International Journal of Scientific Advances
ISSN: 2708-7972
Volume: 4 | Issue: 3 | May – Jun 2023 Available Online: www.ijscia.com
DOI: 10.51542/ijscia.v4i3.16

On The Nature of Tachyons and The Pioneer Anomaly

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ABSTRACT

One considers tachyon repulsive force f from intergalactic space, by Takaaki Musha, as responsible for the rotation speed of galaxies, as not due to dark matter. Comparisons are made between this tachyon force f and dark energy, as an possible explanation for the pioneer anomaly, and considering the inertial effects of tachyon force f being nonlocal upon the pioneer spacecraft, arising from the vacuum zero point field ZPF, and introduce Mach's principle as an effect of tachyon force f having an effect on the pioneer spacecraft from the future, because tachyons are regarded as travelling into the past. One considers various papers by other authors, and come to the conclusion that the reason tachyons may be undetected, as due to relativistic effects where an observer reference frame sees tachyons as ordinary particles, and that because tachyons also travel into the past, in a region of spacetime inaccessible to an co-moving observer, as why tachyons are not observed. But I also present experimental evidence of the detection of tachyons.

Keywords: tachyons; nonlocal; vacuum ZPF; dark energy; pioneer anomaly; Mach's principle

INTRODUCTION

I consider that the parameter f which is the repulsive force of tachyons, or field in intergalactic space from the vacuum, that Takaaki Musha [1] put forward this idea in his book, Tachyon Universe, as observed of the rotation speeds of galaxies, and considered this in relation to dark energy to the pioneer anomaly, and where both f and dark energy have a repulsive force. That I then decided that dark energy is far too weak a force on the scale of the Solar system to be responsible for the pioneer anomaly, (an unexplained Sunward acceleration by the pioneer spacecraft) and consider that f field may have a stronger effect in the Solar system for the pioneer craft?

I further consider that tachyon particles nonlocally interact with all particles in the universe, and that this is a possible inertial effect the pioneer spacecraft feels from the future. Because tachyons are travelling into the past. One further considers this in relation to Mach's principle in regard to advanced inertial effects from all distant matter in the Universe, and write out an equation for Mach's effect in relation to advanced potentials to m_i which is considered to have advanced and retarded signals, m_i=Q_((a))=1/2 [F_((a))^R-F_((a))^A] that this effect is also nonlocal.

Then I introduce experimental evidence of tachyons, with strong Cherenkov radiation and from other experiments from Tritium β-decay of electron neutrino's, is shown that from experiments, the square of the electron neutrino rest mass seems to be negative, which implies that the electron neutrino has an imaginary rest mass and are therefore tachyons. That these tachyons may propagate into the past, and I introduce the idea for an experiment with tachyons, where one could test out the possibility of creating a causal paradox, now that tachyons have been detected in experiments.

I then consider several papers by different Authors, on tachyons, and arrive at different view points, that tachyons may arrive from the vacuum ZPF in relation to a Machian cosmic reference frame in relation to Abraham Lorentz force, that may have effects from the future. In another paper one considers MOND in relation to tachyons and the comological constant and considered that regarding this, also lends itself to nonlocal effects for the tachyon field f and the vacuum ZPF repulsive force, leading to the pioneer anomaly. From another paper, considering relativistic effects of an tachyon observer, one comes to the conclusion that from the reference ∑frame of an observer, tachyons would be travelling into the past ∑^' and that ∑ would see tachyon ∑^'frame as coming from the future. That to different observers frame of reference, tachyons might appear as ordinary particles (bradyons) and that this may explain why they have not been detected. But that earlier in this paper I show experimental evidence for the existence if tachyons. I then consider the nature of tachyons in relation to equations of the force of tachyons, that such a force has to propagate into the past, and further consider the nature of work and energy of the tachyons as also propagating into the past.

ON THE NATURE OF TACHYONS

Takaaki Musha in his book[1] Tachyon Universe, argued that if virtual tachyon pairs from the vacuum ZPF radiate electromagnetic energy by Cherenkov radiation, that they fill intergalactic space of the Universe, he argues that the rotation speeds of galaxies is effected by an tachyon field in intergalactic space, and that dark matter does not exist. Takaaki Musha introduces the parameter f which is the repulsive force of tachyons, where the kinetic equation of stars can be given by;

$$m\frac{v^2}{r} = \frac{M(r)m}{r^2} + f$$

He suppose $f \approx m\alpha$ where α is the acceleration of stars induced by the repulsive force of tachyon field leading to;

$$v \approx \sqrt{\frac{GM(r)}{r} + \alpha r}$$

Takaaki Musha uses different values of α, and $\alpha = 0$, he obtains the velocity curve of a disc galaxy without the repulsive force of tachyons and it does not match observations of the rotation curve of the galaxy. For $\alpha = 0.01$ for tachyon force, he has a velocity curve that matchs observation rotation curves of galaxies.

The question is then, dose f effect and lead to the effects of the pioneer anomaly? We will come back to this question later. Could f be related to dark energy leading to the pioneer anomaly, of an unexplained Sunward acceleration of $8.74 \pm 1.33 \times 10^{-10} ms^{-2}$ seen in the behaviour of the pioneer probes? f is a repulsive field of tachyons, yet dark energy is also regarded as a repulsive force, are they the same?

I/D/Novikov in his book, 'Evolution of the Universe'[2] on page 60-61 he argues about how the Soviet physicist Ya. B. Zel' dovich put forward arguments that demonstrate how a non-vanishing energy density of the vacuum could emerge, that the vacuum exert an pressure which must be negative, in regard of an gravitational repulsion of the vacuum. Of course if tachyons appear from the vacuum, this would also lead to a pressure or force which must be negative. From the calculation;

$$a_{vac} = -\frac{4}{3}\pi G(\rho_{vac} - 3\rho_{vac})R = \frac{4}{3}\pi G 2\rho_{vac} R$$

Novikov finds that the gravity of the vacuum is not attractive, but repulsive, that this stems from the fact that the vacuum pressure is negative. This is what is called dark energy, as we regard f also being repulsive, but is it the same as the supposed tachyon negative repulsive field f. It is regarded by Takaaki Musha, that tachyons arrive from the vacuum. Is this repulsion due to tachyon force leading to the pioneer anomaly?

On a large scale dark energy is considered to be responsible for the accelerated expansion of the universe. But it is too weak on the scale of the Solar system to have any notable effect to be responsible for the pioneer anomaly. But one could speculate and take the view, that perhaps tachyons that arise from the vacuum might have a stronger effect on the scale of the Solar system to cause the pioneer anomaly?

From the above consideration, how would tachyons interact with ordinary matter, and effect the pioneer spacecraft. One consideration is that virtual particles are nonlocal, that nonlocality of tachyons suggests that tachyons interacts with all particles in the universe. I here start answering this question with an equation on nonlocality of two particles.

The quantum state of two particles prior to measurement is:

$$\text{I}\psi AB >= \frac{1}{\sqrt{2}}(\text{I}0 >_A \text{I}1 >_B - \text{I}1 >_A \text{I}0 >_B)$$
$$= \frac{1}{\sqrt{2}}(1 + >_A \text{I} - >_B - \text{I} - >_A \text{I} + >_B)$$

Where $\text{I}\pm> = \frac{1}{\sqrt{2}}(\text{I}0 > \pm \text{I}1 >)$

According to the notion of tachyons interacting with all particles in the universe, this equation of nonlocality can be re-written of nonlocality of tachyons that interact with all particles in the universe, and re-write the terms in the equation of quantum state of particles prior to measurement. Let T, be a tachyon particle and N, be all particles in the universe. So:

$$\text{I}\psi TN > = \frac{1}{\sqrt{2}}(\text{I}0 >_T \text{I}1 >_N - \text{I}1 >_T \text{I}0 >_N)$$
$$= \frac{1}{\sqrt{2}}(\text{I} + >_\text{T} \text{I} - >_\text{N} - \text{I} - >_\text{T} \text{I} + >_\text{N})$$

One could write this out for an infinite universe, where N_∞ is infinite number of particles in and infinite universe:

$$\text{I}\psi TN_\infty > = \frac{1}{\sqrt{2}}(\text{I}0 >_T \text{I}1 >_{\text{N}_\infty} - \text{I}1 >_\text{T} \text{I}0 >_{\text{N}_\infty})$$
$$= \frac{1}{\sqrt{2}}(\text{I} + >_T \text{I} - >_{N_\infty} - \text{I} - >_T \text{I} + >_{N_\infty})$$

What this equation is saying, is that tachyon particles T permeate the whole universe nonlocally interacting with infinite number of particles N_∞ everywhere in an infinite universe, much in the same way as an probability wave of an electron, spaced out over an whole area until the wave function collapses and the particle is found at a location. One can regard the tachyon particle T over the whole of N_∞ in terms of a field probability wave travelling into the past, and interacting with the whole of the past of N_∞ particles in the whole universe.

Then the tachyon particles might be interacting with the pioneer probes in the past, that the pioneer anomaly be effected by f from the future, so that tachyon interact with all ordinary particles in the past. Because tachyons travel faster than light, they travel into the past. The repulsive force of tachyon field f claimed by Takaaki Musha, would be a repulsive force around galaxies from the future, travelling into the past of the whole galaxy.

In a paper by Feinberg [3] possibility of faster than light particles, he outlines in his paper, that the standard arguments against faster than light particles are not compelling in the context of relativistic quantum mechanics. with its characteristic discontinuous creation of particles, is not in contradiction with special relativity and that such particles might be created in pairs without any necessity of accelerating ordinary particles through the light barrier. That tachyons have negative energy, he says further, that particles which travel faster than light, do not involve logical inconsistencies. Indeed no observation can be logically inconsistent.

Other points he makes for tachyons, is that tachyons speed up as they lose energy. He says on p1091, then the velocity of an object is greater than c, it is possible to change the sense of the propagation in time by an ordinary Lorentz transformation. That is suppose that for one observer, a particle moves through two points, x_1, x_2 at times t_1, t_2 with:

$$\frac{\Delta x}{\Delta t} \equiv \frac{\text{I}x_2 - x_1\text{I}}{t_2 - t_1} > c$$

and $\Delta t = t_2 - t_1 > 0$

For a second observer moving along the z axis with velocity u, we have:

$$\Delta t = \left(\Delta t - \frac{u\Delta x}{c^2}\right)y = \Delta t'\left(1 - \frac{uv > c^2}{c^2}\right)y$$

And clearly by choosing $uv > c^2$ we can make $\Delta t'$ have the opposite sigh to Δt i.e. change the time ordering of the points along the trajectories. It can be seen that this change occurs under the same circumstances as the change in the sign of the energy:

$$\frac{E'}{E} = \frac{\Delta t'}{\Delta t} = y(1 - uv/c^2)$$

This circumstance provides the key to understanding of the negative energies.

So the repulsive force to the galaxy from the tachyon field f in the intergalactic space, this tachyon field as it is travelling into the past, must interact with the whole past of the galaxy and should have negative energies. Dealing with the nonlocal equation again, where T is the tachyon particle and N_{past} is all the number of particles in the past of the universe:

$$\mathrm{I}\psi T N_{past} >= \frac{1}{\sqrt{2}}\left(\mathrm{I}0 >_T \mathrm{I}1 >_{N_{past}} - \mathrm{I}1 >_T \mathrm{I}0 >_{N_{past}}\right) = \frac{1}{\sqrt{2}}\left(\mathrm{I}+>_T \mathrm{I}->_{N_{past}} - \mathrm{I}->_T \mathrm{I}+>_{N_{past}}\right)$$

This equation is saying that tachyon particle T permeates nonlocally the whole past universe of number of particles N_{past}. But the question one must answer is do tachyons interact with particles and lead to the pioneer anomaly?

Now we will consider tachyon f field of force in relation to Mach's ideas. There is an equation by Sciama [4] (A look at the abandoned contributions to cosmology of Dirac, Sciama and Dicke' by Alexander Unzicker). On page 4 Unzicker says that Sciama focused on the question how to realize Mach's principle in a quantitative form, having noticed that in Newton's theory the value G is an arbitrary element, he derived a dependence of the gravitational constant:

$$G = \frac{c^2}{\sum_i \frac{m_i}{r_i}}$$

whereby the sum is taken over all particles and r_i denoting the distance to particle i. This is much more concrete and quantitative than Mach's ideas. It provides an distance and alleviates the somewhat mysterious property that G should feel the whole universe. Brans and Dicke took the relation as one that determines G^{-1} from a liner. Superposition of inertial contributions m/rc^2 the typical one being from a mass m at a distance r from the point where G is measured. Since m/r is a solution of a scalar from wave equation with a point source of strength m, one can assume $\phi \sim G$

$$\phi \sim G = \frac{c^2}{\sum_i \frac{m_i}{r_i}}$$

ϕ can be the gravitational potential. Sciama also considered the gravitational potential:

$$\phi = -G \sum_i \frac{m_i}{r_i} = -c^2$$

But here Sciama is assuming that the gravitational potential is at the speed of light c^2. But if inertia is instant from distant matter in the universe, then $\phi \sim G$ has to be faster than light, so there is no delay. For the galaxy if G was at the speed of light, it would take billions of years to reach the outer regions of the galaxy, and the galaxy would be unstable. I will later show in this equation that m_i is due to advanced effects. To show that this is due to advanced effects one can use the equation for a particle in an external force, we have:

$$mv = Frad + Fext = mt^{\circ}v + Fext$$

Where $Frad$ is radiation, and where $t^{\circ} = \frac{\mu_{\circ} q^2}{6\pi mc}$ where $\mu_{\circ}$ is permeability of free space. This equation can be integrated once to obtain:

$$mv = \frac{1}{t^{\circ}} \int_t^{\infty} ext\left(-\frac{t'-t}{t^{\circ}}\right) Fext(t')dt'$$

The integral extends from the present to infinitely far in the future. Thus, future values of the force affect the acceleration of the particle in the present. The future values are weighted by the factor $\left(-\frac{t'-t}{t^{\circ}}\right)$ which falls off rapidly from times greater than t° in the future. Therefore signals from an interval approximately t° into the future affect the acceleration in the present.

Now one can write:

$$\phi \sim G = \frac{c^2}{\sum_i \frac{m_i}{r_i}} = m_i v = \frac{1}{t^{\circ}} \int_t^{\infty} ext\left(-\frac{t'-t}{t^{\circ}}\right) Fext(t')dt'$$

This equation says that the gravitational potential ϕ of all the particles m_i in the universe feel a future force $m_i v$ where $m_i = Q(a) = \frac{1}{2}[F^R(a) - F^A(a)]$. We say here that (a) and retarded F^R fields that contributes signals into the past of the particle (from the future) leads to or due to $\phi \sim G = \frac{c^2}{\sum_i \frac{m_i}{r_i}}$ Mach's principle. And the last term in the equation as earlier explained is due to advanced force on the particle. This will explain why inertia is instant over far distances, that gravity must be faster than light. One can apply this to tachyons or the tachyon repulsive field f that effects particles in the past, according to Takaaki Musha $f \approx m_i \alpha$ one can write:

$$\phi \sim G = \frac{c^2}{\sum_i \frac{m_i}{r_i}} = f \approx m_i \alpha = \frac{1}{t^{\circ}} \int_t^{\infty} ext\left(-\frac{t'-t}{t^{\circ}}\right) Fext(t')dt'$$

One can say then that there is a channel or flow of time into the past, as well as the retarded one, due to tachyon field. This will explain why inertia is instant over far distances, that gravity must be faster than light. That gravity has to be faster than light across the whole galaxy, otherwise gravity would take billions of light years to cross the galaxy, because it would be at the speed of light, and there would be a time delay and the galaxy would be unstable and would not be in a disk shape. And the tachyon field f acts nonlocally causing inertial effects leading to the pioneer anomaly. That f might be related to inertial effects on the pioneer spacecraft.

These ideas follow from Jayant V Narliker [5] in a paper he wrote, Mach's principle. Where he describes gravitational influence across the universe by advanced effects due to Mach's principle. He says in his paper, that cosmological boundry conditions are necessary in the action-at-a distance framework. Any retarded signal emitted by a particle will get an advanced reaction back. In the 1930s it had been demonstrated by Dirac that why an electric charge accelerates, the force of radiative damping that it is subjected to the retarded and advanced field of the charge and the advanced field of the charge on its own worldline (a): $Q(a) = \frac{1}{2}[F^R(a) - F^A(a)]$

The Wheeler - Feynman theory is formulated in a time symmetric manner with advanced solutions on equal footing with retarded ones. Thus a typical particle a, generates a direct particle field, defined by: $F(a) = \frac{1}{2}[F^R(a) + F^A(a)]$

Which is manifestly symmetric with regard to its advanced and retarded components. As seen above, the universe as a whole generates a response to individual fields of the changes, and in the wheeler - Feynman theory the correct response from the universe to the motion of a, is precisely:

$Q(a) = \frac{1}{2}[F^R(a) - F^A(a)]$

The presence of both advanced and retarded effects on an equal footing, makes the problem nonlocal, indeed it brings in cosmology. This may have a bearing on tachyons, when I said earlier of these nonlocal effects on matter in the past. It can be shown that for the correct response, the future part of the universe (lying on the future light cone of the radiating system) must be a perfect absorber of all retarded, i.e. future - directed signals, and the past part on the universe and imperfect absorber of all advanced, i.e. past - directed signals. But I do not feel that the past part of the universe is an imperfect absorber of all advanced, past directed signals. This has to be symmetrical in time, for $Q(a) = \frac{1}{2}[F^R(a) - F^A(a)]$. That advanced signals do not cancel out. Can one apply such ideas as this to Mach's principle, as I said in equation $\phi \sim G = \frac{c^2}{\sum_i \frac{m_i}{r_i}} = m_i v$ Where $m_i = Q(a) = \frac{1}{2}[F^R(a) - F^A(a)]$ for inertia being instant, gravity must propagate faster than light.

Are the pioneer anomalies of an unexplained Sunward acceleration of $8.74 \pm 1.33 \times 10^{-10} ms^{-2}$ seen in the behaviour of the pioneer probes, due to the effect of an tachyon field f in the vacuum, being a repulsive force. I consider also that dark energy is also considered to be a repulsive force and perhaps this is really the tachyon field, created in space ZPF?

But maybe not, the main problem here is that dark energy is extremely weak repulsive force, on the scale of the solar system and the pioneer anomalies seems to be an inertial effect of a stronger force, perhaps due to the creation of a tachyon field in space, which is also repulsive? But one has to consider then or show that such a tachyon field being far stronger than dark energy, which I have not done in this paper. But if it does, would such an tachyon field have anything to do with inertia and Mach's principle in the equation:

$$\phi \sim G = \frac{c^2}{\sum_i \frac{m_i}{r_i}} = f \approx m_i \alpha$$

$$= \frac{1}{t^\circ} \int_t^\infty ext\left(-\frac{t' - t}{t^\circ}\right) Fext(t')dt'$$

And the inertial effects of the pioneer anomalies might be due to the repulsive tachyon field from the future, because tachyons are travelling into the past, as said earlier in this paper, the effect might be nonlocal, as tachyons may interact with the whole past of the galaxy and also be responsible for the rotation speeds of galaxies, and not being due to dark matter, but an tachyon field as explained by Takaaki Musha.

EXPERIMENTAL EVIDENCE OF TACHYONS

But what evidence is there for the existence of tachyons? In an experiment at CERN [6] in 2000 in a paper Particles and Nuclei, by 3 Russian scientists, A. S. Vodopian, V. P. Zrelov and A. A. Tyapkin. They detected strong Cherenkov radiation of tachyons, they say in there paper, the first experimental indication of the Cherenkov radiation caused by superluminal particles, tachyons is informed about. This conclusion has been made on the basis of the analyses of the anomalous Cherenkov radiation when the beam of relativistic lead ions of SPS accelerator at CERN was passing through a gas radiation. They say further that according to some theoretical predictions, the tachyons, (if they exist) are stable particles but lose their entire energy extremely fast $V \to \infty$ in the wide range of frequency from 0 to $E/\hbar$.

I still claim that tachyons travel from the future to the past, that they might have negative energy. I feel tachyons have to violate causality. More experiments should be done to confirm this experiment at CERN. Scientists still say that tachyons don't exist. But this paper by these Russian scientists is giving evidence of tachyons, and shows that they do exist. This experiment was done in 2000, but of something of this importance, I can't understand why no one else followed it up and repeat this experiment.

There is also experimental evidence of tachyons, in a book by Takaaki Musha [1] 'Tachyon Universe', p20-22. 4. Experimental results at the Laboratories. Takaaki Musha says that measurement of electron neutrinos rest mass carried out by measuring the end point of the energy spectrum emitted in the decay tritium $\beta -$ decay, has shown that the square of the electron neutrino rest mass seems to be negative, which implies that the electron neutrino has an imaginary rest mass:

(1986) $-158 \pm 253 eV^2$
(1991) $-147 \pm 109 eV^2$

Which is not acceptable in existing theories for the neutrino, but it suggests that electron neutrinos are tachyons. Most tritium $\beta -$ decay experiments has given negative values for m^2 . Such results would be fairly conclusive evidence that electron neutrino was a tachyon:

(1973) $-0.29 \pm 0.90 MeV^2$
(1980) $-0.102 \pm 0.119 MeV^2$
(1982) $-0.14 \pm 0.20 MeV^2/c^4$
(1984) $-0.163 \pm 0.080 MeV^2/c^4$

For an tachyon moving inside the atom, must be propagating into the past, .i.e. $\beta -$ decay. If it's common for tachyons to appear in atoms, then part of that atom has an state that propagates into the past? But it would suggest that such atoms feel the influence of other atoms in the past, or that atoms feel an influence from the future. Regarding the energy momentum of tachyons $E^2 - P_*^2 c^2 = m_*^2 c^4$ from a paper by Takaaki Musha [13]'The possibility of Neutrinos detected as tachyons'. In this paper takaaki Musha writes an equation for the time interval of an particle emitted from the atomic nucleus travelling in a FTL state, is given by:

$$\Delta t \approx \frac{4\hbar^4}{m_*^4 c^5 L^3}$$

Where L is the size of the atomic nucleus.

Because tachyons travel into the past, the time interval Δt should be time into the past, so one can write:

$$\frac{4\hbar^4}{m_*^4 c^5 L^3} \approx \Delta t' = (t_2 - t_1) > 0$$

In regard to that experiment at CERN on detection of tachyons with strong Cherenkov radiation, one could repeat the experiment to produce tachyons, to test if they have negative energy and set up causal loops or an temporal paradox? The closed curve followed by the tachyonic signal viewed in the rest frame of A. The tachyon is sent by A at time $t_\circ$ (Event $E_\circ$) and received by B at t_1 (event E_1). Since B moves with respect to A, the tachyonic signal he sends back to A is actually received before it was sent, at time $t_2 < t_\circ$ (event E_2). this is razing the spectre of faster than light communication and the attendent of causal paradox. But now that tachyons have been detected, such an experiment to create a causal paradox could actually be done! Also a causal violation can be set up in an experiment, where A receives the signal from B in the past, before A sends his signal to B, but does not send a signal to B!

THE PIONEER ANOMALY

Here I will be considering several papers dealing with the nature of tachyons and comparing these papers to ones considerations. The first paper [7] by EM. E. McCulloch, 'Modelling the pioneer anomaly as modified inertia'. From the abstract of McCulloch's paper, he says that he proposes an explanation for the pioneer anomaly: an unexplained Sunward acceleration of $8.74 \pm 1.33 \times 10^{-10} ms^{-2}$ seen in the behaviour of the pioneer probes.

Two hypotheses are made: (1) Inertia is a reaction to unruh radiation and (2) this reaction is weaker for low accelerations, because some wavelengths in the unruh spectrum do not fit within a limiting scale (twice the Hubble distance) and are disallowed: A process similar to the casimir effect. When these ideas are used to model the pioneer crafts trajectories there is a slight reduction in their inertial mass, causing an anomalous Sunward acceleration of $6.9 \pm 3.5 \times 10^{-10} ms^{-2}$ which agrees within error bars with the observed pioneer anomaly beyond 10 AU from the Sun. But also predicts and anomaly within 10AU of the Sun, which has not been observed. Various observational tests for the idea are proposed.

One possibility for a model of inertia is that of Haisch [8] Bernard Haisch, Alfonso Rueda, H. E. Puthoff, 'Inertia as a zero-point-field Lorentz force'. Who proposed that an accelerated object feels a magnetic Lorentz force through its interaction with a zero point field ZPF, similar to the unruh field. This force is given by $F = -\Gamma\omega_c^2\hbar a/2\pi c^2$ where Γ is the Abraham Lorentz damping constant. I myself also wrote a paper [9] 'Is Abraham damping constant and inertia in matter a consequent echo of its future state?'. Where I comment: There is another interesting effect that is explained from the Wheeler-Feynman absorber theory, where we have radiation resistance and this leads to the effect of inertia or the damping constant Γ. Electrical inertia, and this simply means that gravity and inertia are the result of advanced energy in matter, of matter responding to its own echo of its own future state. The result of advanced effects in matter causes the Abraham Lorentz damping constant:

$$\Gamma = 2e^2/3m^{\circ}c^2$$

That this mechanism of electrical inertia of advanced effects of radiation:

$$\sum_n Eadv\, n(x,t)$$

With the Abraham Lorentz force Γ there is the result that they get in their calculations of Γ of signals from the future, and this is a problem for them. There are solutions using the Abraham Lorentz - Dirac equation that anticipates a change in the external force and according to which the particle accelerates in advance of the application of a force! The so called pre-acceleration solutions:

$$\frac{1}{\Delta t}\int_{\circ}^{t} pdt = \frac{1}{\Delta t}\int_{\circ}^{t} F.Vdt$$

So what I found about the damping constant Γ in physics is full of these problems they have with advanced effects in their calculations of it and lends support to Wheeler-Feynman absorber theory of being the cause of Γ, inertia. Regarding the equation by Haisch $F = -\Gamma\omega_c^2\hbar a/2\pi c^2$.

Where Γ is the Abraham - Lorentz damping constant of the parton being oscillated, $\hbar$ is the reduced Planck constant, ω_c is the compton scale of the parton below which the oscillation of the ZPF have no effect on it, c is the speed of light and a, is acceleration. Haisch showed that this force behaves like inertia.

One could argue then, that the inertial effects on the pioneer anomaly is caused by a future echo from the future, from tachyon field f in a Machian view point. Where Haisch says the ZPF could thus serve as the Machian cosmic reference frame. This may be related to the cosmic distribution of matter in the context of the model of dynamically balanced absorption and remission of ZPF radiation and remission of ZPF radiation, by mass distributed over cosmological space.

But can one also regard this absorption and remission of ZPF radiation given rise to an tachyon field f that from the future (because tachyons travel into the past) behaves like inertia effects leading to the pioneer anomaly. One can then write the equation according to Mach's principle:

$$\phi \sim G = \frac{c^2}{\sum_i \frac{m_i}{r_i}} = f \approx m_i a$$
$$= \frac{1}{t^{\circ}}\int_t^{\infty} ext\left(-\frac{t'-t}{t^{\circ}}\right) Fext(t')dt'$$

where f is the tachyon repulsive field of force, and a is acceleration of stars induced by the repulsive force of tachyon field around galaxies, and $m_i = Q(a)\frac{1}{2}[F^R(a) - F^A(a)]$. But from what has been said about Γ that they get in there calculations of signals from the future, one could write $\Gamma > 0$.

Considering all this, experiments should be done to try to detect advanced effects in the Abraham - Lorentz force Γ. This would settle this theoretical issue by observation. McCulloch concludes in his paper that (1) inertia is a reaction to unruh radiation, one can say to this, that this is no more different in regarding unruh radiation as the same as the vacuum ZPF giving rise to tachyon repulsive field f. He says (2) that this reaction is weaker for low accelerations because some wavelengths in the unruh spectrum do not fit within a limiting scale (twice the Hubble distance) and are disallowed: a process similar to the Casimir effect.

This is interesting, perhaps experiments to test this out should be done, using these ideas. The pioneer acceleration anomaly was predicted to be $6.9 \pm 3.5 \times 10^{-10} ms^{-2}$, which agrees within error bars, beyond 10AU from the Sun, with the observed value of $8.74 \pm 1.33 \times 10^{-10} ms^{-2}$. This scheme is appealingly simple, and does not require adjustable parameters. However the model predicts an anomaly within 10AU of the Sun which is not observed.

The next paper to be considered [10] Mordehai Milgram, 'The modified dynamics as a vacuum effect'. Milgram says in his paper, that to explain the appearance in MOND of a cosmological acceleration constant $a_\circ$ he suggests that MOND inertia, as embodied in the actions of free particles and fields, is due to effects of the vacuum. The same vacuum effects enter both MOND (through $a_\circ$) and cosmology (e.g. through a cosmological constant Λ). For example, a constant acceleration (a) observer in de sitter universe sees unruh radiation of temperature $T \propto [a^2 + a_\circ^2]1/2$ with $a_\circ \equiv \left(\frac{\Lambda}{3}\right)1/2$, and he notes that $T(a) - T(a_\circ)$ depends on a, in the same way that MOND inertia dose.

Specifically the theory holds that when gravity is well below the $a_\circ$ value, its rate of change, including the curvature of spacetime, increases with the square root of mass (rather than linearly as per Newtons law) and decreases linearly with distance (rather than distance squared).

One possibility is to treat Milgroms law as a modification to Newtons second law, so that the force on an object is not proportional to the particles acceleration a, but rather to $\mu\left(\frac{a}{a_\circ}\right)a$. In this case the modified dynamics would apply not only to gravitational phenomena, but also those generated by other forces e.g. electromagnetism. Alliteratively Milgrom's law can be viewed as leaving Newton's second law intact and instead modifying the inverse-square law of gravity, so that the gravitational force on an object of mass m, due to another mass M, is roughly of the form:

$$\frac{GMm}{\mu\left(\frac{a}{a_\circ}\right)r^2}$$

In this interpretation, Milgrom's modification would apply excusievely to gravitational phenomena. The dependence in MOND of the internal dynamics of a system on its external environment (in principle the rest of the universe) is strongly reminiscent of March's principle and may hint towards a more fundamental structure underlying Milgrom's law. In this regard, Milgrom has commented it has been long suspected that local dynamics is strongly influenced by the universe at large, a la Mach's principle. But MOND seems to be the first to supply concrete evidence for such a connection. This may turn out to be the most fundamental implication of MOND, beyond its implied modification of Newtonian dynamics and general relativity, and beyond the elimination of dark matter.

The value of $a_\circ$ that emerges from such analyses ($\approx 10^{-8}cms^{-2}$) is of the order of $CH_\circ$ ($H_\circ$ is the Hubble constant) which is an acceleration of cosmological significance. Even if $a_\circ$ is a fingerprint of cosmology on local dynamics, it is not necessarily a proxy for $a_{ex} \equiv CH_\circ$. There are other cosmological acceleration scales that one can define e.g. $a_c \equiv c^2/R_c$ where R_c is the curvature (spatial or space-time), or $a_\Lambda \equiv c\Lambda^{1/2}$ where Λ is the cosmological constant $a_\circ$ might be a proxy for any of these cosmological parameters.

In regard to Newtonian force under MOND $F_N = m\mu\left(\frac{a}{a_\circ}\right)a$. If $a_\circ$ is due to vacuum ZPF with $a_\circ \equiv (\Lambda/3)1/3$ could relate to f tachyon field of force, because it may also arises in the vacuum ZPF. As Mulgrom says, either cosmology has a causative effect on inertia because it affects the state of the vacuum which in turn, affects inertia, or cosmology and inertia are both affected by the vacuum dynamics, which then enters cosmology say as a cosmological constant Λ and MOND through $a_\circ \approx c\Lambda^{1/2}$.

But dark energy of Λ is too weak on the scale of the solar system to have the effect of the pioneer anomaly, unless of course it's the tachyon field of force f that arises from the vacuum, might have a stronger effect on the pioneer spacecraft, but I have not done the calculation on this if f is stronger effect for the pioneer anomaly? One can use $a_\circ \equiv (\Lambda/3)1/3$ in the equation, expressing Mach's principle and advanced potentials for dark energy or the cosmological constant, which amounts to the same thing:

$\phi \sim G = \frac{c^2}{\sum_i \frac{m_i}{r_i}} = m_i a_\circ \equiv (\Lambda/3)1/3 = \frac{1}{t^\circ}\int_t^\infty ext\left(-\frac{t'-t}{t^\circ}\right)(t')dt'$

MOND as modified inertia $AmS[r(t)a_\circ]$

Am is effective action, depends only on the body and S depends on the trajectory $r(t)$. Am can be the rest mass of the body (gravitational or inertial) for such systems the approximate statement of MOND would be that cosmology, is connected to local dynamics only through the one parameter $a_\circ$ which is of the order of the accelerations found in these systems. It was shown for instance, that Galilei invariance combined with the two limits in $a_\circ$ requires that S be a nonlocal (in time) function of the trajectory. This would not be viewed as an imposition. On the contrary, nonlocality appears naturally is effective action as ours must be. Also nonlocality might be a blessing as nonlocal theories need not suffer from the maladies that are endemic to higher-order theories.

Nonlocality could be correct for f the tachyon repulsive field of force, that comes from the vacuum, effects all particles as in the equation, that leads to the pioneer anomaly, would be nonlocal . Dealing with the nonlocal equation again, where T is the tachyon particle and N_{past} is all particles in the past of the universe:

$$\mathrm{I}\psi T N_{past} >= \frac{1}{\sqrt{2}}\left(\mathrm{I}0 >_T \mathrm{I}1 >_{N_{past}} - \mathrm{I}1 >_T \mathrm{I}0 >_{N_{past}}\right)$$
$$= \frac{1}{\sqrt{2}}\left(\mathrm{I} +>_T \mathrm{I} ->_{N_{past}} - \mathrm{I} ->_T \mathrm{I} +>_{N_{past}}\right)$$

This equation is saying that Tachyon particles T permeates nonlocally the whole past universe of number of particles N_{past}. Therefore we can write the repulsive field of force as $f > 0$. Because the tachyon field is propagating into the past, so that one can re-write Takaaki Musha's equation again, of kinetic equation of stars:

$$m\frac{v^2}{r} = G\frac{M(r)m}{r^2} + f > 0$$

f comes from the future to effect the past, this is expressed in the equation:

$$\phi \sim G = \frac{c^2}{\sum_i \frac{m_i}{r_i}} = f \approx m_i \alpha$$
$$= \frac{1}{t^\circ}\int_t^\infty ext\left(-\frac{t'-t}{t^\circ}\right)Fext(t')dt'$$

Where $m_i = Q(a) = \frac{1}{2}[F^R(a) - F^A(a)]$

f would also be nonlocal, that tachyons interact nonlocally. According to what Milgrom has been saying and according to Mach's principle, that inertia is nonlocal - perhaps this leads to the pioneer anomaly?

The next paper to consider [11] by Ross L. Dawe and Kenneth C. Hines, 'The physics of tachyons', I. Tachyon kinematics. In this paper, they develop a new formulation on the theory of tachyons using postulates of special relativity. They argue, that the inertial frame used by a bradyonic observer (ordinary particle under the speed of light speed) $\sum$, that in such a frame the observer considers himself to be at rest and measures all other objects relative to the coordinate system. The same is true for the inertial frame used by a tachyonic observer $\sum'$. In this frame the observer considers himself to be at rest and so measures all other objects relative to his own coordinate system, regardless of whether they are travelling faster than or slower than the speed of light. As light travels at speed c relative to this coordinate system used by $\sum'$. Then $\sum$ is able to calibrate his rods and synchronise his clocks in exactly the same manner as any other relativistic observer.

Regarding what they said above in there paper, I don't think the authors took account that tachyons are travelling into the past, so that from $\sum$ frame, $\sum'$ would be travelling back in time to the past. From $\sum$ frame would see $\sum'$ propagate into a space-time region inaccessible to $\sum$ frame, i.e. the past. In the past $\sum_P$ frame, would see $\sum'$ frame, arrive from the future, and $\sum_p$ frame would regard its own frame as in the present. But to $\sum'$ frame, $\sum_p$ would be in the past. One could consider the notion of an temporal future Machian cosmic reference frame as the vacuum ZPF, in relation to the block model of the universe, where the past and future exist as concrete realities. So for a tachyonic observer in $\sum'$ frame, we have:

$$\sum' = t_2 - t_1 > 0$$

travelling into the past.

Not only are tachyons considered travelling into the past, but the fact that different observers $\sum$ in this frame might see tachyons as bradyons, perhaps this is why tachyons are not observed or detected, because they are mistaken for bradyons and travel into the past or an area of space-time inaccessible to a co-moving observer $\sum$.

They say in there paper on p617, that switching is purely an artefact of the observers motion relative to the viewed object. The object does not change in any way because of switching, only the observers perception of the object changes. For example, a tachyonic electron will always be an electron, even through observers in switched frames will measure the electron as having a positive charge. The switching principle may appear to be a mere mathematical artifice, but the fact that it automatically allows tachyons to obey the laws of conservation of energy, momentum and electric charge in a given reference frame shows that it has deep physical significance. Again one can say to this, that switching may explain why tachyons might not normally be observed. But as I said earlier that tachyons have been detected in experiments.

Now I consider another paper by the same authors [12] Ross L. Dawe and Kenneth C. Hines, 'The physics of tachyons', II. Tachyon dynamics. In their paper p735, they say, consider the work done on a particle by a force F moving that particle through a displacement dI. In both Newtonian and relativistic mechanics the work done is defined to be $dW = F.dI$. If it is assumed that all of the work goes into increasing the kinetic energy K of the particle, then $dW = dK$. Hence the rate of increase of kinetic energy is given by $\frac{dK}{dt} = F.\frac{dI}{dt} = F.v$. The kinetic energy is related to the total energy for both bradyons and tachyons, via the relation $K - E - m_\circ c^2$. Force is defined to be the time rate of change of momentum:

$$F = \frac{dp}{dt} = m\frac{dv}{dt} + v\frac{dm}{dt}$$

Where $m = y_v m_\circ$ relativistic mass and $m = y_v m_*$ for tachyons. The relative mass is related :

$$total\ energy\ \ E = \frac{dm}{dt} = c^{-2}\frac{dE}{dt} = c^{-2}\frac{d}{dt}$$

$$(K + m_\circ c^2) = \frac{F.v}{c^2}$$

$$F = m\frac{dv}{dt} + \frac{v(F.V)}{c^2}$$

In regard to the above, what they said, would not F force be going into the past, so that $F > 0$, because tachyons may propagate into the past. From this one can regard the equation:

$$m_i v = \frac{1}{t^\circ}\int_t^\infty ext\left(-\frac{t' - t}{t^\circ}\right) Fext(t')dt'$$

The integral extends from the present to infinitely far in the future. Thus future values of the force affect the acceleration of the particle in the present. The future values are weighed by the factor: $\left(-\frac{t'-t}{t^\circ}\right)$ which falls off rapidly for time greater than t°in the future. Therefore, signals from an interval approximately t° into the future affect the acceleration in the present. With Lienards relativistic generalization of Lamar formula in the co-moving frame, one can show this to be a valid force by manipulating the time average equation for power:

$$P = \frac{\mu_\circ q^2 a^2 y^2}{6\pi c}$$

Where P = power and $\mu_\circ$ is permeability of free space.

Dose this not show that energy in relation to power follows the principle of least action, in these echoes from a objects future state. One can write the equation of work:

$$W = \int_c F.dx = \int_{t_1}^{t_2} Fvdt$$

$dx(t)$ defines the trajectories, c and v is velocity also this trajectory. The time derivative of the integral for work yields the instantaneous power:

$$\frac{dW}{dt} = P(t) = F.v$$

Therefore one can write:

$$\frac{dW}{dt} = P(t) = \frac{\mu_\circ q^2 a^2 y^2}{6\pi c} = F.v$$

We can consider this in relation to the earlier equation for work:

$$dW = F.dI$$

Regarding:

$$F = m\frac{dv}{dt} + \frac{v(F.v)}{c^2}$$

For acceleration is related to:

$$a = \frac{F}{m} - \frac{v(F.v)}{mc^2}$$

For force greater than c of a tachyon we have:

In the case of F is parallel to v: $F = y_v^3 m_* a$

For a objects velocity greater than c, it is possible to change the sense of the propagation in time by Lorentz transformation, for one observer, a particle moves through two points x_1, x_2 at times t_1, t_2:

$$\frac{\Delta x}{\Delta t} \equiv \frac{\mathrm{I}x_2 - x_1\mathrm{I}}{t_2 - t_1} > c$$

and $\Delta t = t_2 - t_1 > 0$

But here we can consider the force of tachyon as travelling into the past $F > 0$. So one can write:

$$y_v^3 m_* a = F > 0 = \frac{1}{dt} = \frac{\Delta x}{\Delta t} \equiv \frac{\mathrm{I}x_2 - x_1\mathrm{I}}{t_2 - t_1} > c$$

and $\Delta t = t_2 - t_1 > 0$

As for energy one can write:

$$E = dW = \frac{dK}{dt} = \frac{F.dI}{dt} = \frac{\Delta x}{\Delta t} = \frac{\text{I}x_2 - x_1\text{I}}{t_2 - t_1} > c$$

and $\Delta t = t_2 - t_1 > 0$

where $E' = \Delta t' = t_2 - t_1 > 0$

From the relation $\frac{E'}{E} = \frac{\Delta t\prime}{\Delta t} = y(1 - \frac{uv}{c^2})$
and:

$$\Delta x' = (\Delta x - u\Delta t)y - \Delta t \quad = \left(\Delta t - \frac{u\Delta x}{c^2}\right)y$$
$$= \Delta t'\left(1 - \frac{uv > c^2}{c^2}\right)y$$

Where choosing $uv > c^2$ we can make $\Delta t'$ have the opposite sign to Δt i.e. change the time ordering of the points along the trajectory.

Regarding equation $E' = \Delta t' = t_2 - t_1 > 0$ can apply to the principle of least action. It applies to the nature of light through the index of refraction through glass. That light takes the shortest or fastest path, and to Newtonian mechanics when one throws a ball, the ball must arrive on time at an location, and in the diffraction experiments in the way a photon will go through two slits. It occurs to me then , that the principle of least action must apply to energy and for the equation $E' = \Delta t' = t_2 - t_1 > 0$. Here the energy is transferred into the past. For $E' > 0$ the energy may have to be negative. But if this is a tachyon, don't forget as tachyons lose energy they speed up. The principle of least action applied to energy, shows how energy behaves through time.

The German Mathematician, Emmy Noether's theorem, proved the following fundamental connection, that every continuous symmetry of a physical system corresponds to a conservation law. She taught us that the conservation of momentum is a consequence of translation symmetry, of a physical quantity that does not change over time. The proof of Noether's theorem is demonstrated in the principle of least action. Energy may be transformed through time, but the balance of energy does not change over time, energy is conserved.

This must be true of energy propagating into the past, $E' = \Delta t' = t_2 - t_1 > 0$, that it must be conserved. Perhaps tachyons have negative energy. Regarding Takaaki Musha's equation of tachyon particles leaving an atomic nucleus and travelling into the past, that I include in this equation:

$$\frac{4\hbar^4}{m_*^4 c^5 L^3} \approx \Delta t' = (t_2 - t_1) > 0$$

And with $E' = \Delta t' = (t_2 - t_1) > 0$

Then one can write:

$$\frac{4\hbar^4}{m_*^4 c^5 L^3} \approx E' = \Delta t' = (t_2 - t_1) > 0$$

in regard to $E^2 - P_*^2 c^2 = m_*^2 c^4$ (FTL state)

Where $\frac{E'}{E} = \frac{\Delta t'}{\Delta t} = y(-\frac{uv}{c^2})$
Of course this energy E' would be propagating into the past. Regarding the index of refraction of the vacuum that keeps the speed of light at c, one can ask if the vacuum index of refraction has any role that effects tachyons, which are travelling faster than light, and why tachyons don't get slowed down by the vacuum to the speed of light, as it is in the case of light?

CONCLUSION

I have considered that the tachyon repulsive field f may act nonlocally from the vacuum ZPF inertial effects, from the future, that might be responsible for the pioneer anomaly. Because tachyons are regarded as travelling into the past. I have presented experimental evidence of the detection of tachyons and considered several papers on the nature of tachyons and dark energy, both being repulsive. But conclude that dark energy is too weak a force on the scale of the solar system, to have any effect on the pioneer spacecraft, and considered the relation of MOND, also related to dark energy and the cosmological constant in relation to the pioneer anomaly. And that the tachyon field f might be stronger on the scale of the solar system, but that it would have to be if it was responsible for the anomaly of the pioneer spacecraft, than dark energy. And considered that the reason tachyons are not normally detected is that due to relativistic effects, tachyons may appear like ordinary particles, to a co-moving observer and another reason that tachyons are not normally detected is because they are travelling into the past, into a space-time region inaccessible to an co-moving observer. But that this might not rule out that tachyons might be detected as coming from the future. And lastly I considered the nature of the principle of least action applied to energy, that is travelling into the past, and that the energy of tachyons may be negative, and that the force accelerating the tachyons going faster than light, also propagates into the past.

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