Velocity-Dependent Inertial Induction: A Possible Tired-Light Mechanism

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The tired-light interpretation of the cosmological redshift is as old as the discovery of the phenomenon itself, and a number of mechanisms have been proposed by researchers in cosmology. This article presents the basic ideas behind the author's recent proposal of an inertial induction model consisting of both velocity- and acceleration-dependent terms which can explain the cosmological redshift both quantitatively and qualitatively. A major difficulty with the various tired-light mechanisms is that no other reliable experimental verification of the proposed theories is possible, whereas the velocity-dependent inertial induction gives rise to a number of detectable astrophysical and astronomical phenomena. A few of these have been studied, and it has been shown that the predicted effects do exist.

Introduction

Since the discovery of the cosmological redshift by E. Hubble, the true nature of the redshift has been the focus of ongoing debate. In the absence of any satisfactory explanation within the framework of known physical principles, the idea of universal expansion and the Doppler interpretation of the cosmological redshift have gained wide acceptance. A direct consequence of the universal expansion is the creation of the universe in a singular explosion—the "big bang". The success of the big bang model in explaining the observed Helium abundance and the microwave background radiation has made this model popular and generally accepted. However, to date no exclusive proof of the existence of a universal expansion has been found, and of late the big-bang model is also facing a few serious problems. In the view of many workers, the cosmological redshift is due to a mechanism through which photons loose energy while travelling through the universe. One of the earliest tired-light mechanisms was proposed by Zwicky (1929); according to Zwicky, the energy and momentum of the photon is transferred to the material objects which lie in the path of the photon. Table 1 lists some of the many tired-light mechanisms that have been proposed (Keys 1987).

The present paper discusses the basic ideas behind the concept of velocity-dependent inertial induction and shows that a number of other predictions from the theory are validated by observations.

Table 1
Non-Velocity Redshift Mechanisms

Year	Originator	Mechanism
1917	Einstein	Electromagnetic repulsion
1929	Zwicky	Gravitational drag
1937	Hubble	Gravitational interaction
1949	Tolman	Extended expansion hypothesis
1949	Weyl	Quantum gravity
1954	Finlay-Freundlic	Photon-Photon interaction
1964	Fürth	Curved photon path
1972	Pecker et al.	Photon-Photon interaction
1974	Hoyle-Narlikar	Variable mass interaction
1975	Konitz	Non-Euclidean geometry
1976	Pecker et al.	Photon-scalar U-particle interaction
1976	Segal	Global and local time hypothesis
1976	Jaakkola	G-E coupling
1979	Crawford	Tidal force in curved space
1981	Tifft	Variable mass
1981	Broberg	Elementary quantum interaction
1984	Ghosh	Velocity-dependent inertial induction
1986	Wolf	Thermal correlations at source
1986	Mathé	Global and local time hypothesis
1986	Pecker-Vigier	Gravitational drag in Dirac ether

Inertial Induction

Since the beginning of the era dominated by Newtonian Mechanics, two fundamental issues have not been resolved in an undisputed manner. Newton supposed the acceleration of bodies to be with respect to absolute space, and this was questioned by George Berkeley thirty years after the publication of *Principia*. According to Berkeley, motion (including acceleration) is meaningful only when it is with respect to other material bodies. However, the tremendous success of Newtonian Mechanics during the next one and half centuries overcame any doubts as to the basic premise of Newton's propositions. In 1872, the question was raised again by Ernst Mach. Mach proposed that the inertial property of any given object depends upon the presence of other material bodies in the universe. Subsequently, this idea came to be known as *Mach's Principle*, and it had a profound influence on Einstein's thinking. The question whether the inertial property of an object is an intrinsic property of matter or represents the interaction with matter in the rest of the universe is still not resolved. Another extremely intriguing feature of Newtonian Mechanics is the exact equivalence of the gravitational and inertial masses. Einstein proposed to resolve the matter with his *Principle of Equivalence*.

The main difficulty in coming to a definite conclusion about *Mach's Principle* was due to the absence of any quantitative model of the theory. Sciama (1961, 1969) was the first to propose a quantitative model of *Mach's Principle*. According to him the gravitational interaction between two masses m_1 and m_2 at a distance r contains a term, over and above the usual attraction term, Gm_1m_2/r^2, which depends on the acceleration between the two bodies. As a result, a body will be subjected to a resisting force of magnitude

$$\frac{Gm_1m_2}{r^2}+\frac{Gm_1m_2}{c^2r}a$$

when it accelerates with respect to another body at the rate a (c and G being the velocity of light and the constant of gravitation, respectively). Hence, when a body of mass m_1 accelerates at the rate a with respect to the rest of the universe (which is assumed to be quasi-static) the total force resisting this acceleration, can be expressed as follows:

$$F=\sum_{Universe}\frac{Gm_2}{c^2r}m_1a \qquad (1)$$

Sciama and others (5, 6) have demonstrated that

$$\sum_{Universe}\left(\frac{Gm_2}{c^2r}\right)$$

becomes of the order of unity when the presently estimated values of the average matter density in the universe and the radius of the observable universe are used. Thus, the inertial law is nothing but the manifestation of the acceleration-dependent gravitational interaction of a body with all matter in the rest of the universe. This was called *inertial induction* by Sciama. This also eliminates the need for the *Principle of Equivalence* as there is only one kind of interaction, *i.e.*, the gravitational interaction (along with an acceleration-dependent term over and above the usual position-dependent term).

Though the above model shows a very interesting result, it still fails to answer the question why

$$\sum_{Universe}\left(\frac{Gm_2}{c^2 r}\right)$$

should be exactly equal to unity.

Extension of Mach's Principle and Velocity-Dependent Inertial Induction

Mach's original idea had been primarily centred around the hypothesis that an accelerating body interacts with the matter in the rest of the universe (the resultant of the position dependent terms being zero due to the isotropy of the universe). However, there is no apparent reason to believe that such an interaction has to be confined to acceleration only. Mach's principle can be extended so that the inertial force is generated not only by the acceleration of a body with respect to the universe, but also by its velocity with respect to the mean rest-frame of a quasi-static universe. Recently, I have proposed (Ghosh 1984, 1986, 1991) that the interacting force between two particles A and B is given by

$$\mathbf{F} = -\frac{Gm_A m_B}{r^2}\mathbf{u}_r - \frac{Gm_A m_B}{c^2 r^2}v^2\mathbf{u}_r f(q) - \frac{Gm_A m_B}{c^2 r}a\mathbf{u}_r f(f) \tag{2}$$

where $\mathbf{F}$ is the force on A due to B, $\mathbf{r}$ ($-r\mathbf{u}_r$), $\mathbf{v}$ ($=v\mathbf{u}_v$), $\mathbf{a}$ ($=a\mathbf{u}_a$) are the position, velocity and acceleration of body A with respect to B ($\mathbf{u}_r$, $\mathbf{u}_v$, and $\mathbf{u}_a$ are the unit vectors); $f(q)$, $f(f)$ with $\cos q = \mathbf{u}_r.\mathbf{u}_v$ and cos

$f = \mathbf{u}_r.\mathbf{u}_a$ represent inclination effects; and m_A and m_B are the masses* of bodies *A* and *B* (Fig. 1). The first term on the right hand side of (2) is the well-known static term; the third term is the term introduced by Sciama. The second term represents an inertial induction that depends on velocity. Both the second and the third terms are of much smaller order of magnitude compared to the static term, and are not easily detected by experiments.

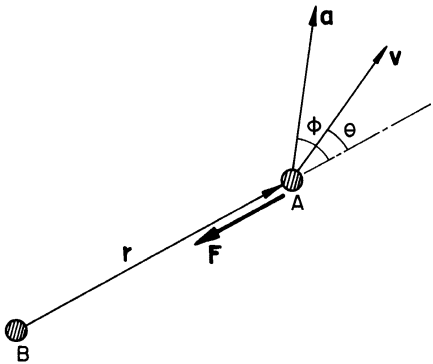


Fig. 1

Little attention has been paid to the possibility of a velocity-dependent term, perhaps because of the fact that such a velocity-dependent drag is practically undetectable.

It will be shown, however, that the introduction of a velocity-dependent inertial induction term represents more than just a small modification to previous theories; it results in some qualitative changes in the phenomenon of inertial induction and has some profound implications.

* Actually these are relativistic gravitational masses. However, except in cases where velocity approaches *c*, the relativistic effect can be neglected.

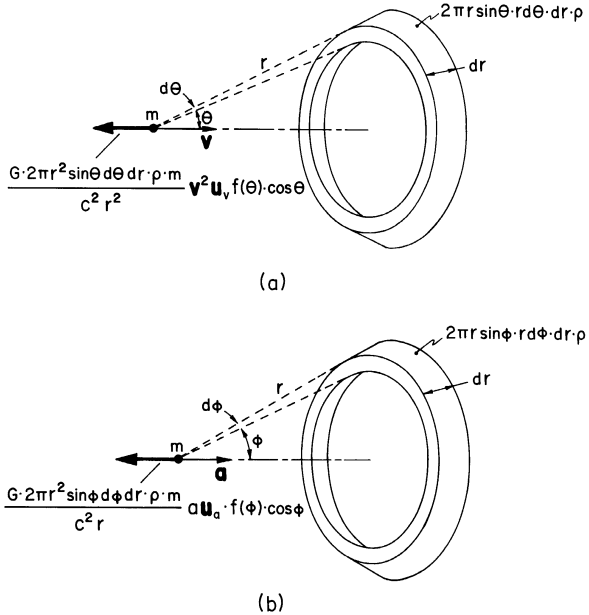


Fig. 2

The particle-particle interaction represented by (2) can be extended to interactions between bodies of finite dimensions. The interaction of a particle with the rest of the universe yields interesting results and is analyzed as follows. The universe is assumed to be quasi-static, homogeneous and infinite. It is further assumed that G (which represents the intensity of gravitational interaction between two gravitating bodies) is not a constant but is directly proportional to the energy of the particles transporting the gravitational effect. Fig. 2(a) and (b) show the interactive forces between a particle of relativistic mass m with an elemental ring of the universe due to its velocity v and acceleration a (with respect to the mean rest-frame of the

universe). When summed over the whole universe the contribution of the first term (*i.e.* the position dependent term) will be zero due to the symmetry, and the resultant interacting force can be expressed as follows:

$$\begin{aligned}\mathbf{F} &= -2\int_0^{\infty}\int_0^{p/2} \mathbf{u}_v \frac{G2\pi r^2 \sin\theta v^2 m f(f)\cos\theta \,\mathrm{d}\theta \,\mathrm{d}r}{c^2 r^2} \\ &\quad -2\int_0^{\infty}\int_0^{p/2} \mathbf{u}_a \frac{G2\pi r^2 \sin\phi\, am f(f)\cos\phi \,\mathrm{d}f \,\mathrm{d}r}{c^2 r} \\ &= -\mathbf{u}_v \int_0^{\infty} \frac{cGm}{c^2 r^2} v^2 r^2 r \,\mathrm{d}r - \mathbf{u}_a \int_0^{\infty} \frac{cGm}{c^2 r} a r^2 r \,\mathrm{d}r\end{aligned} \tag{3}$$

where

$$c = 4\pi \int_0^{p/2} \sin\theta f(\theta)\,\mathrm{d}\theta = 4\pi \int_0^{p/2} \sin\phi f(f)\,\mathrm{d}f$$

To proceed further, the variation of G (which has been assumed proportional to the energy of the gravitons) with r has to be taken into account. Let us assume that the first term on the right side of (3) becomes.

$$-\frac{k}{c} m v^2 \mathbf{u}_v$$

after integration, Thus, if we assume the gravity-transporting particles to move at the speed of light, the magnitude of the drag such particles will be subjected to is given by†

† This drag arises from the interaction of the gravitons under consideration with those originating from the matter present in the rest of the universe.

$$k\frac{E}{c^2}c$$

if E is the energy of the particle at the instant under consideration. When such a particle travels a distance dr, the corresponding decrease in energy due to this cosmic drag can be expressed as follows:

$$\mathrm{d}E = -k\frac{E}{c^2}c\cdot\mathrm{d}r$$

If E at start (*i.e.*, at r=0) is E_0 the solution of the above equation yields

$$E = E_0\exp\left[-\left(k/c\right)r\right] \tag{4}$$

Hence

$$G = G_0\exp\left[-\left(k/c\right)r\right] \tag{5}$$

where G_0 is the local value which is equal to 6.67×10^{-11} m^3 /kg-sec^2. Substituting G from (5) in (3)

$$\begin{aligned}\mathbf{F} &= -\frac{G_0 m v^2\mathbf{u}_v}{c^2}\,c\,r\int_0^\infty\exp\left[-\left(k/c\right)r\right]\mathrm{d}r \\ &\quad -\frac{G_0 m_a\mathbf{u}_a}{c^2}\,c\,r\int_0^\infty r\exp\left[-\left(k/c\right)r\right]\mathrm{d}r \\ &= -\frac{c\,G_0\,r}{kc}mv^2\mathbf{u}_v - \frac{c\,G_0\,r}{k^2}ma\mathbf{u}_a\end{aligned} \tag{6}$$

But the first term has already been assumed to be equal to

$$-\frac{k}{c}mv^2\mathbf{u}_v$$

Hence,

$$\frac{k}{c} = \frac{c G_0 r}{kc}$$

or

$$k = \left(c G_0 r \right)^{1/2}$$

Using the above expression for k, the force due to inertial induction of a particle with the rest of the universe becomes

$$\mathbf{F} = -\frac{k}{c} m v^2 \mathbf{u}_v - ma\mathbf{u}_a \tag{7}$$

Thus, we see that the inertial induction due to acceleration a of a body of mass m is identically equal to $-ma$ and the exact equivalence of gravitational and inertial masses is explained. It should be further noted that in Sciama's scheme, the coefficient of the term $-ma$ is dependent on the density of the universe and its observable radius. Therefore, it is perhaps only by chance that the coefficient turns out exactly equal to unity. In the present model this logical problem does not arise.

For the purpose of numerical computation, the inclination effects represented by $f(q)$ and $f(f)$ have been assumed to be as follows:

$$f\left(q\right) = \cos q \left|\cos q\right| \text{ and } \mathrm{f}\left(f\right) = \cos f \left|\cos f\right|$$

With the above functions $c = p$ and taking $r = 7\times10^{-27}$ kg/m^3 we get $k = 1.21\times10^{-18}\mathrm{s}^{-1}$

Obviously, the force due to the velocity-dependent term is extremely small and cannot be detected easily through experiments. It can be shown that the magnitude of local velocity-dependent inertial induction in the vicinity of massive bodies dominates when compared to that of the interaction with the whole universe. On the other hand,

in case of acceleration-dependent inertial induction, the interaction with the whole universe dominates.

In the subsequent sections a few astrophysical and cosmological consequences are presented. It will be shown that the model yields a number of interesting results which can be considered indirect verifications of the hypothesis.

Consequences of Universal Interaction; A Tired-Light Mechanism for Cosmological Redshift

It was shown in the previous section that velocity-dependent inertial induction of a particle of relativistic mass m moving with a constant velocity v (with respect to the mean rest frame of the quasi-static universe) results in a cosmic drag of magnitude

$$-\frac{k}{c}mv^2$$

It was also shown that $k \sim 1.21\times10^{-18}$ s^{-1}, and the magnitude of the drag is very small. Let us consider the effect of this cosmic drag on photons travelling very long distances. If a photon starts from a source at a distance x from the earth, its energy will gradually drop. The magnitude of the cosmic drag in case of photon is

$$-kc\frac{E}{c^2}$$

where E is the instantaneous energy of the photon. As the photon travels through a distance dx the drop in energy is

$$\mathrm{d}E = -kc\frac{E}{c^2}\cdot\mathrm{d}x$$

Since $E = hn$, where h is Planck's constant and ν is the frequency of the photon, the above equation can be written for a drop in frequency as follows:

$$\mathrm{d}n = -(kn/c)\,\mathrm{d}x$$

Using the initial condition $n = n_0$ when x=0 the solution of the above equation yields

$$\frac{n}{n_0} = \exp\left[-(k/c)x\right] \tag{8}$$

When $(k/c)\,x \ll 1$, the above equation can be approximately linearized and written in the following form:

$$\frac{n}{n_0} = \frac{n - n_0}{n_0} \approx -\frac{k}{c}x$$

Using the relation

$$\frac{\Delta n}{n_0} = -\frac{\Delta l}{l_0},$$

where l represents the wavelength, the fractional increase in the wavelength (*i.e.*, redshift) of the photon when it reaches the earth can be written as follows:

$$\frac{\Delta l}{l_0} \approx \frac{k}{c}x \tag{9}$$

where x is the distance travelled. Thus, even in a stationary universe, the photons are subjected to a cosmological redshift which is proportional to distance. It can be shown that k is none other than the Hubble constant, whose estimated magnitude is approximately 1.6×10^{-18} s^{-1}—very close to the calculated value of k!

Unlike many of the other tired-light mechanisms, velocity-dependent inertial induction can be tested in other situations and has yielded good results in all cases. It is also seen from (8) that the nature of the redshift is also as observed, *i.e.* proportional to wavelength, and deviating from linearity at high redshift values. According to the velocity-dependent inertial induction mechanism of the cosmological redshift, it is expected that such shifts will be more pronounced when the photon travels through portions of space where matter is more concentrated. The observations indeed support this (Karoji & Nottale 1976).

The universal induction model also provides a mechanism for the transfer of linear and angular momentum of moving systems to the rest of the universe.

Consequences of local interactions

Though the universal interaction model leads to the most profound consequences, *i.e.*, an alternate explanation for the observed cosmological redshift and the exact equivalence of gravitational and inertial masses, local interactions (in the vicinity of large bodies) can be much more dominant. In this section a number of situations will be considered where velocity-dependent inertial induction can have measurable effects, and the predictions will be compared with the observations.

It should be further noted that in most situations of local interaction, the effect of the acceleration-dependent inertial induction term will be quite small and can be generally ignored.

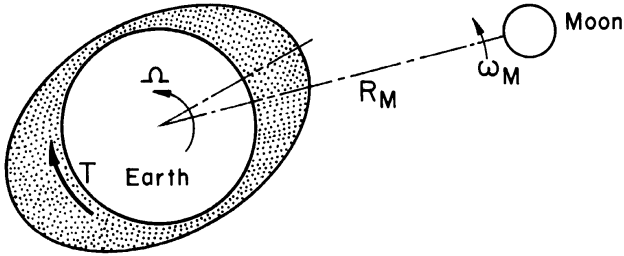


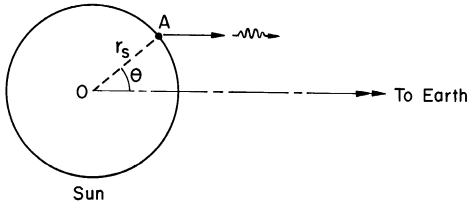
Fig. 3

Secular Retardation of Earth's Rotation: It has now been firmly established that the spin of the earth is gradually slowing down. Tidal friction has long been the accepted explanation for this spin-down, as indicated in Fig.3. There is no direct way of calculating the dragging torque T due to the tidal bulge, but it can be estimated from the values of $\dot{\Omega}$ which has been calculated from various observational data, Ω being the spin rate. However, the tidal bulge causes the moon to gain momentum (which is equal to the amount lost by the earth in conserving the total amount for the earth-moon system), and as a result the orbital radius of the moon, R_M, increases, and the moon's orbital angular speed, w_M, decreases in accordance with Kepler's Law. The tidal friction theory, unfortunately, leads to difficulties if one traces back the evolutionary history of the moon's orbit. To account for the observed spin-down rate ($\dot{\Omega} \sim -6\times10^{-22}$ rad s^{-1}) the value of T is such that it results in $\dot{R}_M \sim 1.3\times10^{-9}$ m s^{-1}. If the moon were actually receding at this velocity, then some 1300 million years ago it must have been so close to the earth that the gravitational pull would have destroyed both the bodies. But the geological evidence does not

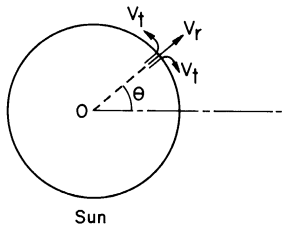
indicate any such disaster during the last 3500 million years, though there is evidence of the presence of tidal phenomena all through.

Analysis of the Sun-earth-moon system (Ghosh 1986a) shows that the velocity-dependent inertial induction produces a resisting torque of 4.75×10^{16} N-m due to the earth's spin, and this results in a spin-down of $\dot{\Omega} \sim -5.5\times10^{-22}$ rad s^{-2}. Only a very small fraction, 0.5×10 rad s^{-2}, is left to be taken care of by tidal friction. When velocity-dependent inertial induction is assumed, it is found that the distance of the moon is presently decreasing at a very slow rate of -0.15×10^{-9} m s^{-1}. Thus the difficulty of the moon's close approach is resolved. A prediction of almost the exact amount of required drag torque by the inertial induction model cannot be pure chance!

Secular Retardation of Phobos: Observation shows that Phobos is accelerating at a rate of 10^{-3} deg yr^{-2} (Pollack 1977, Sinclair 1989). The absence of any ocean on Mars makes it difficult to explain such a large acceleration in orbital motion, though some investigators have attributed this to the presence of a molten core. When the velocity-dependent inertial induction model is applied to the Sun-Mars-Phobos system an approximate model yields a secular acceleration of 26.5×10^{-21} rad s^{-2} (Selak 1984). This is equivalent to 1.5×10^{-3} deg yr^{-2} which is surprisingly close to the observed value. The slight difference could be due to neglecting the inclination effect and an assumption regarding the radial density variation of Mars (in the calculations this has been assumed to be similar to the density variation in the case of the Earth).



(a)



(b)

Fig. 4

Redshift in the Solar Spectrum: Photons are subjected to the effect of drag due to velocity-dependent inertial induction in the vicinity of a massive object, which may result in extra redshift (Ghosh 1986). For example if a photon is emitted from the surface of the sun and proceeds towards the earth as shown in Fig.4a the photon will be subjected to a redshift (due to the gravitational pull and the velocity-dependent inertial drag) as follows (Ghosh 1986):

$$\frac{\Delta l}{l} \approx \frac{GM_S}{c^2 r_S}\left(2 - \frac{1}{3}\sin^2 q\right) \tag{10}$$

where l and $l+\Delta l$ are the wavelengths of the photon at the surface of the sun and on the earth, respectively, r_s is the solar radius, q is the

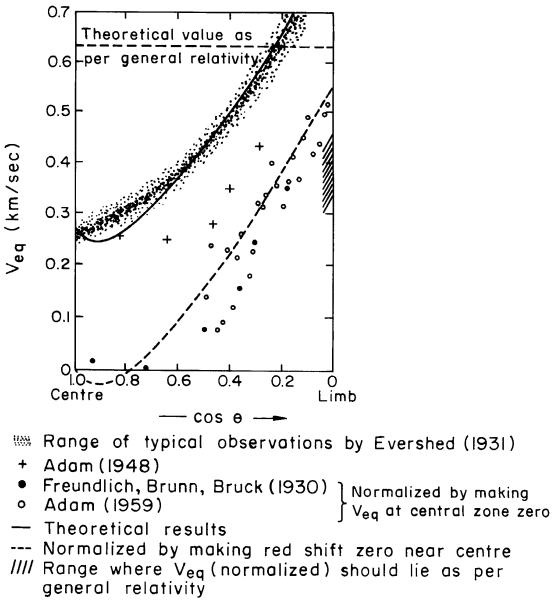


Fig.5

angle shown in Fig. 4a and M_S is the mass of the sun. Due to the solar granulation effect, the source from where the photons are emitted possesses radial and transverse motion as indicated in Fig.4b. The resultant redshift can be expressed in terms of an "equivalent velocity of recession" as follows:

$$v_{eq}(q) \approx \frac{GM_S}{c^2 r_S}\left(2 - \frac{1}{3}\sin^2 q\right) - v_r \cos q - v_t \sin q \qquad (11)$$

Using the observed and estimated values of the various quantities

$$v_{eq}(q) \approx 0.636\left(2 - \frac{1}{3}\sin^2 q\right) - \cos q - 0.2 \sin q \ {}^{km}\!/_{s}$$

Fig.5 shows a plot of the above function along with the measured values of the redshift of the solar spectrum for different values of q. Unless the effect of inertial induction is considered, it has not been possible to explain how the observed redshift near the solar limb can be substantially more than GM_S/c^2r_S, while a variation with q can be explained by the granulation effect.

Redshift of Photons Grazing Massive Objects: When a photon grazes a gravitating object the blueshift caused during the approach is cancelled by the redshift during its recession. Thus, no resultant effect is expected. However if velocity-dependent inertial drag is considered, photons will be subjected to a resultant redshift given by (assuming the gravitating object to be a point at its centre).

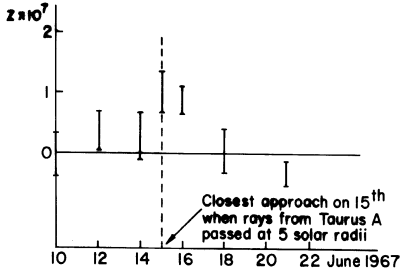
$$\frac{\Delta l}{l} \approx \exp\left(\frac{4GM}{3c^2r}\right) - 1 \qquad (12)$$

where M is the mass of the object and r is the distance of the object centre from the photon's path (the minimum possible value of r being the radius of the object). The orders of magnitude of redshift for different classes of objects are given in Table 2.

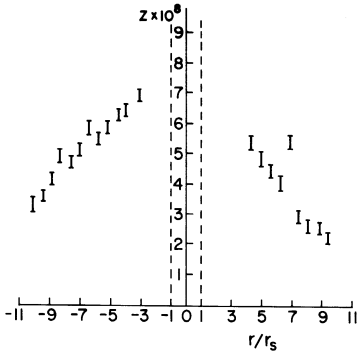
Table 2 - Redshift of Electromagnetic Waves Grazing Massive Bodies

Type of Object	M	R	Dl/l
Jupiter	$0.95\times10^{-3}M_S$	$r_S/10$	2.69×10^{-8}
Typical star	M_S	r_S	2.83×10^{-6}
Typical white dwarf	M_S	$r_S/80$	2.26×10^{-4}
Typical Neutron star	2 M_S	10 km	0.492
"Black hole"	—	Schwarzschild radius	0.95

M_S and r_S are the solar mass and solar radius, respectively. Although no experiment has been conducted to verify the above table, the first



(a)



(b)

Fig. 6

report of such an unexplained redshift was made by Sadeh *et al.* (1968). It was reported that the 21 cm signal from Taurus A near occultation position by the sun suffered a redshift of 150 Hz at a distance of 5 solar radii. Fig.6a shows the results, which agree with the calculated value using (12) insofar as order of magnitude is concerned. The 2292 MHz signal from Pioneer-6 was also found to be subjected to an unexplained redshift when it went behind the Sun (Merat *et al.* 1974). The redshift increased in magnitude as the signal trajectory approached the solar disc. A symmetrical redshift was

found on the other side of the solar disc after the occultation was over. The order of magnitude of this unexplained redshift was found to be of the order of 10^{-7} (Fig.6b). Such grazing experiments with the objective of determining extra redshift can be conducted to verify the theory.

Radial Matter Distribution in Spiral Galaxies: The stars in all spiral galaxies rotate around the respective galactic centres in almost circular orbits. It is interesting to note that the orbital velocity is almost constant except near the centre, as shown in Fig.7. Such a flat rotation curve is possible only when the matter in the galaxy is distributed in a particular way. But since the flat rotation curve is a universal feature of all spiral galaxies there must exist a servomechanism which distributes matter according to the required unique pattern.

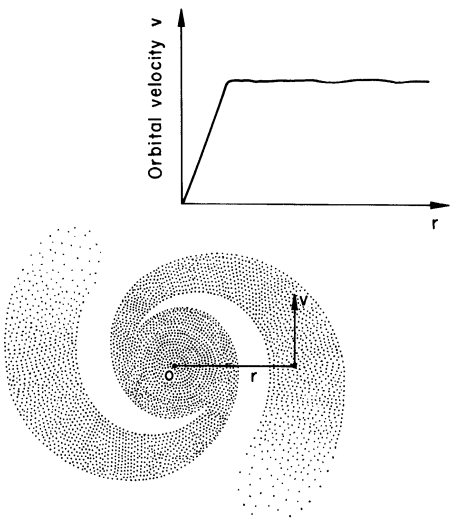


Fig. 7

When the hypothesis of velocity-dependent inertial induction is applied to a self-gravitating and rotating disc-like system (spiral galaxies) it is found that an equilibrium configuration is achieved when a star's motion

(i) satisfies Kepler's Law (slightly modified because of the acceleration-dependent inertial induction term whose effect can be neglected),

and (ii) is such that the pull due to the matter contained inside the star's orbit is balanced by the drag caused by the matter present outside the star's orbit (Fig.8)

It has been shown (Ghosh *et al.* 1988) that such an equilibrium situation invariably leads to almost constant orbital velocity. Thus velocity dependent inertial induction can act as the required servomechanism. Until now no other acceptable servomechanism has been identified.

Nebular Hypothesis of the Origin of Solar System: Mechanism for Transferring Solar Angular Momentum: Modern science unanimously accepts the nebular hypothesis for the origin of the solar system. However, in all such models, it has been necessary to account for the observed distribution of angular momentum by proposing a mechanism which can transfer the solar angular momentum. All the proposed mechanisms are active primarily during the pre-main-sequence period and, therefore, most of the transfer also takes place during the relatively short pre-main-sequence

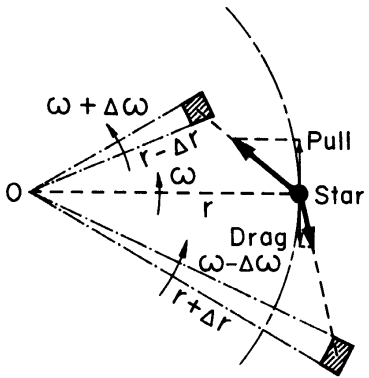


Fig. 8

period (~2×10^7 yrs.). Such mechanisms have not been universally accepted, and considerable doubt exists as to the feasibility of the necessary intensity of the mechanism. But if velocity-dependent inertial induction is assumed, it can transfer angular-momentum from the spinning sun to the protoplanetary disc (during the premain sequence period) and to the planets (during the main sequence period ~4.7×10^9 yrs). It can be shown (Ghosh 1988) that

$$l_S \approx \frac{0.4L^4c^2r_S}{G^3M_Sm^5t}$$

where L is the angular momentum of the original cloud, m is the mass of the fragment dislodged from the original body, and l_s is the angular momentum of sun at time t. Assuming the values of L and m as 10^{44} kg m^2 s^{-1} and 0.023 M_s, respectively (which are logically justifiable)

$l_s \sim 1.\ 4\times10^{41}$ kg m^2 s^{-1} (approximately equal to the present solar angular momentum)

when $t = 4.7\times10^9$ yr. Thus, in the available time the required amount of angular momentum can be transferred from the central body (the proto-sun in the pre-main-sequence period and the sun in the latter part). It should be further noted that unlike other proposed mechanisms, the major fraction of the transfer takes place during the long main-sequence period. This is in agreement with the observation that all new born stars are fast rotators (because comparatively little angular momentum has been transferred in the preceding short pre-main sequence period). This also explains similar situations in many planetary satellite systems where the majority of the system angular momentum belongs to the satellites rather than the central planet.

This mechanism also yields the correct value for the orbital radius of the planet nearest to the central body (Ghosh 1988).

Stellar Drag in Globular Clusters: A perplexing feature of globular clusters is the time required for their formation. The stellar drag due to the gravitational interaction with the rest of the system results in a relaxation time which is too high to be accepted. When the velocity-dependent inertial induction is taken into consideration, the relaxation time of a star in a typical globular cluster drops down to the order of magnitude of 10^{17} sec, a much more realistic value.

Concluding Remarks

It can be seen from the foregoing sections that the model of a dynamic gravitational interaction can lead to some very interesting consequences. One very important result is the exact equivalence of gravitational and inertial masses, since the inertial effect is nothing but a manifestation of the gravitational interaction of a body with the rest of the universe. Unlike in Sciama's model of inertial induction in this model the equivalence is not accidental, but a direct result of the phenomenon itself. This model also explains a number of unexplained and ill-explained phenomena in astronomy and astrophysics. Yet the most important point to be noted is that velocity-dependent inertial induction also provides for a tired-light mechanism which satisfies all the observed characteristics of the phenomenon.

If all these surprisingly accurate results in so many unconnected phenomena are not due to pure chance, then a strong case certainly exists for conducting experiments to directly verify the theory. One acceptable verification would be to detect the predicted amount of extra redshift in light from a star when a light ray grazes the surface of a planet (or satellite).

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