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TYPE: ACTION DOCUMENT NUMBER: 9201603
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FROM: HUSSEIN, Mahir S.: UNIVERSIDADE DE SAO PAULO

TO: DR. D.A. BROMLEY

MAY 5 1992

DATE OF
CORRESPONDENCE: 04/15/92

SUBJECT: HE IS WRITING TO ASK DR. BROMLEY'S OPINION OF SOME
RECENT ARTICLES CONTAINING IDEAS DEVELOPED BY THEIR
GROUP CONCERNING PARTICLE ACCELERATION USING
POWERFUL LASERS.

DIRECTORATE STAFF
ASSIGNED: PHYSICAL SCIENCES ASSIGNED: Lee Schroeder

ACTION
REQUIRED: REVIEW FOR DAB & Draft response STAFF
ACTION: See letter into it with
drafted by [unclear] letter sent
under test signature

SENDER'S DUE DATE:
OSTP DUE DATE: 05/14/92 STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

COPIES TO: D. Allan Bromley
INTERNATIONAL/POLICY

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CENTRAL FILES: Physics -



June 1, 1992

TO: Karl Erb
FROM: Lee Schroeder
RE: Background + Recommendation Doc. #: 9201603
(Particle Acceleration via Lasers)

The letter to DAB from Dr. Mahir S. Hussein (Universidade de Sao Paulo) contains 2 preprints (The Super Collider Revisited and Theory of Free Wave Acceleration) + a copy of a published article (Phys.Rev.Lett. 68,1136 (1992)) on the acceleration of charged particles using a laser and transverse static E-field.

Specific to the preprint on the SSC, the preprint suggests using their technique + strong superconducting magnets (10T) for transport/focussing to construct an accelerator 20X smaller than SSC. Relevant to this is the following:

- o they are talking about a linear collider, not circular machine
- o the spot size is several mm's, rather than microns needed for luminosity
- o my own opinion + discussions with Andy Sessler (LBL-advanced accelerator techniques) indicate that decade or more R&D needed to make such a device work at the luminosities required by the SSC (ie., $10E33$).

Recommended response: Letter, under my signature, thanking authors for papers; brief statement of time-scale to convert concepts to real device and wish them well in their continuing research.

Lee - Do you have an
intuitive feeling for how
this inverse Brems
acceleration works? \$
Karl

yes
Thanks
LEE 6/7/92

← the E field is
perp to direction
of acceleration
however.



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Prof. D. Allan Bromley
Science Advisor
The White House
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USA

MAIL ROOM

April 15 1992

Dear Professor Bromley

I am pleased to send you some very recent articles containing ideas developed by our group here and also with the collaboration of Prof. A. Kerman concerning particle acceleration using powerful lasers. We predict quite smaller accelerators for very high energy physics.

Hope to hear of your opinion soon, I remain

Yours sincerely

Mahir S. Hussein
Mahir S. Hussein

THE SUPER COLLIDER REVISITED*

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Abstract

We suggest a revised version of the Superconducting Super Collider (SSC) that employs the planned SSC first stage machine as an injector of 0.5 TeV protons into a powerful laser accelerator. The recently developed Non-linear Amplification of Inverse Bremsstrahlung Acceleration (NAIBA) concept dictates the scenario of the next stage of acceleration. Post "Star Wars" lasers, available at several laboratories, can be used for the purpose. The 40 TeV CM energy, a target of the SSC, can be obtained with a new machine which can be 20 times smaller than the planned SSC.

* Supported in part by the CNPq

April/1992

The SSC as presently planned purports to accelerate protons to 20 TeV in C.M. collider apparatus. The eventual aim of this gigantic project is the verification of the existence of the ever so elusive Higgs boson predicted to have a mass of > 50 GeV. The dimension of this planned machine is, as is already known, colossal, with an estimated cost of several billions of dollars. Clearly the physics dictates the cost. However, one still wonders about possible cheaper alternatives. In this communication we propose a new accelerator that could reduce the dimension by more than an order of magnitude.

In a recent paper¹⁾, we proposed the non-linear amplification of inverse bremsstrahlung electron acceleration (NAIBEA) as a way of accelerating electrons to a very high energy with the aid of powerful lasers which are available at several laboratories, in conjunction with an optimally determined applied electric field. Similar effects are obtained with an applied magnetic field²⁾. In the work of Hussein and Pato¹⁾, the initial electron energy was taken to be about 35 MeV. To obtain similar effects with protons one would need an initial energy of about 70 GeV and a laser 10^4 more potent than the one used in Ref. 1.

Our proposal for a smaller Higgs machine is to inject protons with about 500 GeV energy (proton initial velocity $v_0/c = \beta_0 = 0.999998$), which is the energy attained in the first stage of the SSC, in conjunction with a powerful laser (say of a power of 6.6×10^{20} W/cm² for a wavelength of $\sim 5 \times 10^{-5}$ m). The laser wave would merely pump and subsequently remove a very large amount of energy into/from the protons. In fact, during a half cycle interaction with the laser, the protons are accelerated to about 1 TeV within a distance of $\frac{\beta_0}{1-\beta_0} \lambda = 25$ meters. No net energy is gained in a full cycle encounter with the laser. In the process of pumping/removing energy into/from the protons, the proton energy oscillates. To obtain net acceleration, one would require to change the maxima in the proton energy into inflection points. This is obtainable with an appropriate applied electric, E_{app} , or magnetic, B_{app} , field. Significant acceleration can be obtained (up to the TeV regime) with an array of E_{app} or B_{app} with interchanging signs placed in

optimally determined positions^{1,2)}. The dimensions involved are not as great as those in the planned SSC machine. We now turn to a detailed analysis of the proposal.

To reach a proton energy of 20 TeV we need, an array of applied magnetic field of an intensity of about 10 teslas. The sign changes of this field are made at macroscopic distances dictated by the requirement that, the particle is well contained in the transversal direction $p_y(\varphi = n\pi) = 0$ where φ is the laser phase. These features of the physics become particularly transparent if we look at the equation of motions when the motion is ultrarelativistic in the z-direction,¹⁾

$$\dot{p}_z = e \beta_y (E_y^{(0)} + B_{app}) \quad (1)$$

$$\dot{p}_y = -e \beta_z B_{app} \quad , \quad (2)$$

and the energy equation ($\varepsilon = \gamma$ in unit of the rest mass of the particle)

$$\dot{\gamma} = e \beta_y E_y^{(0)} c \quad . \quad (3)$$

In the above equations, $E_y^{(0)} = B_x^{(0)}$ is the laser electric field intensity and $\beta_i = \frac{v_i}{c}$. The applied constant magnetic field in the x-direction is B_{app} .

Now the solution of the above equations can be expressed in the form

$$\varepsilon = p_z - e B_{app} y + u_0 \quad (4)$$

$$p_y = p_y^{(0)} - e B_{app} z \quad (5)$$

$$p_z = \frac{1 + p_y^2 - (-e B_{app} y + u_0)^2}{2(-e B_{app} y + u_0)} \quad . \quad (6)$$

In Equation (4), u_0 is a constant determined from the initial conditions; $u_0 = \gamma_0 (1 - \beta_0 \cos \theta_0)$ where θ_0 is the injection angle.

It is obvious from Eq.(4) that to make ϵ increase, $B_{app} y$ must be made positive ($< u_0$). From obvious arguments y is oscillatory so as to keep the particle in the path of the laser pulse. This means that p_y is also oscillatory. Thus $B_{app} z$ must oscillate. Since z is always increasing, one naturally reaches the conclusion that B_{app} should change sign at appropriate z 's, dictated by the machine characteristics.

Now the change in energy of the protons in the first stage of acceleration is given by¹⁾

$$\Delta \epsilon = \frac{e E_{y_0}^{(0)} \lambda}{\pi} \left[\frac{m c^2 \gamma_0 \beta_0 \sin \theta_0 + \frac{e \lambda}{2\pi} E_{y_0}^{(0)}}{m^2 c^4 + \beta_0^2 \gamma_0^2 m^2 c^4 \sin^2 \theta_0} \right] \gamma_0 \beta_0 m c^2 (1 + \beta_0 \cos \theta_0) \quad (7)$$

where the laser electric field is represented by $E_y^{(0)} = E_{y_0}^{(0)} \sin \varphi$, φ being the phase and λ the wave length, and θ_0 is the injection angle of the protons ($\cos \theta_0 = \hat{y}_0 \cdot \hat{z}_0$). The overall change in energy, $\Delta \epsilon_f$, of the proton after n inflection points (generated by n alternating sign magnetic fields (or electric fields)), is then, for $\gamma_0 \gg 1$,

$$\Delta \epsilon_f = n \Delta \epsilon \approx n \left[\frac{e E_y^{(0)} \lambda}{2\pi} \right] \left[\frac{2 \sin \theta_0 (1 + \cos \theta_0)}{1 + \gamma_0^2 \sin^2 \theta_0} \right] \gamma_0^2 \quad (8)$$

or

$$(\Delta \gamma)_f \equiv n \cdot B \cdot \left[\frac{2 \sin \theta_0 (1 + \cos \theta_0)}{1 + \gamma_0^2 \sin^2 \theta_0} \right] \cdot \gamma_0^2$$

where we have introduced the laser parameter $B \equiv e E_y^{(0)} \lambda / 2\pi m c^2$. If we take $\gamma_0 = 500$, $n = 20$, $\theta_0 = 0.1^\circ$, and $B = 0.5$, we reach the value of $\Delta \epsilon_f \simeq 20$ TeV.

The important question we address ourselves to now is how long the accelerator

tube will be. This is determined primarily by the intensity of the applied field B_{app} , and the injection angle θ_0 among other things such as the Doppler effect mentioned earlier.

To quantify the above discussion, we have used the NAIBA model to calculate the length of the proton accelerator taking for $\gamma_0 = 500$, $B_{app} = 5.14 \times 10^{-7} E_{y0}^{(0)}$, $P = 6.6 \times 10^{20} \text{ W/cm}^2$, $\lambda = 5 \times 10^{-3} \text{ cm}$ and $\theta_0 = 0.02$. A laser pulse of a Gaussian shape with a width of $\Delta = 3\pi$ is employed. The results are shown in Figure 1. The applied magnetic field was made to change sign 11 times along the accelerator tube. The length of the accelerator tube, Δz , needed to reach 20 TeV energy is about 3.0 km. This value is consistent with the slightly improved version of the estimate made by HPK⁽²⁾, namely

$$\Delta z \simeq 2\gamma_0^2 (1 + \nu_0^2) n \lambda / (1 + \bar{\beta}_y^2 \gamma_0^2) \quad (9)$$

where ν_0^2 is the intensity of the laser pulse's vector potential⁽²⁾, and $\bar{\beta}_y$ is an average value of the y-component of the particle velocity.

It is very important to realize that the overall characteristics of our machine is strongly dependent on the values of the available variables. An extensive analysis of optimization must be made in order to reach final conclusions concerning the size of the accelerator (as small as possible), the final energy of the protons (as high as possible), the laser and applied field intensities (as low as possible) and the injection angle, θ_0 .

The new SSC which we are proposing here consists of two injectors of 0.5 TeV protons some 6.0 km apart. The protons are injected into two NAIBA linear accelerators of 3.0 km in length that face each other. The resulting collider energy in the center of mass system will be the same as the proposed 100 km circular collider. Clearly many questions remain to be answered. The most important to our mind, is the luminosity of the beam which should be about $10^{33} \text{ cm}^{-2}\text{s}$. Since the luminosity is inversely proportional to the intersection area of the two beams, this requires a very small beam cross-section area.

In turn this implies a very small laser transversal extension. Our calculations indicate that

key point (as suggested) is $\int \int \dots$ and repetition rate integrated $\int \dots$

the proton dispersion in the y -direction is in the range of few mm's. This must be made smaller, possibly by using a combined applied electric and magnetic fields.

In conclusion, we have proposed in this paper a new linear super collider that is 20 times smaller than the planned SSC. The basic components of our proton accelerator are two 0.5 TeV proton injectors, two very powerful lasers ($P = 6.6 \times 10^{20} \frac{\text{W}}{\text{cm}^2}$, $\lambda = 5 \times 10^{-3} \text{ cm}$) and an array of (~ 22) several powerful magnets ($B_{\text{app}} \sim 10$ teslas) with alternating signs. The values of these parameters can be easily changed to better the optimization of the machine. The question of radiation damping, an important one not considered here, will be discussed in Ref. 3).

Acknowledgments

We thank Carlos Escobar and Arthur Kerman for useful and informative discussion.

REFERENCES

- 1) M.S. Hussein and M.P. Pato, *Phys. Rev. Lett.* 68, 1136 (1992); M.S. Hussein and M.P. Pato, in preparation.
- 2) M.S. Hussein, M.P. Pato and A.K. Kerman, submitted for publication.
- 3) M.S. Hussein, M.P. Pato and A.K. Kerman, to be submitted.

FIGURE CAPTIONS

Fig. 1: The relativistic factor, γ vs. z . A Gaussian laser pulse with a width of $\Delta = 3\pi$ is used in the calculation (see text for details).

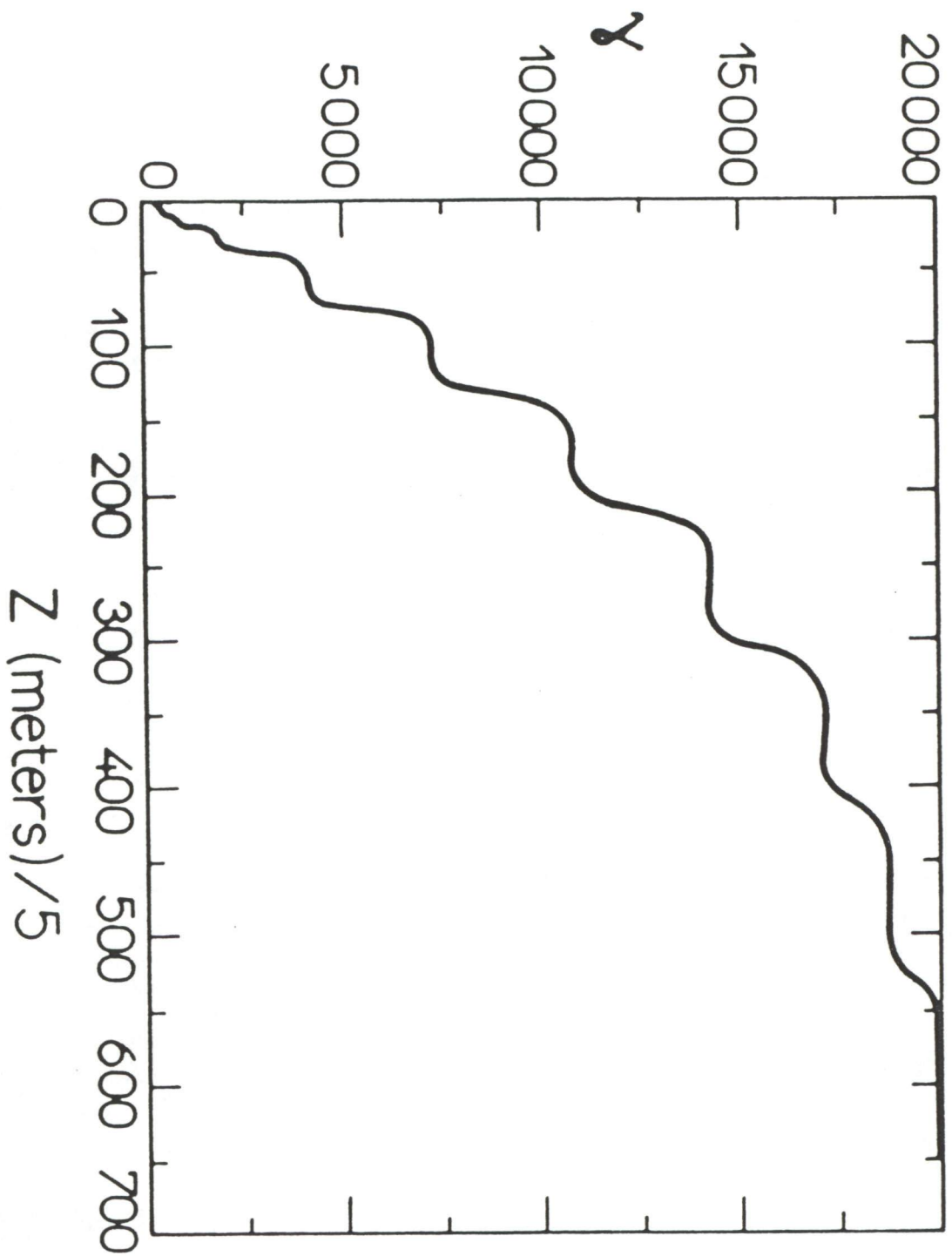


Fig. 1

THEORY OF FREE WAVE ACCELERATION

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Abstract

Laser acceleration of electrons is considered. A general formulation of the problem is developed which would allow the recently proposed NAIBEA accelerator to function with any state of polarization and shape of the laser pulse, and any kind of applied field. Analytical estimates as well as numerical analysis for the case of an applied magnetic field are made. It is found that electrons, injected with few tens of MeV's, can be accelerated to GeV energies using a NAIBEA accelerator of a length of few meters.

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March/1992

Laser acceleration of particles, has been the focus of significant attention in the last few years. Recently, two of us¹⁾ have proposed a method of linearly accelerating electrons with the aid of a powerful laser coupled to an optimally determined static electric field which is made to change sign at appropriate places along the accelerator. With initial electron energy of 35 MeV, a laser power of 10^{15} W/cm² for a wavelength of $10 \mu\text{m}$ and an applied field intensity of $\sim 10^{-5}$ that of the laser intensity, we predicted a final electron energy of, say, ~ 400 MeV if three inversions of the static field are made along an accelerator tube of a length of about 3 meters! The advantages of such a machine obviously calls for a more general discussion concerning how optimum the set up is and the dependence on the laser parameters as well as the nature of the applied field.

In the present paper we develop a very general formulation of the problem that allows both semi-analytical and numerical answers to the above questions. Before entering into details, we first give some general remarks concerning the new acceleration principle which we called non-linear amplification of inverse bremsstrahlung electron acceleration (NAIBEA) in ref. 1). First, the new machine is meant to be a very high energy booster; the initial particle energy should already be highly relativistic. The reason is very simple. What sets the macroscopic scale of the machine is basically the Doppler shift of the laser wavelength as seen in the particle rest frame. Calling the laser wavelength λ_0 and, the velocity of the particle v_0 then the shifted wavelength obtained with the appropriate Lorentz transformation is

$$\lambda = \lambda_0 \left[\frac{1 + \beta_0}{1 - \beta_0} \right]^{1/2}, \quad \beta_0 = v_0/c. \quad (1a)$$

Whereas λ_0 is microscopic (μm 's), λ becomes macroscopic (cm's) if β_0 is close to unity. The distance Δz travelled by the electron in the laboratory during a one cycle encounter

with the laser is then

$$\Delta z = v_0(\lambda/c)\gamma = \lambda_0 \frac{\beta_0}{1 - \beta_0} . \quad (1b)$$

Clearly Δz is one of the quantities that would decide the size of the accelerator.

Secondly, the rate of change of the particle energy is determined by $\vec{v} \cdot \vec{E}$ and thus to keep the particle gaining energy from the laser, $\vec{v} \cdot \vec{E}$ should be made always positive. This calls for another degree of freedom to couple to the system. A possible simple form for this extra degree of freedom, was found in Ref. 1) to be an array of applied static electric field with interchanging signs placed at appropriate positions along the accelerator. Clearly a more general form for this degree of freedom can be found that would make the machine more efficient. A combination of electric and magnetic fields, not necessarily static could be one of the choices. To better determine the nature of the applied field, one needs an equation, which we now turn our attention to its derivation.

To simplify the presentation, we consider the units of mass in mc^2 , the vector potential A in mc/e , the distance x in $1/k$, where k is the wave number and time, t in $1/\omega$; ω being the frequency. We take the direction of wave propagation and particle, acceleration to be along z . The Hamiltonian of the system, particle + laser + applied field is (note that we are working in the temporal gauge)

$$H = \sqrt{1 + P_z^2 + (P_x - A_x)^2 + (P_y - A_y)^2} \equiv \gamma \quad (2)$$

in our units.

In Eq.(2) $\vec{A} = \vec{A}^{(0)}(t-z) + \vec{A}_{app}(t,z)$. Then $\vec{E}_{app} = -\dot{\vec{A}}_{app}$ and $\vec{B}_{app} = \vec{\nabla} \times \vec{A}_{app}$ are the external applied fields which add to those of the traveling laser pulse $\vec{A}^{(0)}(t-z)$.

Hamiltons equations follow from Eq.(1), i.e.

$$\begin{aligned} \dot{P}_z &= -\frac{\partial \gamma}{\partial z} ; \quad \dot{P}_x = 0 , \quad \dot{P}_y = 0 \\ \dot{\gamma} &= \frac{\partial \gamma}{\partial t} = \frac{\vec{P} - \vec{A}}{\gamma} \cdot \left[\frac{\partial \vec{A}^{(0)}}{\partial t} + \frac{\partial \vec{A}_{app}}{\partial t} \right] . \end{aligned} \quad (3)$$

Futher reduction of $\dot{P}_z$ gives

$$\dot{P}_z = \frac{\vec{P} - \vec{A}}{\gamma} \cdot \left[\frac{\partial \vec{A}^{(0)}}{\partial t} + \frac{\partial \vec{A}_{app}}{\partial z} \right] . \quad (4)$$

Combining $\dot{\gamma}$ and $\dot{P}_z$ we obtain

$$\dot{\gamma} - \dot{P}_z = \frac{1}{\gamma} \left((\vec{A} \times \vec{B}_{app})_z + \vec{A} \cdot \vec{E}_{app} \right) \quad (5)$$

which, when integrated yields

$$\gamma = P_z + u ; \quad u = u_0 + \int_{-\infty}^t \frac{((\vec{A} \times \vec{B}_{app})_z + \vec{A} \cdot \vec{E}_{app})}{\gamma} dt' , \quad (6)$$

$$u_0 = \frac{1}{\gamma_0} (1 + \beta_0)^{-1} = \left[\frac{1 - \beta_0}{1 + \beta_0} \right]^{1/2}$$

At this point, we remark, as was done in Ref. 1), that since $\vec{A}^{(0)}$ will be the dominant field, it is more convenient to use the phase $\varphi = t - z$ as an integration variable. Then, since $\dot{\varphi} = 1 - \dot{z}$ and $\dot{z} = \partial \gamma / \partial P_z = P_z / \gamma$ and from (6), $1 - \dot{z} = u / \gamma$, we have $d\varphi / u = dt / \gamma$. Further, since $\dot{u} = (1 - \dot{z}) du / d\varphi = (u / \gamma) du / d\varphi$, we obtain from Eq.(6)

the following

$$u^2(\varphi) = u_0^2 + 2 \int_{-\infty}^{\varphi} \left((\vec{A} \times \vec{B}_{\text{app}})_z + \vec{A} \cdot \vec{E}_{\text{app}} \right) d\varphi' , \quad (7)$$

and from $\gamma^2 = (P_z + u)^2 = 1 + P_z^2 + \vec{A}^2$ (Eq. 2) ,

$$\gamma(\varphi) = \frac{1 + \vec{A}^2 + u^2}{2u} ; \quad P_z = u \frac{dz}{d\varphi} = \frac{1 + \vec{A}^2 - u^2}{2u} \quad (8)$$

$$z(\varphi) = \int_{-\infty}^{\varphi} \left[\frac{1 + \vec{A}^2 - u^2}{2u^2} \right] d\varphi' = \int_{-\infty}^{\varphi} \left[\frac{\gamma(\varphi')}{u(\varphi')} - 1 \right] d\varphi' . \quad (9)$$

The x and y coordinates of the particle are determined from the equations $\dot{P}_x = 0$ and $\dot{P}_y = 0$, which yield for the canonical momenta, $P_x = 0$ and $P_y = 0$, and thus the physical momenta are given by

$$p_x = \gamma \dot{x} = -A_x \quad \text{and} \quad p_y = \gamma \dot{y} = -A_y \quad (10)$$

or

$$x(\varphi) = - \int_{-\infty}^{\varphi} \frac{A_x(\varphi') d\varphi'}{u(\varphi')} \quad (11)$$

$$y(\varphi) = - \int_{-\infty}^{\varphi} \frac{A_y(\varphi') d\varphi'}{u(\varphi')} . \quad (12)$$

The set of equations (7–11) constitutes the Free Wave Accelerator (FWA) equations. These equations are important generalizations of the NAIBEA equations of Ref. 1 in that: 1) the laser could be in any state of polarization, and have any pulse shape, and 2) the applied EM field E_{app} and B_{app} is quite general. Note that since $\vec{A}$ is defined to within an arbitrary constant, we have here full freedom in giving the electron non zero initial value of p_x and/or p_y (Eq. 10). The trajectory parameter, Q , which was introduced in Ref. 1 is here generalized to be a vector in the x - y plane and is defined by the equation

$$\frac{d\vec{Q}}{d\varphi} = -\vec{A} \quad . \quad (13)$$

It is a simple matter to show that the second derivative of $\vec{Q}$ can be written as

$$\frac{d^2\vec{Q}}{d\varphi^2} = \frac{-d\vec{A}^{(0)}(\varphi)}{d\varphi} + \frac{\gamma}{u} \vec{E}_{app} + \left[\frac{\gamma}{u} - 1 \right] \vec{B}_{app} \quad (14)$$

and the rate change of γ with respect to φ

$$\frac{d\gamma}{d\varphi} = (p \cdot \vec{E})/u = -\frac{1}{u} \vec{A} \cdot \vec{E} = \frac{1}{u} \frac{d\vec{Q}}{d\varphi} \cdot \vec{E}(\varphi) \quad . \quad (15)$$

For γ to increase with φ , $\frac{d\vec{Q}}{d\varphi} \cdot \vec{E}(\varphi)$ must always be positive (notice that $u(\varphi) > 0$)

$$\frac{d\vec{Q}}{d\varphi} \cdot \vec{E} > 0 \quad . \quad (16)$$

The above is the condition that guarantees that when $E_i(\varphi_j) = 0$, $p_i(\varphi_j) = \frac{dQ_i}{d\varphi_j}$ is also zero, then $\frac{d\gamma(\varphi_j)}{d\varphi} = 0$ and $\frac{d^2\gamma(\varphi_j)}{d\varphi^2} = 0$. Having such an inflection point in γ at φ_j

(instead of a maximum) guarantees that γ keeps increasing for $\varphi > \varphi_j$. If B_{app} is taken to be zero as Ref. 1, then $\vec{p} \cdot \vec{E} = \vec{p} \cdot \vec{E}^{(0)} + \vec{p} \cdot \vec{E}_{\text{app}}$. If $\vec{E}$ is taken in the y-direction, then we have $p_y E_y^{(0)} + p_y E_{\text{app}} > 0$. Since $E_y^{(0)}$ is the dominant field, except when passing through zero, the above condition says that we use E_{app} to "fine tune" the sign of p_y so that it is always the same as that of $E_y^{(0)}$. The fundamental role of the applied field is to guarantee the validity of Eq.(16). This can happen even if $E_{\text{app}}/E^{(0)}$ or $B_{\text{app}}/B^{(0)}$ or both are much smaller than unity. The injection of electrons with a non-zero $p_x(0)$ or $p_y(0)$, albeit very small, is very important to set the machine to work. This is so since in the x-y plane the motion of the electron must be oscillatory in accordance with Eq.(16).

We turn now to specific choices of the accelerator. We consider a linearly polarized pulse with $\vec{A}$ taken to be along the y direction. We first consider a constant applied electric field, E_{app} , then

$$\vec{A} = \left[A_y^{(0)}(\varphi) - E_{\text{app}} t - p_y(0) \right] \hat{j} . \quad (17)$$

With the $\vec{A}$ above used in the FWA equations we recover the NAIBEA equation of Ref. 1. Inversions of E_{app} are made at appropriate values of z to assure the validity of Eq. (16), namely $p_y(n\pi) = 0$. This means that the applied field is inverted at φ_j 's such that $\left. \frac{dp_y(\varphi)}{d\varphi} \right|_{\varphi_j = \frac{n\pi}{2}} = 0$.

We now replace E_{app} by a constant magnetic field along x. Then

$$\vec{A} = \left[A_y^{(0)}(\varphi) - B_{\text{app}} z - p_y(0) \right] \hat{j} . \quad (18)$$

The resulting NAIBEA equations are almost identical to those of Ref. 1 except for a

change in sign of the second term in Eq.(8) of that reference (with E_{app} replaced by B_{app}). Further, Eq.(7) reduces to

$$u^2 = u_0^2 - 2 B_{app} Q \quad . \quad (19)$$

The y-component of the momentum is given by (Eq. 10)

$$p_y(\varphi) = p_y(0) - A_y^{(0)}(\varphi) + B_{app} z \quad . \quad (20)$$

The continuous acceleration of the particle results if B_{app} is chosen so that $p_y(n\pi) = 0$. This requires changing the sign of B_{app} at appropriate places ($\varphi \simeq \frac{n}{2} \pi$).

We consider the following numerical example. The initial value of γ , $\gamma_0 = 70$, $P = \frac{3}{2} \nu_0^2 10^{+15} \text{ W/cm}^2$ for $\lambda_0 = 10^{-3} \text{ cm}$. The parameter $\nu_0 = 1$ refers to the maximum value of electric field of the pulse in our units. We also take nine cycles within the pulse. The shape of the pulse is taken to be a Gaussian, $\bar{A}_0^2 = \exp(-\varphi^2/\Delta^2)$, Fig. 1, with $\Delta = 3\pi$. The applied field intensity is taken to be 2.34 teslas which corresponds to $\sim 5 \times 10^{-5}$ that of the laser. The electrons are injected at an angle of 0.6° with respect to the z-axis ($p_y(0) \approx \frac{0.6}{180} \pi \gamma_0$). We consider, as an example nine changes in the sign of the modulated applied magnetic field. Since we have not self consistently chosen the position of the field reversal we have not actually optimized the decrease of u in Eq.(6). In figure 2 we show the change of γ vs. z . The gain in energy is a factor of 35 over a distance (accelerator length) of seven meters! The accelerator length could be made smaller if full optimization is accomplished. The corresponding trajectory of the particle, confined in the (z,y)-plane is shown in figure 3. The undulation in $y(z)$ is a consequence of the changes in the sign of B_{app} and it guarantees that the particle remains in the path of the laser if one insists that

$$y = - \int_{-\infty}^{\varphi} \frac{A_y^{(0)}(\varphi')}{u(\varphi')} d\varphi' , \quad (21)$$

is contained within the laser transversal extension. As we see from figure 2, at the end of the acceleration the dispersion in y is ~ 2 mm which could be within available laser transversal dimensions²⁾.

Before ending we comment briefly on the case of circularly polarized laser pulse,

$$\vec{A}^{(0)} = \bar{A}(\varphi) [\hat{i} \cos \varphi + \hat{j} \sin \varphi] , \quad (22)$$

$$\bar{A}(\varphi) = \nu_0 \exp(-\varphi^2/2\Delta^2) .$$

Thus, clearly $\vec{A}^2$ is just $\bar{A}^2(\varphi)$, which does not oscillate. Then we get approximately for the accelerator length

$$\Delta z = \frac{1 - u_0^2}{2u_0^2} T + \frac{\nu_0^2}{2u_0^2} T \approx (2\gamma_0^2)(1 + \nu_0^2) T \quad (23)$$

where T is $\Delta\varphi$ of the pulse defined as $\int_{-\infty}^{\infty} A^2 d\varphi' = \nu_0^2 T \equiv 2\pi \nu_0^2 n$, where n is the number of oscillations in the pulse. Thus Δz is determined by three large factors (γ_0^2, ν_0^2, n) which can easily make it macroscopic even though it is in units of $\frac{\lambda}{2\pi}$. This generalizes the simple Doppler shift argument concerning the size of the accelerator.

In conclusion, we have developed here a general formalism for Free Wave Acceleration. A combined powerful laser pulse plus an optimally determined EM field, which could be time-dependent, was found to be able to accelerate electrons to very high

energies with relatively small accelerator dimensions. Radiation damping has not been included in our theory and it may modify some of our conclusions, even in setting a limit to the final energy of the particle^{3,4)}. After the completion of this paper we learned of related work done in Refs. 5) and 6).

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FIGURE CAPTIONS

- Figure 1. The laser pulse vs. φ used in our calculation the width $\Delta = 3\pi$.
- Figure 2. The energy of the particle in units of mc^2 vs. the traveled distance z .
- Figure 3. The trajectory of the particle in the y - z plane. Inset: scale of y in mm.

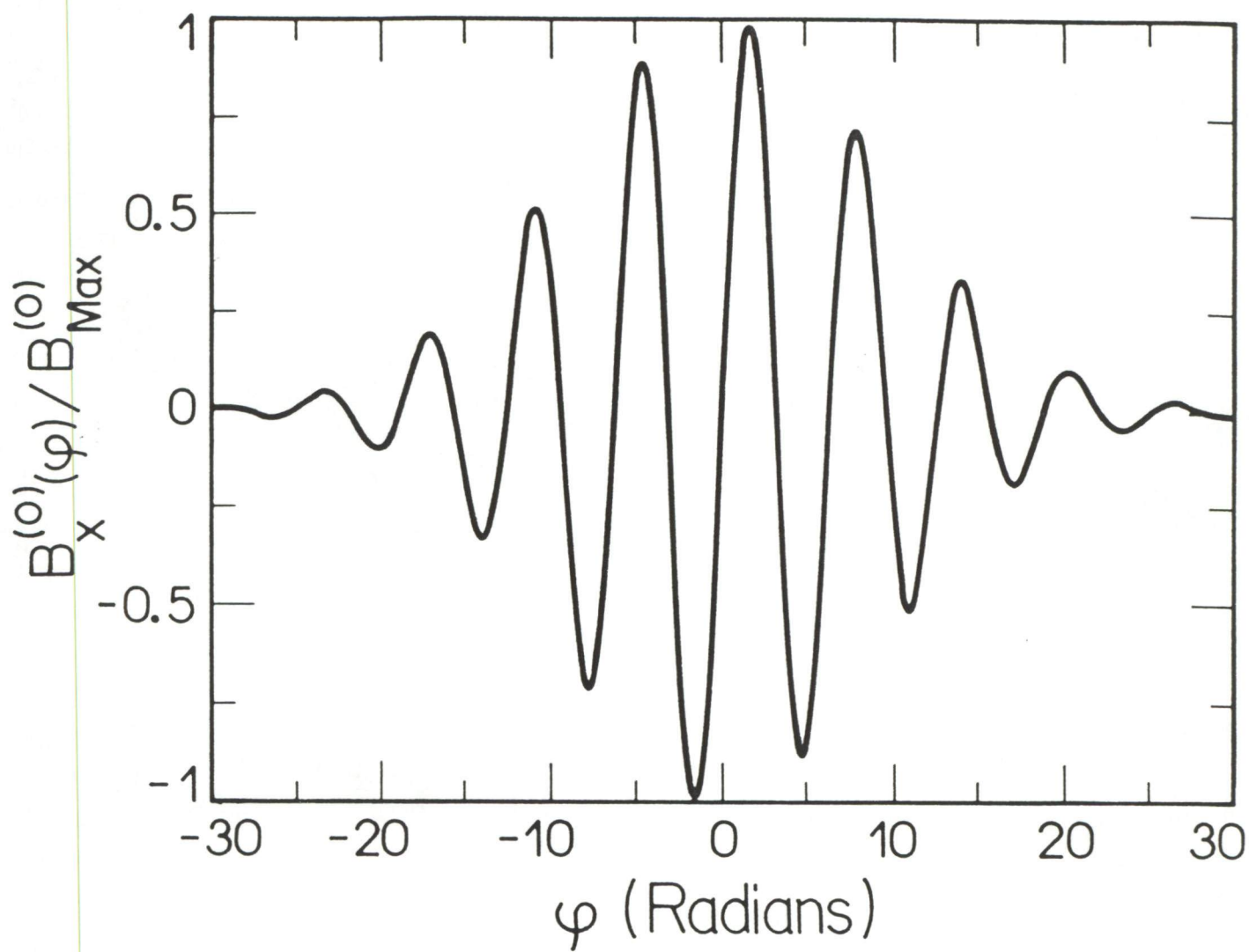


Fig. 1

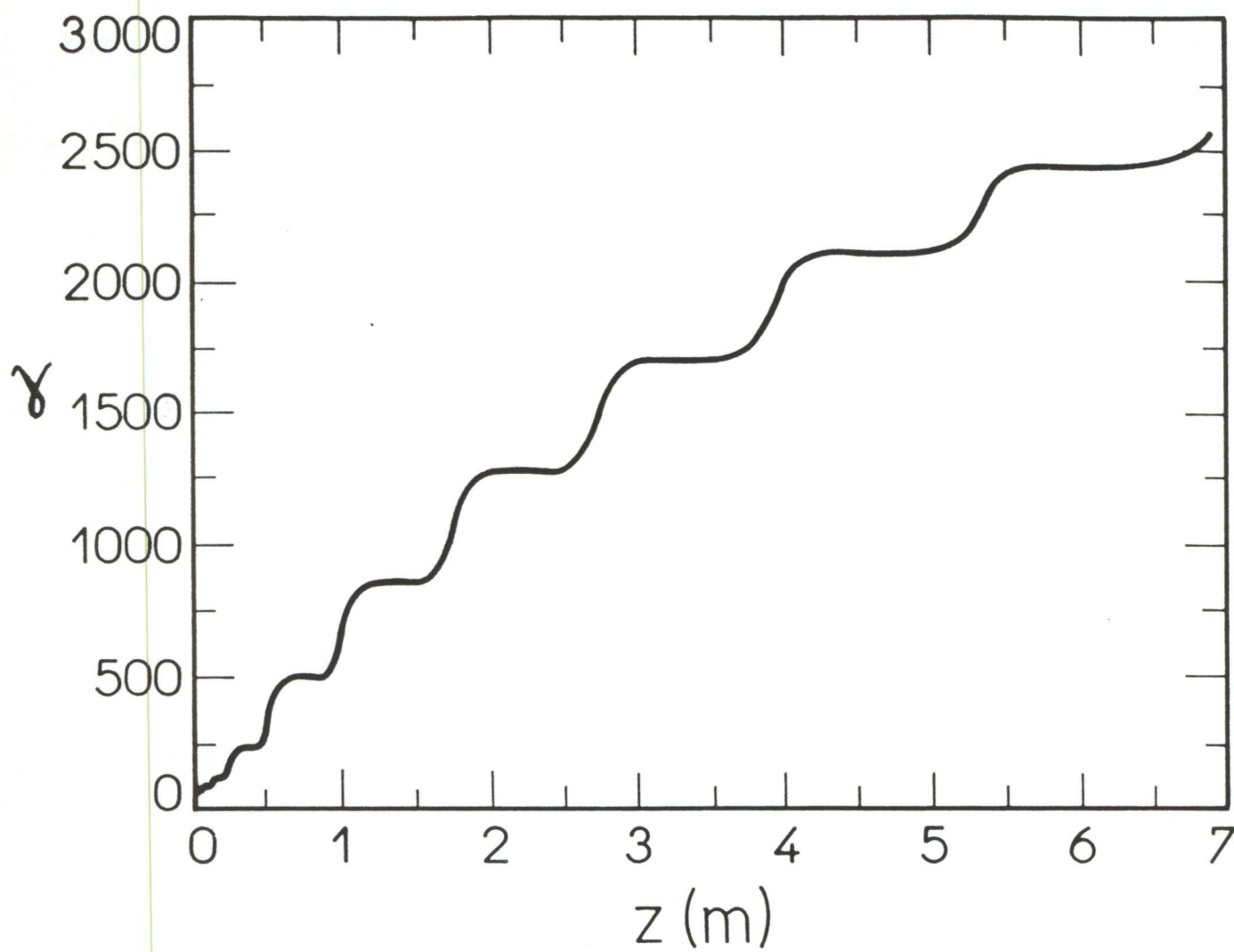


Fig. 2

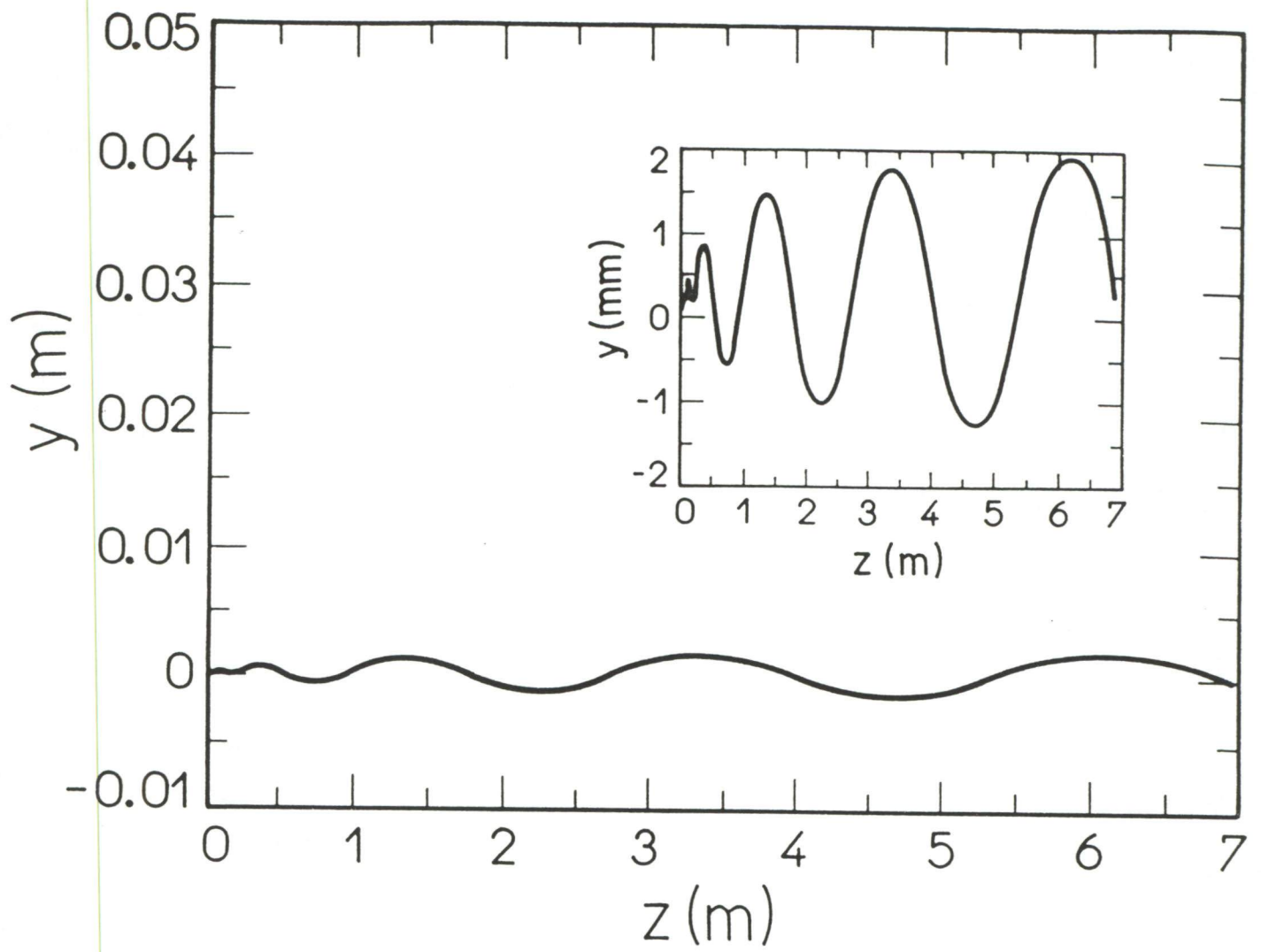


Fig. 3

Nonlinear Amplification of Inverse-Bremsstrahlung Electron Acceleration

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(Received 20 December 1991)

The acceleration of electrons using a laser and a static electric field perpendicular to the former is considered. The coupled particle-field equations are reduced to a second-order nonlinear inhomogeneous equation which determines the trajectory of the particle. The particle energy equation is considered and found to exhibit fold catastrophes, which may occur whenever the wave phase is $n\pi$ if the direction of the applied weak field is reversed at $(2n-1)\pi/2$, further net acceleration occurs. The trajectory equation is found amenable to analytical treatment.

PACS numbers: 41.75.Fr, 29.17.+w

Laser acceleration of particles without plasma has been proposed as a means of gaining energy without the difficulty of plasma control [1-3]. In this method one uses a strong laser field (typically the power is $\sim 10^{15}$ W/cm² for a wavelength of 10 μ m) to set the particles in motion, and a weak perpendicular static electric or magnetic field (with a intensity of 10^{-5} that of the laser field). The resulting slightly deformed electromagnetic (EM) field allows for the acceleration of the particles. Clearly the laser field alone only sets the kinetic energy of the particle oscillation without any net gain [4].

In a recent paper, Kawata *et al.* [5] discussed in detail the optimal conditions for electron acceleration with a laser plus small perpendicular static electric field, E_{app} . Through single-particle computation and particle simulation, they found that the electron is accelerated in both half wavelengths of the wave, and its relativistic factor γ increases by as much as a factor of 3.

In this Letter we analytically analyze the work of Ref. [5] and show that the coupled electron-EM-field system is governed by a set of equations containing one nonlinear and several linear ones. The nonlinear equation can be solved exactly and it governs the bulk of the physics; the linear equations are then solved from the knowledge of the solution to the nonlinear one. We predict, among other things, that the increase of γ can be made much larger than given in Ref. [5] by applying, at optimally determined positions, an array of E_{app} 's with interchanging signs.

The starting point of our analysis is the coupled particle-field equations (see Fig. 1)

$$\frac{dP_x}{dt} = -e\beta_y E_y, \quad (1)$$

$$\frac{dP_y}{dt} = -e(1-\beta_x)E_y - eE_{app}, \quad (2)$$

where E_{app} is the applied field intensity, $\beta_x = v_x/c$, $\beta_y = v_y/c$, and $B_z = E_y = -E_{y0}\sin\phi$ with $\phi = k(ct-x)$. P_x and P_y are the x and y components of the linear momentum of the particle. The energy equation can be easily derived from Eqs. (1) and (2) by multiplying Eq. (1) by

v_x and (2) by v_y and adding to obtain

$$\frac{d\epsilon}{dt} = -eE_y v_y, \quad \epsilon(t) = mc^2\gamma(t) + eE_{app}y(t), \quad (3)$$

where γ is the time varying relativistic factor which relates P_x and P_y to v_x and v_y through $P_x = m\gamma v_x$ and $P_y = m\gamma v_y$.

From (1), (2), and (3) one can obtain the solutions

$$P_x c = mc^2\gamma + eE_{app}y + K_1, \quad (4)$$

$$P_y c = -(e/k)E_{y0}\cos\phi - eE_{app}ct + K_2, \quad (5)$$

where K_1 and K_2 are constants determined from the initial conditions. We now show that the dynamical equations (1), (2), and (3) can be reduced to a one-dimensional problem through a change of the independent variable from the time to the phase ϕ . This is accomplished by introducing the new coordinate Q ,

$$Q = -(k/2c)(eE_{app}y^2 + 2K_1y), \quad (6)$$

such that $P_y = dQ/d\phi$. Using the fact that $\phi = k(ct-x)$

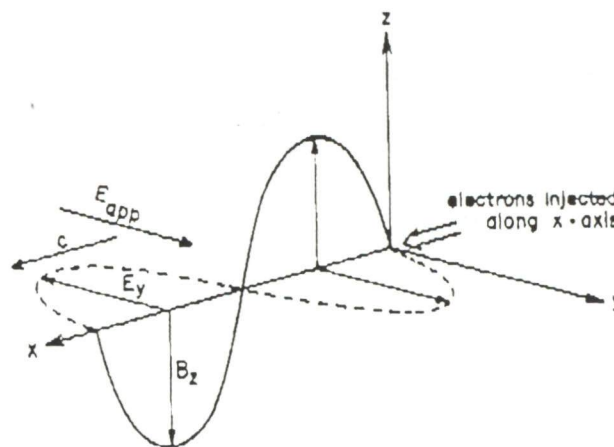


FIG. 1. The coupled electron-laser-static-field configuration.

$-v_x) = -(k/mc\gamma)(eE_{app}y + K_1)$ and from (4),

$$mc^2\gamma = \frac{1}{2} \frac{m^2c^4 + p_y^2c^2}{(K^2 - 2ceE_{app}Q/k)^{1/2}} + \frac{1}{2} \left[K^2 - \frac{2ceE_{app}Q}{k} \right]^{1/2} \quad (7)$$

Taking the derivative with respect to the phase φ of Eqs. (4) and using (5) and (7) we finally obtain

$$Q'' = -\frac{c}{2k} eE_{app} \frac{m^2c^2 + Q'^2}{K^2 - (2c/k)eE_{app}Q} - \frac{eE_{app}}{2kc} + \frac{e}{kc} E_{y0} \sin\varphi \quad (8)$$

and

$$\epsilon' = \frac{ceE_{y0}}{k} \frac{1}{(K^2 - 2ceE_{app}Q/k)^{1/2}} Q' \sin\varphi. \quad (9)$$

Equations (8) and (9) are the inverse-bremsstrahlung electron acceleration (IBEA) equations. Equation (8) is a second-order nonlinear inhomogeneous one that deter-

mines the trajectory of the particle since x and y are explicitly given in terms of Q as

$$x = \frac{1}{k} \left[kc \frac{1}{eE_{app}} \left(-Q' - \frac{e}{kc} E_{y0} \cos\varphi + \frac{K_2}{c} \right) - \varphi \right], \quad (10)$$

$$y = -\frac{1}{eE_{app}} \left[\left(K^2 - \frac{2ceE_{app}Q}{k} \right)^{1/2} + K_1 \right]. \quad (11)$$

The acceleration equation, Eq. (9), is easily solved once a first integration of (8) is done. The important feature to be emphasized here is that ϵ' is proportional to $Q' \sin\varphi$.

Before discussing the solution of Eq. (8), we analyze the expected behavior of the energy as a function of φ (or t). Clearly whenever $\varphi = n\pi$, ϵ' is zero (ϵ is maximum or minimum). If, say, at $\varphi = \pi$, $Q' = P_y$ is also zero, then ϵ is at an inflection point, $\epsilon'' = 0$. This behavior is commonly referred to as a fold catastrophe, according to the classification of Thom [6]. This catastrophe also characterizes the phenomenon of a rainbow. This behavior is shown in Fig. 2, where a case similar to that of Ref. [5] is considered, namely, the amplitude of the EM wave is $E_{y0} = 0.1E_0$, where $E_0 = mc^2/(e\lambda/32) = 1.636 \times 10^7/\lambda$ (V/cm), λ is the wavelength in cm, and $E_{app}/E_{y0} = 4.28 \times 10^{-5}$. The laser power is 3.5×10^{15} W/cm² for $\lambda = 10 \mu\text{m}$. The initial electron velocity is $v_0 = 0.9999c$. The electrons are injected at an angle of 0.608° with respect to the laser direction (along x). The figure exhibits $\epsilon(\varphi)$ and $Q(\varphi)$. The inflection point alluded to above is clearly shown (indicated by the arrow). At later times ϵ reaches a maximum at $\varphi = 2\pi$ and then just oscillates along with the wave. If the applied field is reversed at $3\pi/2$, the original maximum in ϵ at $\varphi = 2\pi$ becomes an inflection point and the particle energy is then pushed up to another maximum at 3π after which the oscillation sets in again. The net gain in energy after the first kick is about 300%, whereas after the second kick it is 600%. Thus one can double the gain by reversing the direction of the applied electric field at the appropriate time (or x). In Fig. 3 we show $\epsilon(t)$ vs t which exhibits the stair-

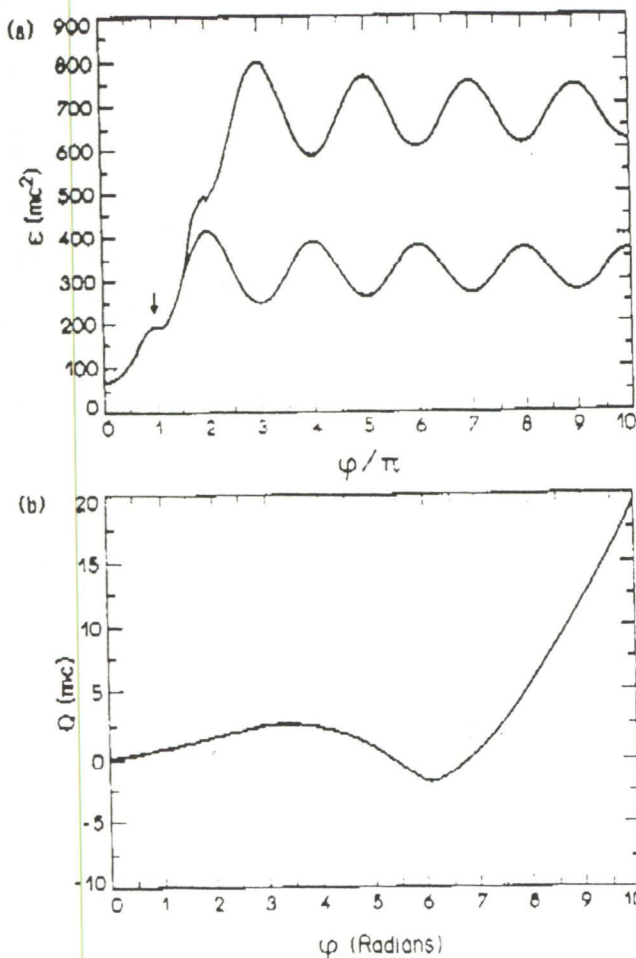


FIG. 2. (a) The energy ϵ in units of the electron rest mass mc^2 vs the laser phase. The lower curve is the result of Ref. [5], whereas the upper one is our result (see text for details). (b) The trajectory variable in units of mc vs the laser phase.

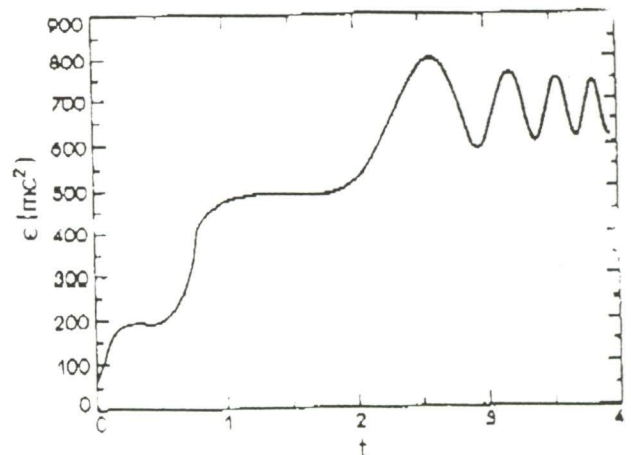


FIG. 3. The energy ϵ in units of mc^2 vs the time in units of $1.01 \times 10^6 \lambda/32c$ (see text and Ref. [5] for details).

structure of the acceleration quite clearly.

The mechanism responsible for this doubling of the gain in the particle energy is governed by nonlinear equations. We therefore call it the nonlinear amplification of inverse-bremsstrahlung electron acceleration (NAIBEA). Clearly the NAIBEA can be repeated several times by merely alternating the sign of the applied field at the appropriate phase of the wave. A simple estimate of the net gain in energy after the elapse of $n\pi$ in φ , with accompanying changes in the sign of E_{app} , is $\sim n(\Delta\epsilon)$, where $\Delta\epsilon$ is the gain after the first kick (in our case $\Delta\epsilon$ is about 150 MeV). The way to accomplish this is by arranging an array of E_{app} 's with interchanging signs at appropriate positions along the x direction. These locations are obtained from Eq. (10). The position x_1 at which the first inflection point in ϵ occurs is

$$x_1 = \frac{E_{y0}}{\pi E_{\text{app}}} \lambda + \frac{cP_y(0)}{eE_{\text{app}}} - \frac{\lambda}{2} \approx 0.11 \text{ m}. \quad (12)$$

If the applied field is reversed at $\varphi = 3\pi/2$, which corresponds to the position x'_1 ,

$$x'_1 = \frac{1}{k} \left[\frac{kc}{eE_{\text{app}}} \left(-Q'_{3\pi/2} + P_y(0) + \frac{e}{kc} E_{y0} \right) - \frac{3\pi}{2} \right] \approx 0.243 \text{ m}, \quad (13)$$

then the position of the second kick or inflection point is

$$x_2 = x_1 + \frac{2|Q'_{3\pi/2}|c}{eE_{\text{app}}} - \frac{\lambda}{2} \approx x_1 + 0.365 \text{ m} = 0.474 \text{ m}. \quad (14)$$

It is easy to show that the position of the n th reversing of the static field is given by

$$x'_n = \frac{K_2^{(n-1)} + |Q'_{(2n+1)\pi/2}|}{eE_{\text{app}}} - \frac{2n+1}{2k} \pi, \quad (15)$$

where $K_2^{(n-1)}$ is given by

$$K_2^{(n-1)} = K_2^{(n-2)} + 2Q'_{(2n+1)\pi/2}, \quad (16)$$

and the corresponding following kick by

$$x_{n+1} = x_n + \frac{2Q'_{(2n+1)\pi/2}}{eE_{\text{app}}} - \frac{\lambda}{2}. \quad (17)$$

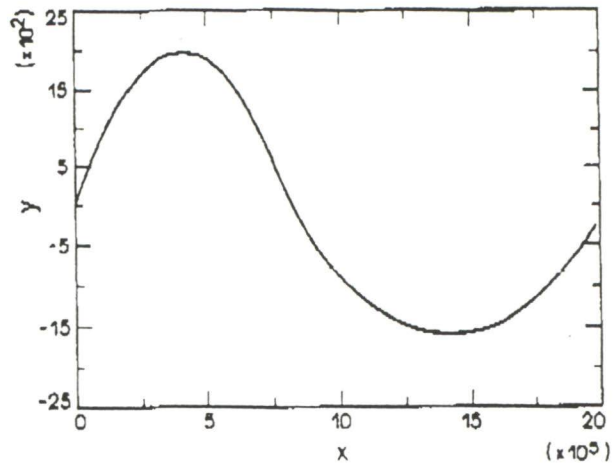


FIG. 4. The trajectory of the electron. Axes y and x are given in units of $\lambda/32$, where λ is the wavelength of the laser wave (see text for details).

The values of Q' can be calculated from the trajectory equation, Eq. (8), to which we turn our attention below. Before doing this we mention that the trajectory of the electrons accelerated with the NAIBEA mechanism is well behaved. Figure 4 shows a typical case. The dispersion (oscillation) along the y direction is quite small.

Numerical integration of Eq. (8) is quite simple. However, to gain more insight into what to expect we develop in what follows a procedure through which an analytical solution can be obtained albeit in an approximate way. To proceed we write the solution of $q \equiv Q/mc$, as

$$q = q_0 + Bq_1 + B^2q_2 + \dots, \quad (18)$$

where B is the laser parameter,

$$B = eE_{y0}/kmc^2 = 0.5093. \quad (19)$$

In Eq. (18) q_0 satisfies the nonlinear equation

$$q_0'' = \frac{1}{4} \frac{1+q_0'^2}{q_0 - k_0},$$

whereas q_1 and q_2 are both given by linear eq.

$$q_1'' + \frac{q_0'}{2(k_0 - q_0)} q_1' + \frac{1+q_0'^2}{4(k_0 - q_0)^2} q_1 = -\frac{1}{2} BG + B \sin \varphi, \quad (21)$$

$$q_2'' + \frac{q_0'}{2(k_0 - q_0)} q_2' + \frac{1+q_0'^2}{4(k_0 - q_0)^2} q_2 = \frac{1}{4} \frac{q_1'^2}{q_0 - k_0} - \frac{q_0' q_1 q_1'}{2(q_0 - k_0)^2} + \frac{(1+q_0'^2) q_1^2}{4(q_0 - k_0)^3}, \quad (22)$$

where

$$k_0 = \frac{kK^2}{2mc^2 e E_{\text{app}}}, \quad G = \frac{E_{\text{app}}}{E_{y0}}. \quad (23)$$

Equation (20) can be easily solved analytically, and from the solution, q_0 , Eqs. (21) and (22) can be integrated. The details of the full solution will be presented elsewhere [7]. In Fig. 5 we present a comparison between the analytical method, based on Eq. (18) (dashed line), and the numerically generated one. We have here an agreement to better than

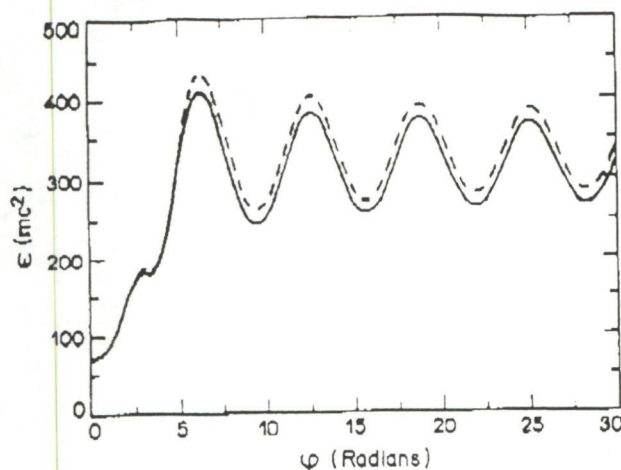


FIG. 5. Solid curve: Numerically generated solution of Eqs. (8) and (9) in the one-kick case of Ref. [5]. Dashed curve: The result obtained from the analytical method, Eqs. (18), (20), (21), and (22) (see text for details).

7% at the maxima and minima and better than 2% on the average. Therefore, for all practical purposes, the set of Eqs. (18), (20), (21), and (22) is an excellent substitute for the numerically generated solution.

In conclusion, we have further analyzed the IBEA model of Kawata *et al.* [5], and found it to be amenable to analytical treatment. We also discovered a new way of

increasing the gain in electron energy through the mechanism we coined NAIBEA. Our accelerator involves applying an array of E_{app} 's with interchanging signs at optimally determined positions. Further optimization can be obtained by adjusting (through magnets) the new "entrance" angle after every kick.

This work was supported in part by CNPq.

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OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

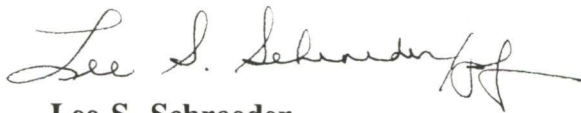
June 8, 1992

Dear Dr. Hussein:

Thank you for your recent letter and enclosed material on new particle acceleration techniques. Dr. Bromley has asked me to respond to it.

I have read your papers with considerable interest. As we have seen in high energy physics, the need to probe yet higher energies, has required ever larger machines which in turn have pushed the limits of accelerator technology outward, e.g., use of superconducting magnets. The SSC, with its present magnet design, is coming along nicely. Full size prototype dipoles will be operated in a string test later this summer at the SSC laboratory, and I am optimistic that their technical properties will allow completion of the accelerator complex by the end of the decade--assuming Congress appropriates the requisite funds. For the longer term, and future generations of particle accelerators, ideas such as yours, involving powerful lasers in conjunction static electric fields and high magnetic field magnets, need to be carefully considered. Of course, as pointed out in your preprint, you discuss a linear collider rather than a synchrotron and thus the question of achieving sufficient luminosity is a critical issue. From discussions that I have had on this subject, I would expect that considerable time and energy will be required, both on the theoretical and experimental side, to demonstrate the feasibility of the technical approach that you are proposing for particle acceleration. However, it is through such efforts as those of you and your colleagues that breakthroughs in accelerator technology occur and I wish you continued success in these endeavors.

Sincerely yours,



Lee S. Schroeder
Assistant Director

Dr. Mahir S. Hussein
Nuclear Theory and Elementary Particle
Phenomenology Group
Instituto de Fisica
Universidade de Sao Paulo
Caixa Postal 20516
01498-Sao Paulo, S.P.
BRAZIL

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TYPE: ACTION DOCUMENT NUMBER: 9200682
ORIGINATOR: 02 STATUS I DIRECTORATE STATUS

FROM: LLOYD, Jeremiah Edward

TO: DR. D.A. BROMLEY

MAR 3 1992

DATE OF
CORRESPONDENCE: 02/24/92

SUBJECT: HE IS REQUESTING ASSISTANCE WITH PROMOTING HIS
FINDINGS TO THE SCIENTIFIC WORLD.

DIRECTORATE STAFF
ASSIGNED: PHYSICAL SCIENCES ASSIGNED:

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REQUIRED: AS NECESSARY

STAFF
ACTION:

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D. Allan Bromley
Assistant to the president
for science and technology
Director of O.S.T.P.
C/O The White House
Washington, D.C.

RE

Jeremiah Edward "loyd
17641 Eastbreeze Circle
Sacramento, Calif.
95828
Tele. (916) 689-1641
Feb. 24, 1992

92 MAR 2 14

MAIL ROOM

Doctor Bromley,

Your position Qualifies you to receive and evaluate, any and all, scientific discoveries of national interest. This letter concerns significant discoveries related to the structure of atoms and molecules. My writing skills are poor, so, if you will bear with me, the message intended may be conveyed.

I need help in promoting my findings to the scientific world. These findings are philosophically proven and are further ascertained by their rationale leading to a numerical order (I found) in all mass.

This numerical order is likened unto the numbers of formation noted in the electrons configuration. I've found the electron to be a residual particle, left over from the fusion of nucleus particles and a number of formation to exist in these nucleus particles, before that of the electrons. The gravitational attraction (by these heavier nucleus particles), hold the electron, much the same as our earth "holds" its moon. I further state-- The electrons configuration is preordained by the formations of which exist in the nucleus particles.

The awesome prospect of being able to place a numerical order to molecular structure, may fill one's mind with thoughts of skepticism. The condition our environment is in and the needs of man, to find cures for the many ills that afflict us, should be the incentive one needs to overcome any doubts as to whether my claims should be investigated, or not.

I would like to present my findings to an audience, that is capable of contemplating an alternative to the (present-day) atom theory. In this alternative theory, I propose the nucleus to be comprised of particles other than protons and neutrons. These particles I've dubbed DYOLLS, as a means to identify them. DYOLL, in the singular.

I have drafted two charts that is used to establish the actual number of atoms making up any molecule. One of these charts list the number of Dyolls per atom. This chart, I refer to as--"THE DYOLL PER ATOM CHART". The second chart is one listing completed patterns of Dyolls and is listed consecutively. THIS CHART---is one attesting to the concepts of a continuum in mass, as conceived in speculating an infinite universe. Therefore, this chart is to infinity and will never be completed. This chart I refer to as "THE POTENTIAL ARRANGEMENTS OF DYOLLS". The numerical order (as noted in the electrons configuration) applies to the nucleus particles of atoms and extends beyond the electrons domain to include the number of particles in other atoms. Betwixt and between, a "compatibility" is formed to allow molecules to be formed.

This letter is not going to explain the whole of my findings, since it is only intended to instill an interest and thereby, gain me the audience I require. I've given enough information to warrant a fair hearing to my findings. A fair hearing should consist of----at least two dozen scientist who are acquainted with the present-day atom theory, but capable of contemplating an alternative. The need for those versed in advanced math (such as most physicist of nuclear physics) is nil, since this numerical order is so simple as to only require ninth grade math. The Newtonian approach to reality may have some valid use to the scientific world, but not in atomic and molecular structure. The positions they hold will fall to chemist that better understand, molecular structure and this numerical order. I claim.

If this letter has aroused any interest, I may be reached at the telephone number listed in the heading of this letter. If I am not in, please leave a message on the answering machine. Thank you for any considerations given this letter and thank you for your time.

SINCERELY:

Frederic C. Lloyd

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TYPE: ACTION

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STATUS I

DOCUMENT NUMBER: 9200222

DIRECTORATE STATUS

FROM: BROWN, Vernon

JAN 24 1992

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 01/15/92

SUBJECT: HE IS SENDING A COPY OF HIS REPORT WHICH DESCRIBES A
PHOTON THEORY OF MATTER. HE ASKS FOR ASSISTANCE IN
GETTING NSF TO ACKNOWLEDGE RECEIPT OF THEIR COPIES
OF HIS REPORT.

DIRECTORATE

STAFF

ASSIGNED: PHYSICAL SCIENCES

ASSIGNED:

ACTION

STAFF

REQUIRED: AS APPROPRIATE

ACTION:

SENDER'S DUE DATE:

OSTP DUE DATE: 02/05/92

STAFF DUE DATE

DATE COMPLETED:

DATE COMPLETED/DEPT: 1/24/92

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REMARKS:

Dr. Esh requested: forward info to Bealy & NSF.

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RECEIVED

January 15, 1991

D. Allan Bromley
Science Advisor to the President. 92 JAN 22 012:30
The White House
Washington DC

OSTP
MAIL ROOM

Dear Mr. Bromley,

The inclosed material describes a photon theory of matter which, if proven true, would greatly effect the design of any new particle acceleration experiments. Since billions of dollars are at stake, and at risk, I hope some attention will be paid to the theory.

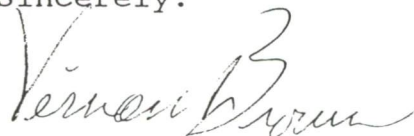
I've sent several copies to the National Science Foundation, but can't get them to acknowledge receipt of them. I don't know if they're just in shock, or I'm getting the crackpot treatment, or maybe a little of both.

You will note that the theory is very specific, testable, falsifiable, and describes mathematical relationships that anyone can see. Those traits, as I'm sure you realize, are usually absent from crackpot ideas.

Please make the inclosed available to anyone who should be interested, and if possible, get the NSF to acknowledge receipt of their copies. Six years of my effort went into this theory, and it seems that disclosure of it deserves at least a response acknowledging receipt.

Thank you, and good luck in your very challenging job.

Sincerely.



Vernon Brown
P.O. Box 1352
Cabot AR 72023
(501) 843-2659

Brown's Monthly Report

on

Photon theories of matter

Some principle uniquely right and uniquely simple must, when one knows it, be also so obvious that it is clear that the universe is built, and must be built, in such and such a way and it could not possibly be otherwise.

John A. Wheeler, "Beyond the End of Time."

BROWN'S PHOTON THEORY OF MATTER

by

Vernon Brown

According to Brown's photon theory of matter, photons comprise all of mass. An electron consists of a one-photon loop held together by the electric charge caused by the photon's bent path, and protons and neutrons are composed of similar high-frequency photon shells.

The size of any one-photon particle, such as an electron, is one half the wave length of a photon whose energy is equal to the mass of the particle. Size may thus be calculated with the equation, $d = h / 2mc$, where d is diameter, h is planck's constant, m is mass in grams, and c is the speed of light in centimeters per second.

Proton's and neutrons are composed of several electrically charged one-photon shells whose sizes conform to the above equation. The mass of the neutron's outer shell is 2.5499146 electron masses and it begins a square-of-the-shells sequence which determines the mass of three inside shells.

An electron thus has a mass of one, a neutron's outer shell(1) a mass of 2.5499, a proton's outer shell(2) a mass of 6.5021, the next smaller shell(3) a mass

of 42.2768, and the final shell(4), a mass of 1787.33 electrons. The sum of shells 2, 3, and 4 is the proton's total mass, and the sum of shells 1, 2, 3, and 4, is the neutron's total mass.

Sizes of elemental particles are:

Electron = 1.21432×10^{-10} cm.
Neutron = 4.76220×10^{-11} cm.
Proton = 1.86759×10^{-11} cm.
Shell(3) = 2.87231×10^{-12} cm.
Shell(4) = 6.79404×10^{-14} cm.

Results of electron-probe measurements made in the past indicate that shells(3) and (4) were detected and correctly measured within the accuracy of the equipment. Outer shells and electron sizes were not detected because of their relatively small energy values. These will be detected when probe energy is carefully chosen.

Protons and neutrons merge shells 1, 2, and 3 to form nuclear bonds. Proton-proton bonding force is thus shell(2) + shell(2) + shell(3) + shell(3), which adds up to 97.5578 electrons worth of force. Proton-neutron bonding force is the same plus add shell(1) to get 100.1077 electrons worth of force.

Gravity is caused by remnants of photon fields which have not been completely neutralized because opposite fields can

never catch the expanding wave front of the fields they cancel. Expanding wave fronts exist as a jumble of electric and magnetic remnants which use part of the total available electric and magnetic action of space, which is 6.6256×10^{-27} erg-seconds, (Planck's constant). A photon's point of maximum amplitude saturates at a slight offset toward increasing field strength of these field remnants because the remnants have used up part of the available action. This slight offset is the cause of gravity.

All mass is thus composed only of photons, and massiveness itself is the movement of photons. That's why moving a massive object causes it to be more massive, why mass can never exceed the speed of light, why mass and energy equate, why the theory of relativity is real, and many other things too numerous to mention in this short one-page essence.

A ten-thousand-word report is available from Photonics, P.O. Box 1351, Cabot AR 72023, free to schools.

Personalized collectors copies with your name on each page are available for \$10.00 each.

WHAT IS A PHOTON

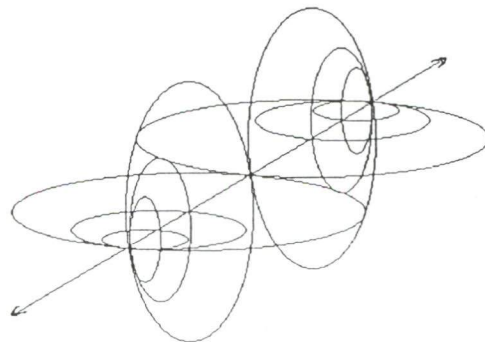
Electromagnetic propagation through space was first described by James Clark Maxwell just before the turn of the twentieth century. According to Maxwell, a changing electric field always created a magnetic field, and a changing magnetic field always created an electric field. It was like perpetual motion, because once started the changing fields chased each other through space each creating the other over and over again.

These two fields existed as crossed planes of force moving at the speed of light. An electric force was visualized as a plane extending up and down, and a magnetic force was visualized extending left and

right. The center line where the planes crossed extended forward in the direction of travel. It was like two pie plates merged through the center of each other to form crossed planes, moving edge on in the direction of least wind resistance.

Each of these were followed immediately by their exact opposite in which magnetic and electric fields were flip-flopped so that south canceled north and plus canceled minus. This whole assembly, regardless of frequency, was called a photon. It could exist with its up-down-left-right sense rotated without limit and could penetrate space in any direction.

Two photons created at the same time share the same fields. Points of maximum values occur where the electric and magnetic planes cross causing photons to appear to be particles. The photon's fields cancel or reinforce when overlapped causing photons to appear to be waves.



BROWN'S PHOTON THEORY OF MATTER.

According to Brown's photon theory of matter, at the very front end of Maxwell's photon there must naturally exist a point where electric and magnetic fields change more rapidly than at any other point. One quarter wave length back from that most forward point there must exist a point where electric and magnetic fields reach greater amplitude than at any other point. These two points must be immediately followed by similar points of exactly opposite polarity and electric charge so that electric and magnetic effects on points in space cancel to neutral after the photon has passed.

Photon fields extend outward forever from their points of maximum values diminishing in amplitude as the square of the distance. Opposite fields which cancel a field's effects can never quite catch the leading edge of the field ahead of it since both travel at the same speed. This leaves a jumble of thin string-like strips of force which move outward from all photons. They are immediately followed by their exact opposite, which cancels them to neutral.

Atoms cannot absorb these thin veils of remnant electric and magnetic fields because

atoms require the energy of the photon's point of maximum rate of change and so only absorb complete photons. For this reason, these remnant fields penetrate all mass with no resistance and very little effect. But there is some effect. These tiny remnants contribute toward the total possible electromagnetic action of points in space. This total possible action has been observed to be 6.256×10^{-27} erg-seconds, and is called Planck's constant.

When a robust photon moves through space which is partially saturated it finds less wiggle room. It must reach its total possible energy at a point offset slightly toward increasing field strength of the tiny remnant fields. The effect is a slight migration of photons toward increasing field strength. Thus the source of gravity is the photon, and the cause of gravity is photon migration.

The fields of a photon determine its direction of travel. They are usually exactly balanced, so the photon moves in a straight line. Points of maximum change and maximum amplitude of photons are observed as particles. Fields which determine the photon's direction of travel are observed as electromagnetic waves.

When a photon encounters an external force field its own fields are no longer completely balanced. This causes the photon's path to bend. When in the condition of bending its path a larger area exists on the side away from the bend than on the inside of the bend. This larger area is more powerful than the smaller area so the most forward point of the photon is pushed away. This causes the photon's path to bend more in the same direction as that caused by the external field. The amount of in-

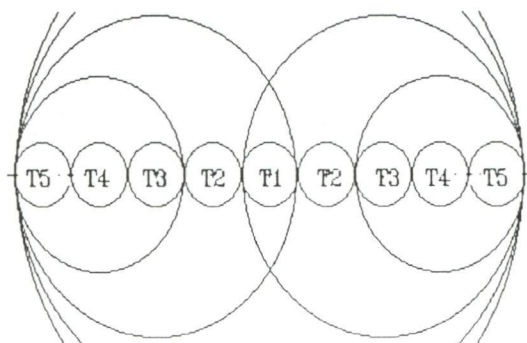
creased bending exactly matches the initial bending. This doubles the amount of bending caused by the external field. When the external field has passed, the photon's own field only produces enough unbalance to cause half the amount of bend, so its path straightens out.

Curved photon paths are thus the fundamental cause of all electric charge. All photons produce the same amount of charge when bent, but in longer wave-length photons the charge is spread over a greater area. The amount of charge is determined by the sharpness of the bend.

A tightly curved path thus produces a greater concentration of charge than a loosely curved path. Since any measurement considers the source of the charge to be a point at a distance of the radius of the curve, the amplitude always measures the same. This is the reason why all electric charge seems to be in whole units of electron charge. Actually, very high frequency photons can have charge concentrations thousands of times greater than that of an electron.

At certain high frequencies, electromagnetic forces can cause the path of a photon to bend so much that its forward point finds its rearward point. When the angle and phase of this encounter are exactly correct, the photon snaps into resonance. When in this condition of resonance, the external field is no longer needed and the photon's own unbalanced fields are enough to keep its path bent. It then remains fixed, trapped forever in a tight

A pair of photons created at time T1 move through space. All the fields of the photon's past follow it and determine where it will be in the future. Fields of other photons help to determine this also.



loop, until it is torn apart by equal or greater forces.

There are two possible directions of bend relative to a photon's magnetic plane. One of these produces a negatively charged particle and the other produces a positively charged particle. Two such stable particles are the electron and the positron.

Photons which are not of the correct frequency to produce an electron or positron are not stable by themselves, but many photons of a higher frequency can produce short-lived unstable particles. Many of these are created when atomic nuclei collide. These particles are created out of photons generated by the collision forces. They therefore have nothing to do with the composition of the atomic nuclei.

Photon loops which are not stable disintegrate by unfurling. They unfurl because their unbalanced fields produce only half the amount of force needed to maintain the bend that produced the force.

Photons therefore always find a loop which is stable when their original bend is great enough and their frequency is within the range of stability.

The diameter of any one-photon particle may be calculated. In the c-g-s system of measure, Einstein's $E = mc^2$ and Planck's $E = h\nu$ can be restated to solve for this diameter.

This restatement yields $d = h / 2mc$ where d is the diameter, h is Planck's constant in erg-seconds, c is the speed of light in centimeters per second, and m is mass in grams. Using this equation to calculate the size of an electron, one obtains, 1.21431×10^{-10} cm.

This is at least seven orders of magnitude larger than scientists had thought in the past. They probably failed to find electron structure because they were looking for an impenetrable sphere instead of a photon ring. Since a hydrogen atom is 7.5×10^{-9} cm in diameter, there is still plenty of room for the electron, which is about seventy times smaller.

Photons thus comprise all of mass. They are the cause of all observed phenomena. Their role in the creation of mass has been obvious and has been observed repeatedly for over a hundred years. Einstein even said it is several of his papers. In one paper published in 1927, he stated, "People gradually got used to regarding the electromagnetic field as the final irreducible constituent of physical reality."

Had Einstein followed through on this idea, he would surely have succeeded in his most sought-after goal. He would have unified all the forces over fifty years ago. Science would have had a fifty year head start.

Instead, we struggle here today trying to show a reluctant world a great truth that brings reason back to the physics. Students now abandon unreasonable physics at an increasing rate. How sad if we fail.

WHAT IS MASS

According to the theory of relativity and according to what is observed, adding movement to any massive object makes it more massive. Some portion of the massiveness of any moving object must therefore be due only to movement.

All the components of mass are in a jumble of related motion. Protons, neutrons, electrons, atoms, and molecules comprise mass; they all vibrate and orbit and whiz around inside of mass. So rest mass can only be imagined, never really measured, but most scientists assume that there is a fundamental kind of massiveness called rest mass. So, now we have massiveness which is due only to movement, and another fundamental kind of mass called rest mass.

But, can the cause of massiveness really be two fundamentally different things?

It is not reasonable in nature that there could be two fundamentally different kinds of massiveness. Rejecting that notion, one is left with the obvious. All massiveness is really only the movement of some fundamental thing in nature.

Searching through ideas of the past, one quickly finds that massiveness has been described with an equation that

contains only one variable and two constants. The variable it contains is the rate of change, or movement, of electromagnetic fields.

This simple equation can be derived from Einstein's $E=mc^2$ and Planck's $E=hv$. When taken together and solved for mass the result is $m=(h*v)/(c*c)$. The only variable on the right side of the equation is v , which is the movement of electromagnetic fields expressed as frequency.

Gamma-ray photons are observed to become electrons and positrons. Scientists in the past thought the energy of the gamma-ray photons separated virtual electron-positron pairs which existed naturally and invisibly in all of space. But given the reasoning above, that cannot be what really happens. What must really happen must simply be exactly what is observed to happen and nothing more. Gamma-ray photons are observed to become electrons and positrons.

When electrons and positrons collide at speeds near the speed of light, protons and neutrons are created in the collision. Protons are observed to be almost exactly 1836.11 times more massive than electrons, and neutrons are about 2.5 electron masses greater than that.

Atomic destruction of protons and neutrons produce distinc-

tive patterns showing that three jets of matter explode out of the particles. Protons should then be composed of three photons. If so, neutrons must be composed of four photons in order for electric charges to cancel.

Subtract the mass of a proton from that of a neutron and the result is, 2.549914546 electron masses. This could be considered to be the mass of the outside shell of the neutron. Using the two equations given above, we can solve for the diameter of this outer shell. Its diameter would be $= h / 2mc$ which turns out to be 4.76219×10^{-11} centimeters.

Square the above 2.549914546 and the result is 6.5020642 which could be considered to be the mass of the outside shell of the proton. Calculate the proton's diameter using the above equation and the result is 1.86759×10^{-11} centimeters.

Square the above 6.5020642 and the result is 42.2768 electron masses. This could be considered to be the mass of the in-between shell of the proton, which calculates to a diameter of 2.87231×10^{-12} centimeters.

Square the above 42.2768 and the result is 1787.33 electron masses. This could be considered to be the mass of the inside shell of the proton, which is 6.79404×10^{-14} centimeters in diameter.

Add the masses of the inside three shells and the result is 1836.11, the proton's measured mass. Add the mass of the neutron's outer shell to that, and the result is 1836.66, the neutron's measured mass.

Add the mass-energy of the middle and outer shells of two protons and get 97.55, the observed proton-proton binding force of the strong nuclear interaction; add the neutron's outer shell to this and the total is 100.10, which is the observed value for neutron-proton strong nuclear interaction.

Merging a proton and neutron together, there would at first be a repelling force as the two positive shells passed through each other. This weak force matches the value of the weak nuclear interaction.

Since an electron's mass is less than the outside shell of a neutron, the electron must be larger in diameter than either a proton or a neutron. Scientists have observed this, but preferred to call the condition

a fuzzy character of the electron. They insisted that the electron was actually a point charge which they considered to be at the center of the electron's photon shell. Using the equation above, an electron is calculated to be 1.21431×10^{-10} centimeters in diameter. This is still much smaller than a hydrogen atom which has been measured to be about 7.5×10^{-8} centimeters in diameter.

When left alone, neutrons always throw off their outer shell after an average time of about 898 seconds. This outer shell then expands to become an electron with some free photons and possibly an anti-neutrino left over. What is left of the neutron, naturally is a proton.

Photon frequency is infinitely variable, so there is an infinite range of energy values available to photons. What is observed, however, is that mass will absorb and emit photons only in discrete bundles of energy. There must be a

natural and reasonable explanation for this.

The reason may be that photons must exist in mass in a condition of resonance. Schrodinger showed many years ago that electrons can only exist in orbits that allow this resonance. His elaborate study was called, wave mechanics, and went very close to describing mass without the need for the idea of particles.

Falsifiability.

Any scientific hypothesis must be subject to tests which could possibly prove it false. Scientists call this quality, falsifiability.

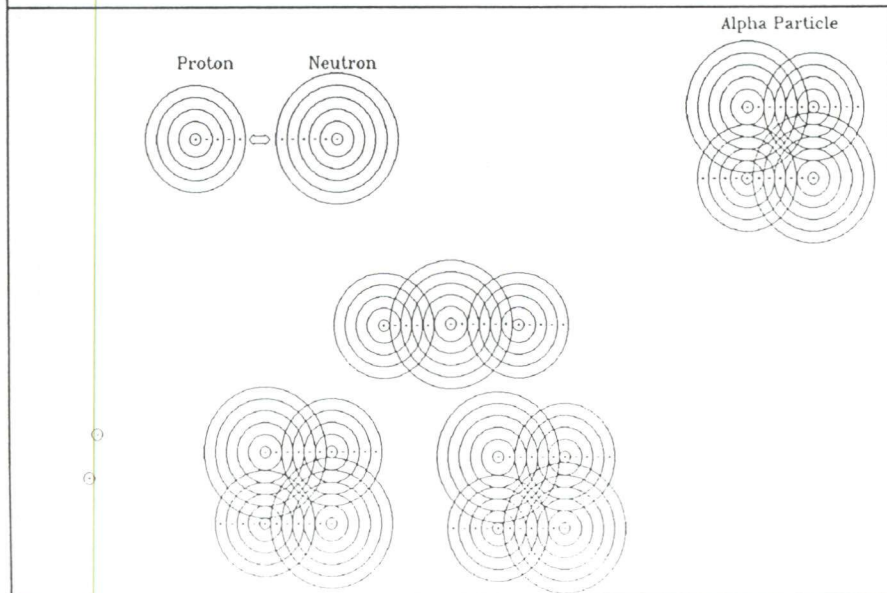
Brown's photon theory of matter is falsifiable. Following are some testable predictions that could prove fatal.

(1) Bending the path of a photon produces an electric charge. This is the fundamental cause of all electric charge. There is no other cause.

Amplitude is that of an electron measured at the distance of the center of the radius formed by the bend. All photon bending will thus produce the same amount of measured charge. It is impossible, therefore, for any measurement to be other than in units of electron charge when considering the source to be a point. This rules out the existence of quarks or anything else with partial electron charge.

(2) Diameter of an electron is 1.21431×10^{-10} cm.

The strong force is caused by the sharing of the outer photon fields when a proton and neutron merge together.



(3) Diameter of a neutron is 4.76219×10^{-11} cm.

(4) Diameter of a proton is 1.86759×10^{-11} cm.

(5) Neutrons and protons exist as shell structures.

(6) The innermost shell diameter is 6.79494×10^{-14} cm.

(7) The next shell diameter is 2.87231×10^{-12} cm.

(8) Neutron mass is proton mass plus shell 1 mass.

(9) Proton-antiproton collisions at the lowest possible relative speed will produce unstable decay particles near in value to the square-of-the-shells values for proton components. These are 1787.33, 42.2768, and 6.5020642 electron masses, and various combinations of these.

(10) There is no component of mass which cannot become photons.

(11) Electric charge caused by bending the path of a photon

produces positive feedback which bends the path of the photon more in the same direction. Amount of feedback is just enough to cause bending of one half the amount of bend that produced the charge.

(12) Photons moving perpendicular to a gravity source will be red shifted and their paths bent toward the gravity source. Amount of bending will be double the amount caused by gravity because of the feedback described above.

(13) Photons are the fundamental and only source of gravity.

(14) Photon migration is the fundamental and only cause of gravity.

(15) Photon frequency--movement--is the fundamental and only cause of massiveness.

(16) Energy content of the elementary particles constitutes the totality of the particles.

(17) If electrons only move through space perpendicular to their direction of spin, a statistical analysis of the spin planes of electrons at rest will show them to favor an alignment perpendicular to the direction of the constellation Leo.

Many details of the Brown's photon theory of matter need yet to be solved. Those who begin this study now can occupy the ground floor of the greatest change in understanding physical reality that has happened in the twentieth century. Reality is very persistent. It remains real, no matter the credentials or the power of its advocates, or its detractors.

DICK BARTHOLOMEW, ROD JOHNSON DIALOGUE WITH VERNON BROWN

on

AN ELECTROMAGNET FORMAT FOR MATTER REALITY

BJ SERIES-1

We are in complete agreement with your thesis that photons comprise the observed elemental sub atomic particles. That is the natural extension of where ideas on sequenced reality sort of blend with quantum thought. As you note from the material sent my main contribution to the questions around a unified field theory is a conceptual one.

From our more intimate examination of your Photonics theory the first area of question lies in implications of the elemental periodic chart. How do photons fit in the inner structure of elemental matter? How do they provide insight to what is valance electron charge. As the composition of elemental particles photons seem to answer all of the observed free space phenomena and quantum calculations around them. However, in the virtual reality of the sub- molecular they would inherit all of their inertial problems. As long as the photon composite of electrons protons and neutrons are couched in atoms in molecules they do not simplify the foundation of matter. The particle in-

finiteness is simply extended through some plausible variation in photon mechanics. Light itself is a myriad phenomenon not a finite.

So photons seem to be the perfect answer for the mechanism of energy-force transitions in real space. They certainly supersede the difficulty of inertial particles that limp along on a superimposed wave technicality.

The Photonic application is very compatible with sequency at the level of matter reality that the sequential theory defines as the limit threshold of matter. In this light, real space, everything outside of the limit threshold of matter, could be called the photon reality. However, within the limit threshold the possibility of just photons has two possible problems in explaining physical phenomena.

The first is, that as the finite, the theoretical electromagnet structure of photons does not lend itself well to the infinite structures of molecular mass. The perpendicular phase of photons would need some ex-

plained discrepancy in their nature or origin to provide the varied phasing required in the construct of elemental mass.

The second is that in order to justify the force energy relationships seen as the basis of particle theory, photons have to behave as inertial particles also. It is this inertial behavior within the atom that generally frustrates the overall quantum construct as a finite medium. Photons as the composite of particles would have the same possible affinities as do charged particles. Photons would justify the electrodynamic phenomena but would add little to the proposed physical dynamics. Hence if Photonics theory is holding to the inertial dynamic of electron, proton, nucleus within atoms as a construct of molecules then there is much left to be explained.

This part of the question is understandably vague as it relates to a wide variety of quantum phenomena. It is not actually dealt with in the Full Report on Photonics and may need expansion.

COMMENTS

by

Vernon Brown

As pointed out in the material from Mr. Rod Johnson and Dick Bartholomew, there are many ends to be tied up in Brown's photon theory of matter. There are also many realities yet to be discovered.

One is the structure of a photon. There may be an infinite variety of things elemental to the photon, but the photonics hypothesis does not

explore them. It was not intended to; it merely unified all forces at the photon level.

What is agreed is that electromagnetic forces comprise the whole of the universe. Realities that may be discovered are such things as the size and structure of the elementary particles. These things are bound to be discovered; experiment will agree with one concept or another.

The Bartholomew-Johnson SEQUENTIAL PHYSICS, like the photonics hypothesis,

has some weaknesses. In its present state, it has not provided a set of predictable phenomena that may be tested by experiment. It has not yet solidified into a form that can be pinned down to expose potential fatalities. So, I would ask Mr. Johnson and Mr. Bartholomew, what is a discovery that if that discovery were made in the future, would prove fatal to their Sequential Physics?

RELATIVITY IS REALLY SIMPLE

by

Vernon Brown

Einstein thought of two people at opposite ends of a railroad track. They wanted to flash a light signal at each end of the track at exactly the same time. This required some setup and testing which they did by flashing a signal light in time with a clock and asking an observer stationed at mid point between them if the flashes happened at the same time. When the observer said one flash happened before the other they adjusted their clocks and tried again. They did this over and over until the observer said the flashes happened at the same time.

Einstein then placed the observer on a moving railway car and noted that the observer moved some distance while the two flashes of light were in route. This caused the observer to see the forward flash before the rearward flash, and the time difference could be used as a measure of the speed of the train.

After a time the two experimenters decided to invent a speedometer using this principle. First they put the light flashers on the train and put the readout in the middle, just as before. They then synchronized their clocks before the train started in motion.

From their observation post at the center of the train, they saw the forward flash then the rearward flash as the train accelerated. The time between flashes exactly matched their speed. Their speedometer worked.

But, Einstein pointed out that in order for this speedometer to continue to work, each clock must be kept in sync with the other. So, while they were still moving, the inventors hauled the clocks back to the center of the train to make sure they showed the same time. Lo and behold, when the clocks were side by side at the observing post they were not in time with each other. But, that was okay; the inventors simply adjusted the clocks so that each showed the same time and moved them back into position at opposite ends of the train.

Then the two inventors found something very strange. Flashes of light from both ends of the train happened at exactly the same time. That showed the train speed to be zero. Worse still, when the train slowed to a stop, the rear flash happened first showing the train to be backing down the track. Their speedometer didn't work anymore.

Einstein explained that the problem was in the moving of the clocks. In order to bring the clocks side by side, the rear clock was moved faster than the

train and the front clock was moved slower. That difference in movement caused the clocks to change by the exact amount needed to indicate the speed of the train. After the clocks were adjusted to show the same time, moving them into position caused the reverse action wherein the clocks changed by the exact amount to show the train to be motionless.

Einstein used a series of these thought experiments to show that it was impossible to measure any motion except relative motion. He showed also that it was not only clocks that changed when they moved but mass became more massive, physical size changed and other strange things happened as well. That was the essence of his theory of relativity. It was so very simple that most anyone could understand it.

What was not so simple was, why did clocks and other material things behave that way? Einstein offered no reason why. He simply stated what was observed in terms that most could understand, then went on to prove his explanation in mathematical terms that only a few could understand. Most who thought Einstein was wrong really objected to the observations, not with Einstein's ideas about them.

Einstein figured all this out using just two simple ideas that

were taken to be facts because of observations. These were:

(1) All laws of nature must be the same in one inertial frame of reference as in another.

(2) The speed of light must be the same in one inertial frame of reference as in another.

An inertial frame of reference is any physical place like inside a box, or on a planet, or on the moon, etc.

Using these two ideas, he went through one page of equations which started out very simple then gradually reached the complexity of a pretty stiff high school algebra course. His end result was the Lorentz transformations which must be used to fully describe the shape,

weight, and time experience of any massive body in motion.

But, Einstein may have been wrong about the most fundamental thing in his theory. Two scientists at Bell Labs found that an electrical background noise poured down on Earth from all directions in space. Close observation showed this background radiation to be doppler shifted--that action that causes a train whistle to be higher pitched when the train is approaching than when the train is going away--due to the earth's motion through it. Measurements showed the earth to be moving through this radiation at about

300 miles per second toward the constellation Leo.

Einstein, who was correct in almost everything he predicted, may have been wrong about his most closely held assumption. That assumption was that there was no such thing as absolute motion against fixed space and time. That assumption may have cost Einstein his most prized lifetime goal. He struggled most of his life for it, but could never quite find a unifying principle that showed all the forces of nature to be one. Could it be that this unifying principle required the idea of fixed space and time? Brown's photon theory of matter shows that it did..

PHOTON LIFE STORY

Deep in the churning bowels of fury that formed the center of an old galaxy, a photon was twisted into being from the torture of plasma debris. Other photons were absorbed by atoms and spit out again, but this photon was so energetic with such a high frequency that atoms did not absorb it. It was a high energy gamma-ray photon.

Most photons bounced around in the star for years before finding a way out but after only a few months, this new photon found the edge of its star of birth and its path straightened, free of interfering forces for the first time. It sped away at its natural speed of light, slowed only slightly by the pull of the huge star's gravity.

Sometimes, as it wandered through space for billions of years, the photon would pass other photons. Most of these were low in frequency and so were not energetic enough to bother this photon at all. But, once every few billion years or so, another photon of great energy would pass close enough to bend this photon's path.

Then, one instant billions of years after its birth, this photon passed almost dead center through another gamma-ray photon. The bending of paths caused by the high energy fields of both photons curled each into a loop so tight that they

passed right through themselves.

Immediately after the encounter, this photon began to unfurl toward a straight line again, because its unbalanced field provided only half the force needed to sustain the bend that created the unbalanced field. On its way to a straight line the photon unfurled through its own fields. Its forward end began to feel the in-phase condition of its rearward end as it unfurled toward it. Then, there was a snap of resonance and the power was enough to keep this photon's path locked in a tight loop just 1.2143×10^{-12} meters in diameter.

It spun there, chasing its tail at the speed of light, a curling cork screw migrating slowly through space. Spinning thus, it kept its magnetic plane curled into a north-south pole that pointed toward the direction of movement. This photon had become an electron. Close by, spinning at the speed of light and moving slowly away, there was a positron that was created in the same collision.

Opposite fields of the electron sped through fields of the positron and those of the positron moved through those of the electron. But the force of the fields diminished as the square of the distance. Their force diminished too fast to pull the particles together again.

This electron spun through space for more billions of years. Because of its unbalanced charge it felt force fields thrown out by galaxies far away. These increased the electron's speed. It was finally spiraling along at almost the speed of light.

Then, one instant, a positron came by and force fields collided. Crossing lines of force began to spew out low energy photons that grew more and more energetic. Then there was the most violent instant when centers of force fields intertwined.

The photon found a piece of itself curled tightly as it had been at the time of the electron's birth, but about forty two times as tight as before. It unfurled around a piece of the positron that was curled 42 times more tightly than itself. There it quickly found resonance.

The inside positron shell was only 6.7940×10^{-16} meters in diameter. And this new tightly squeezed electron was only 2.8723×10^{-14} meters in diameter.

Just then, a piece of positron curled around this electron, sucked in by the opposite charge. Its diameter was just 1.8676×10^{-13} meters in diameter.

Finally, one last electron loop about 2.5 times as energetic as a normal electron formed

making four loops in all. A neutron was born, and close by, vibrating and spinning away, was an anti-neutron formed out of the same collision debris. Each neutron's outside shell was 4.7622×10^{-13} meters in diameter.

But the neutron and anti-neutron both threw off their outer shells becoming a proton and an anti-proton. The proton soon picked up an electron that orbited it at a diameter of 7.5×10^{-9} meters.

It was then a neutral atom, and was no longer bashed about by force fields, but it did feel tiny remnants of photon fields. These tiny remnants were both electric and magnetic, but so weak they did not react either electrically or magnetically. The only reaction was a very weak tug toward the direction of greater intensity of the remnant fields.

After a few billion more years, this atom found itself among others of its kind. There was a huge cloud of them, churning around, colliding, bouncing away, absorbing low energy photons into themselves and converting their energy into movement.

This cloud grew more dense, squeezing itself into swirls of hot energetic atoms. Then, one instant, squeezed into frenzied movement, this hydrogen atom found itself nudged by a neutron. It merged right through the neutron's outer shell, and found itself bound by the force of its number 2 shell, its number 3 shell, the neutron's number 2 shell, the neutron's number 3 shell, and the neutron's outer shell. Added together, these shells

had force equal to that of 100 normal electrons. It was the strong nuclear force.

Shortly after, another proton which had itself bound with a neutron came crashing in and the two bound together forming a helium atom. This released some photons which were absorbed by nearby atoms, boiling them into even more frenzy. Many atoms bound this way until the massive swirl of hydrogen erupted into a star.

The star exploded into life with such force that it blew away the hydrogen gases that were not near enough to be held tight by its gravity. Some rocky debris remained close in, however, and these began to clump together after a few million years.

Churned and bounced in the middle of the star, the helium atom which was formed of the proton which was formed of the original photon, was constantly tormented. It collided with ever increasing energy with others of its kind. Toward the end of the life of the star, about ten billion years after its birth, this torment grew to the point that helium atoms combined with each other.

But this was not the end. The cycle kept going until heavier and heavier elements were formed. Then one instant, there was a gigantic increase in pressure and many heavy elements fused. Iron, carbon, and all the elements of nature were among the products.

This aging star could not survive the stress. It collapsed upon itself, then blew apart with a shock wave that carried much of itself out into space.

Left behind was a very dense core that smoldered and cooled with age.

The original photon was now combined with others in a carbon atom that drifted away from the dying star. For billions of years this carbon atom moved through space, until it was caught up in another cloud of young hydrogen atoms. Finally, out of this cloud, another star was born. But this time, the carbon atom found itself in a rocky clump of debris ninety three million miles from the center of star birth.

This carbon atom was among the debris of the third debris ring from the star. There was another ring of rocky debris further out, and some gaseous rings after that.

After a few million years, these rings coalesced into planets. A few billion years more and the fourth planet from the star cooled into a water cycle. This was the temperature that allowed water to be liquid on its surface.

Life teemed on the water-rich fourth planet, but on the third planet, this carbon atom simmered in heat. Liquid rock flowed so hot that there was no place for life. But, a couple billion years later, the third planet cooled into its water cycle. This carbon atom was caught up in life.

First it lived in crawling things, which lived and died and were eaten by others. This carbon atom moved through life after life, and age after age being recycled through birth and death of living things.

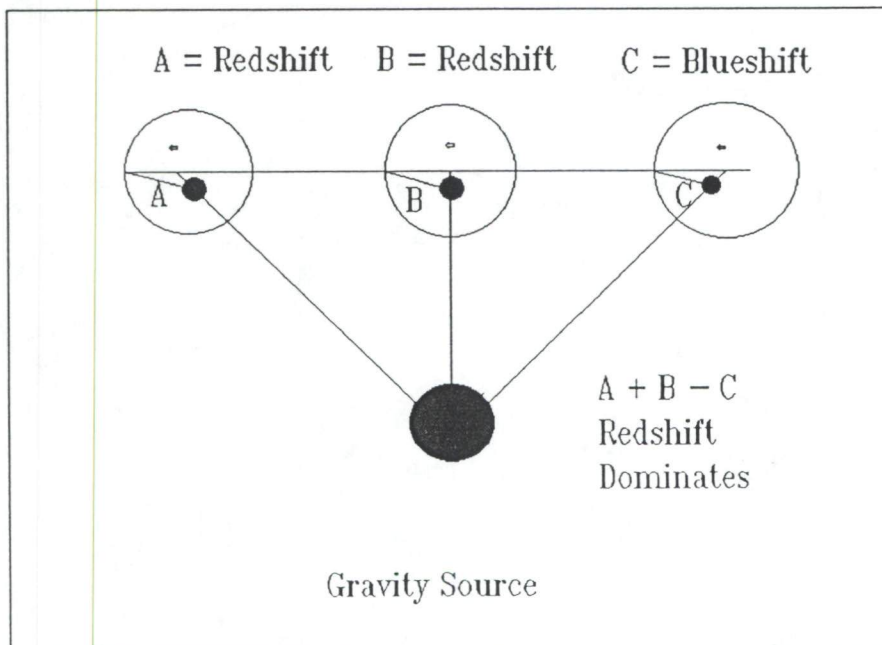
After a couple more billion years, the third planet cooled till water could only be ice and

its atmosphere grew thin. Life forms ended on the third planet, but a few million years later, the second planet cooled into its water cycle. Life flourished there for about two more billion years.

Then, all was still in the aging star system. Life was gone and it grew old. Its first death came with an explosion that spread its debris into space to create other star systems. Many billions of years later, its second death came in the center of its aging galaxy.

Deep in the churning bowels of fury that formed the center of this old galaxy, a photon was twisted into being from the carbon plasma gas of this dying atom. Other photons were absorbed by atoms and spit out again, but this photon was so energetic with such a high frequency that atoms did not absorb it. It was a high energy

gamma-ray photon. It went on and on and on in this repeating cycle from ever and ever ago to forever and forever again.



Redshift dominates because a photon's point of saturation is offset toward a gravity source. The hypotenuse of the angle formed by this offset is longer most of the time. A longer hypotenuse means a longer wavelength which means a red shift.

FOR COLLECTORS

Brown's photon theory of matter ties all observable phenomena together in one cohesive, simple, and easily understood idea that is reasonable and can not be proven false. As it continues to survive the scrutiny of great thinkers in the established scientific community, copies of these first original papers grow more and more valuable. Photonics is maintaining a list of those who own original personalized papers. This list of owners will be available to future collectors who may wish to bid for the purchase your original.

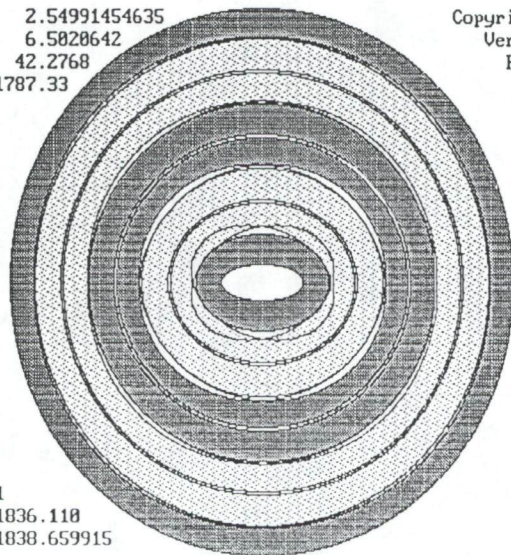
The price is yours to set, but we suggest that no one accept a bid less than \$20.00 per month since the issue date of their copy. No one should accept less than \$1000.00 for the November 1991 issue which contained the first account of the neutron model. No one

should accept less than \$10,000.00 for original copies of the August 1989 issue of Factory Product News, which contained the first published account of the Photonics hypothesis. The article was called, "The Electromagnetic Theory of Everything."

Owners are urged and hereby authorized to make copies of their originals and send them to anyone who may be interested. Each copy must be clearly marked to protect the value of your original. This can easily be done by taping a little piece of paper marked, "COPY," to the glass plate of the copier or the original. The most valuable original will surely be that one that sets off the explosion of interest in the scientific community. It could be your original that does it.

shell 1 mass = 2.54991454635
shell 2 mass = 6.5020642
shell 3 mass = 42.2768
shell 4 mass = 1787.33

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Vernon E. Brown
P.O. Box 1351
Cabot AR 72023



electron mass = 1
proton mass = 1836.118
neutron mass = 1838.659915

NEUTRON MODEL
Version 911118

Electron size = 1.21432×10^{-10} centimeters in diameter
Neutron size = 4.76220×10^{-11} centimeters in diameter
Proton size = 1.86759×10^{-11} centimeters in diameter
Shell 3 size = 2.87231×10^{-12} centimeters in diameter
Shell 4 size = 6.79404×10^{-14} centimeters in diameter

Model of neutron shows four photons phase locked front to back and inside to outside. Photons complete one frequency cycle each trip around circle. Mass-energy of each circle is the square of the next circle out. Outside circle mass-energy is proton mass-energy subtracted from neutron mass-energy. Strong nuclear force is shell 2 plus shell 3 doubled then add shell 1.

Dark shading is negative fields, light is positive fields of photons.

In c-g-s units of measure
Shell size = $h / 2mc$

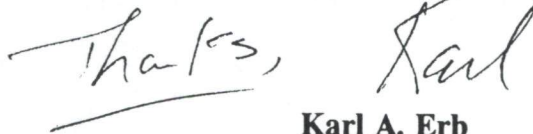
EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

January 28, 1992


Dear Dr. Berley:

Would you please ask someone to reply to Mr. Brown concerning the attached correspondence?

Sincerely,



Karl A. Erb
Acting Associate Director for
Physical Sciences and Engineering

Enclosures

Dr. David Berley
Division of Physics
National Science Foundation
1800 G Street, N.W.
Washington, D.C. 20550

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

January 28, 1992

Dear Mr. Brown:

I have forwarded the material you sent to OSTP, concerning your Photon Theory of Matter, to the National Science Foundation Physics Division.

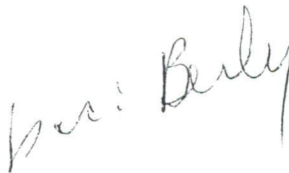
The appropriate official from the Foundation will correspond directly with you.

Sincerely,

A handwritten signature in cursive script, appearing to read "Karl A. Erb".

**Karl A. Erb
Acting Associate Director
for Physical Sciences and Engineering**

**Mr. Vernon Brown
P.O. Box 1352
Cabot, AR 72023**

A handwritten signature in cursive script, appearing to read "Vernon Brown".