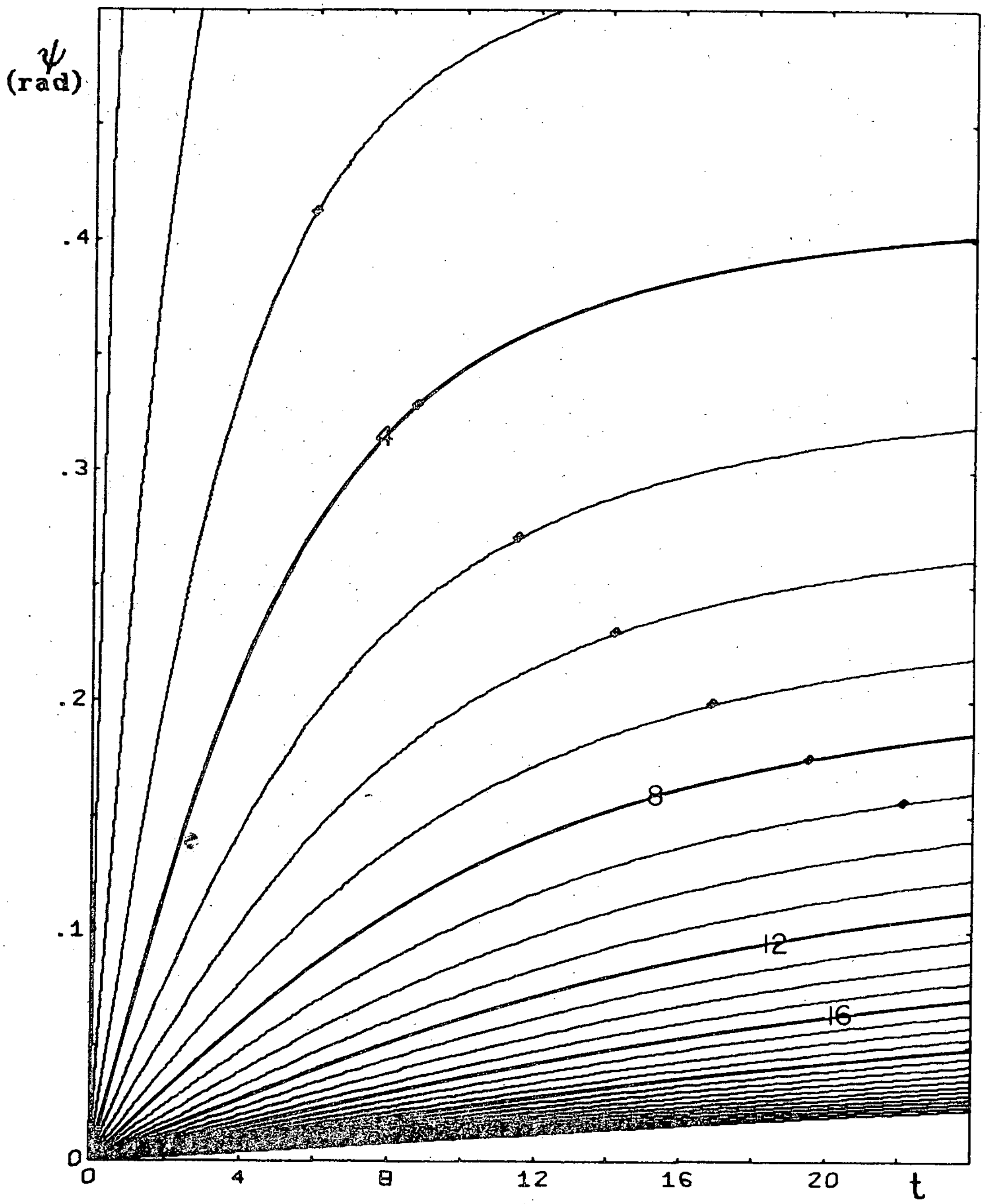
XBL 6910-5698

Fig. 2(b). Same as for 2(a) but for a different range of the normalized path length t.



XBL 6910-5699

Fig. 3(b). Same as for 3(a) but for a different range of the normalized path length t.



XBL 6910-5697

Fig. 4(b). Same as for 4(a) but for a different range of the normalized path length t.

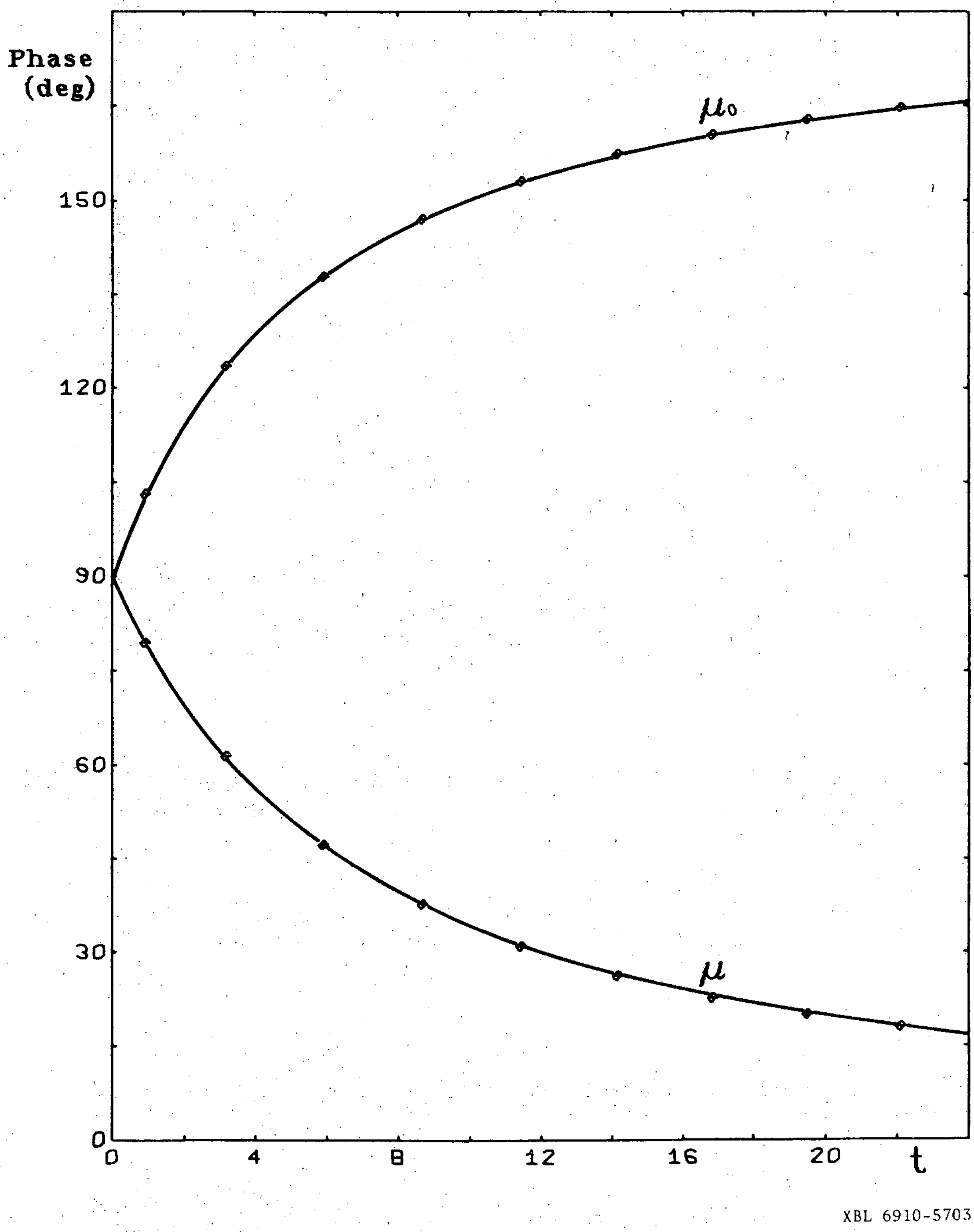


Fig. 5(b). Same as for 5(a) but for a different range of the normalized path length t.

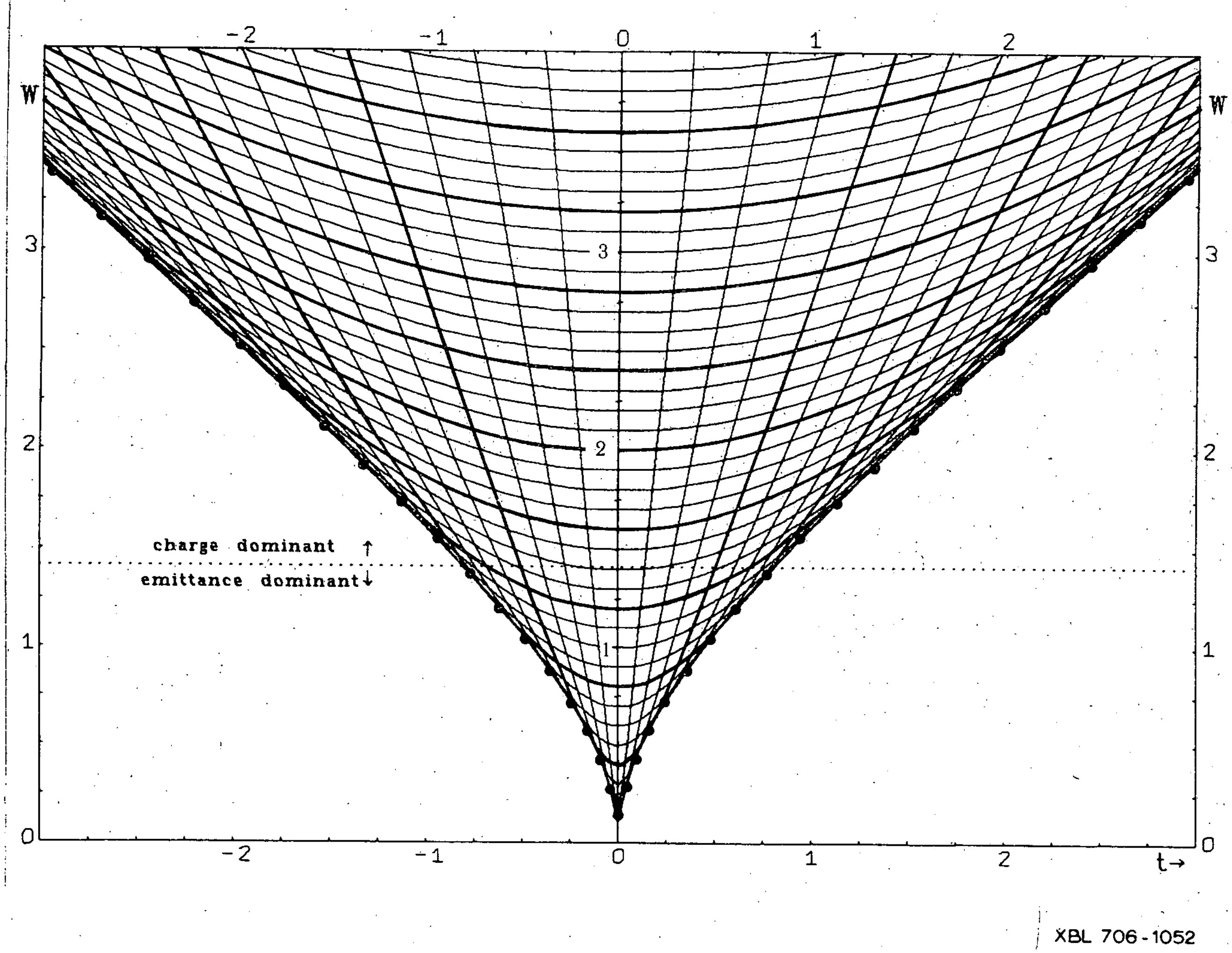


Fig. 1(c). Same as for 1(a) but for a different range of the normalized path length t.

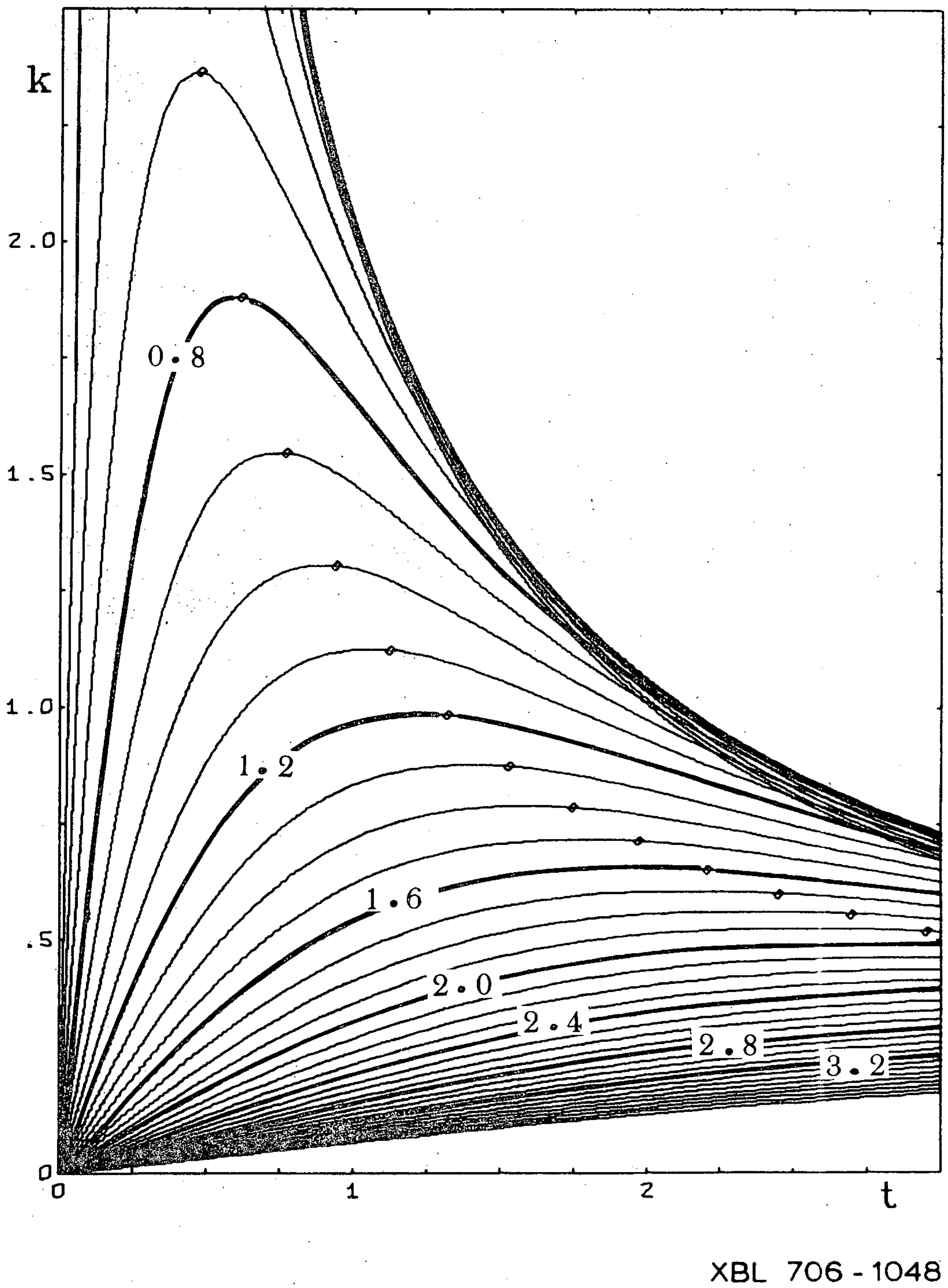


Fig. 2(c). Same as for 2(a) but for a different range of the normalized path length t.

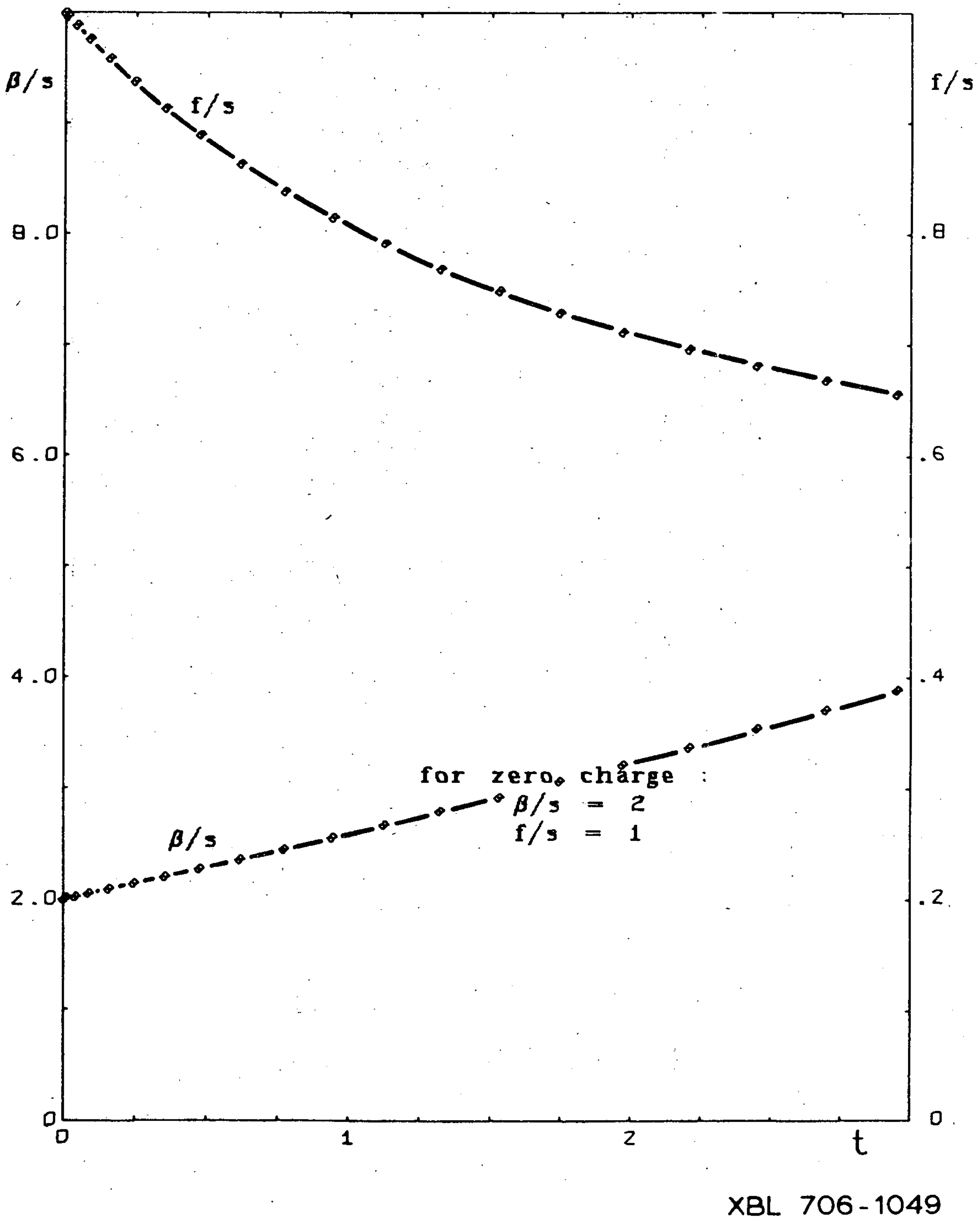


Fig. 3(c). Same as for 3(a) but for a different range of the normalized path length t.

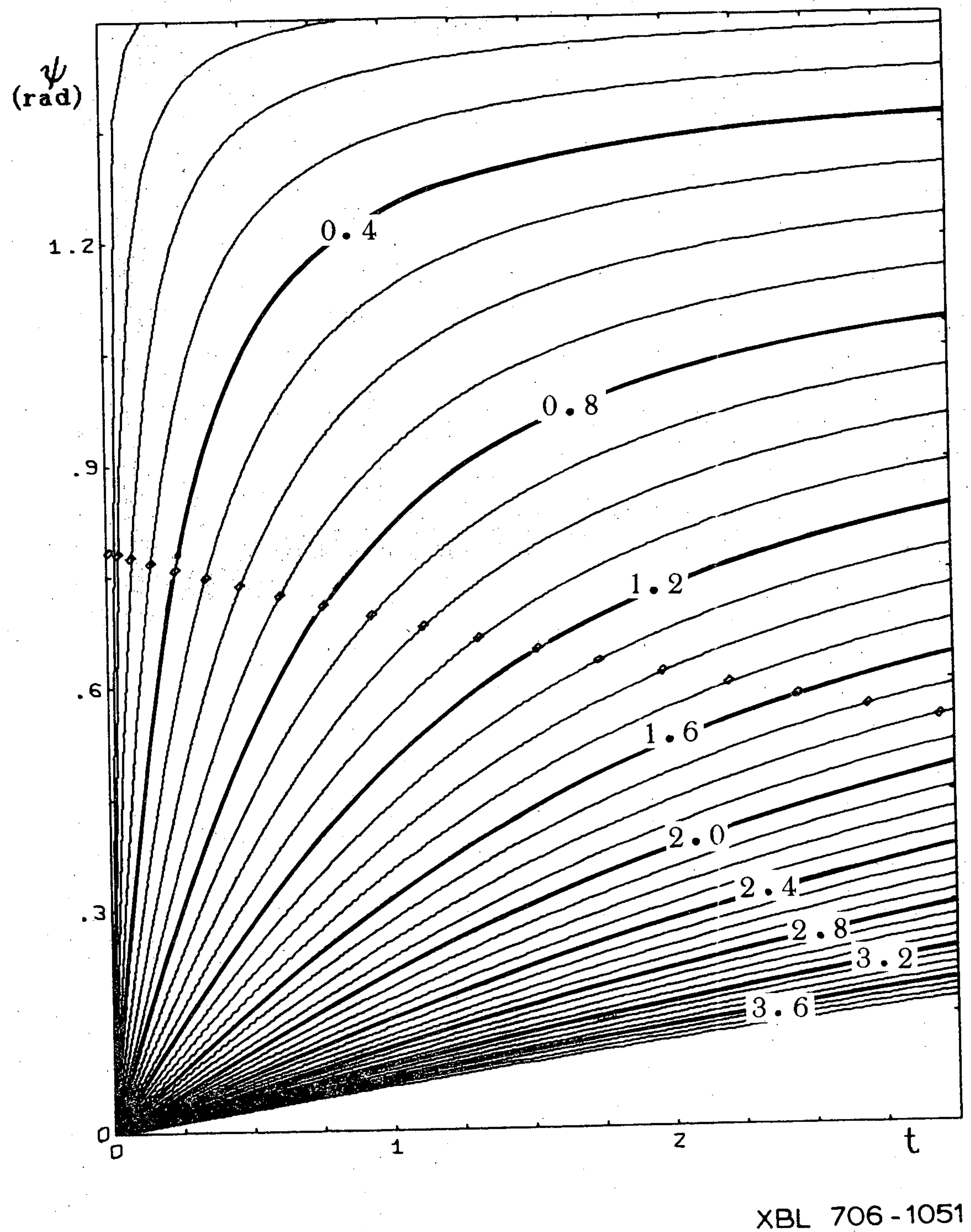
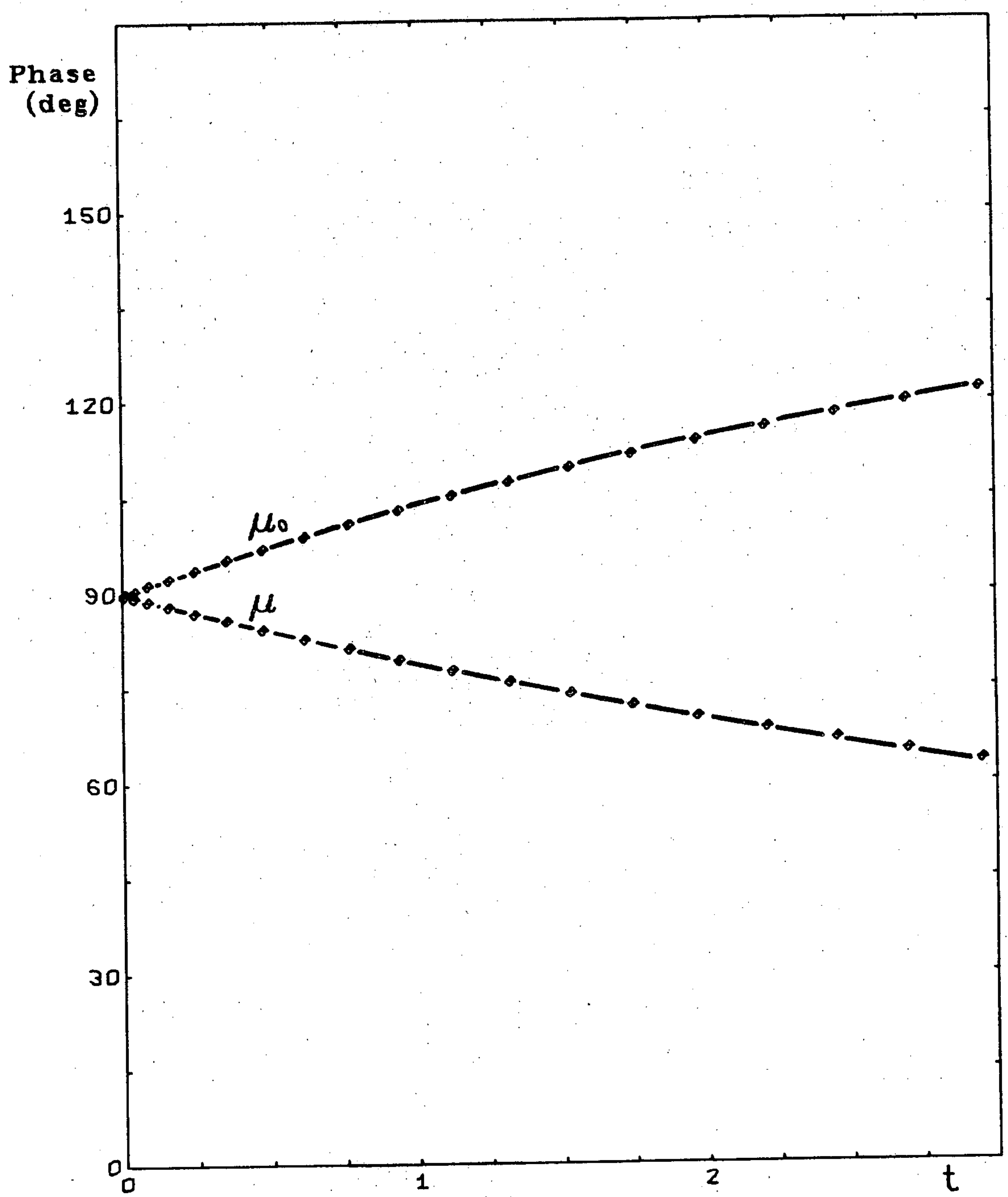


Fig. 4(c). Same as for 4(a) but for a different range of the normalized path length t.



XBL 706-1050

Fig. 5(c). Same as for 5(a) but for a different range of the normalized path length t.

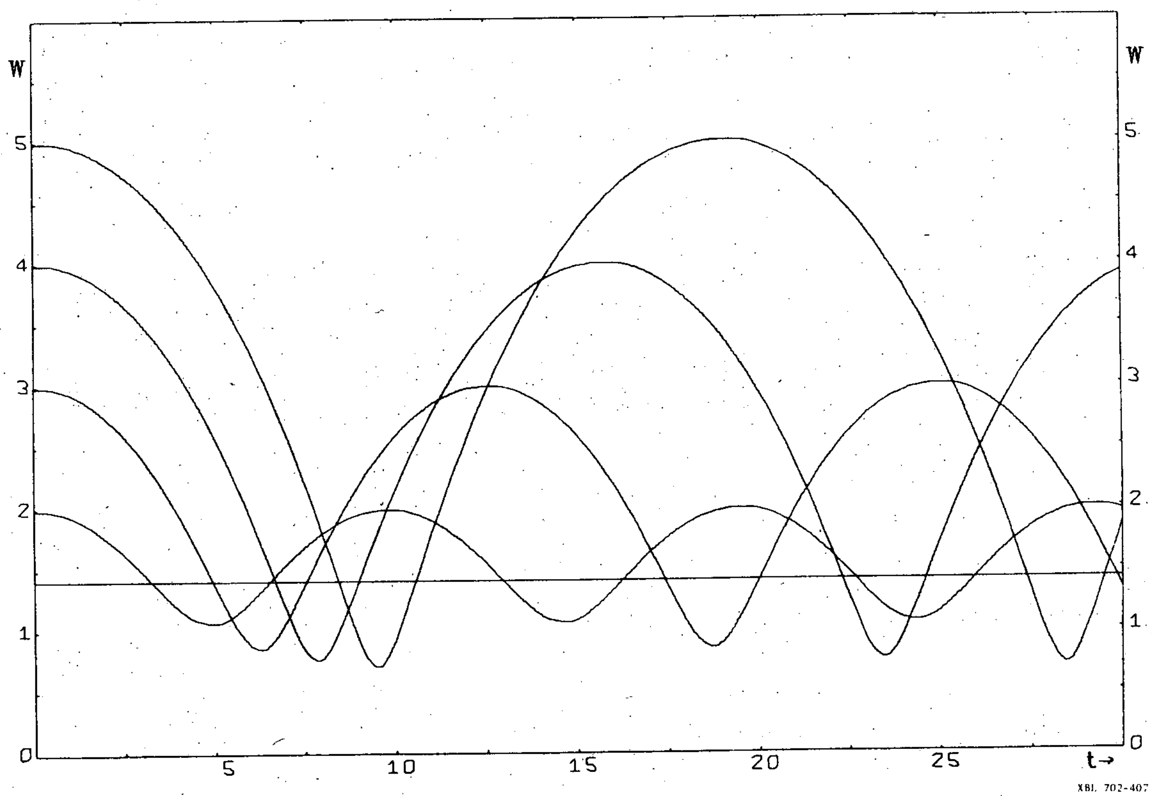


Fig. 6. Envelope radius vs. path length for partly neutralized drifting beams, when $f > \gamma^{-2}$ (see Sec. 5).

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