# A Scalar Gravitation Theory in Absolute Space-Time

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**Abstract**

*Poisson's equation for the Newtonian gravitational potential is extended to include the mass equivalent of the field energy itself as part of the source mass. Time retardation is introduced by converting Poisson's equation to a wave equation with a time-dependent source. Neglecting time retardation, about 40 percent of the unaccounted portion of the precession of the perihelion of Mercury is predicted. The gravitational red shift, the slowing of the speed of light, and the bending of a light ray in a gravitational field follow from Newtonian gravitation and the behavior of photons. Gravitational effects are generally smaller than for Newtonian gravitation. There is no limit, such as the Chandrasekhar limit, for the size of gravitating bodies; so super-massive bodies, being admissible, may account for the missing mass in the universe and the origin of quasars and galaxies. The cosmological red shift is obtained as a gravitational effect, the Hubble constant predicted being in reasonable agreement with observational estimates. According to this theory, the cosmological red shift is not a Doppler shift, the universe is not expanding, the big bang never happened, and the universe must be in steady-state equilibrium.*

**Key words:** scalar gravitation in absolute space-time

## 1. INTRODUCTION

A better gravitation theory is needed because general relativity suffers from many difficulties:

(1) The Schwarzschild singularity, occurring in empty space, violates the requirement of observability, since no actual physical entity that can be observed becomes infinite.

(2) The equivalence of gravitating and accelerating frames would seem to say that a stationary charge in a gravitational field should appear to move or to radiate without any source of energy.

(3) The metricization of the gravitational field, but not other force fields, violates symmetry. It would seem that the gravitational force should not be properly measurable against other forces.

(4) Covariance and equivalence violate Mach's principle that accelerations are determined by all of the matter in the universe and not just the local distributions of matter and fields.

(5) The apparent prediction of the anomalous portion of the precession of the perihelion of Mercury may be merely fortuitous, since it depends upon only a single isolated situation or data point. Also, a single data point involving possible unknown features cannot establish a general theory.

(6) The gravitational red shift, being easily predicted using Newtonian gravitation and the photon nature of light, is not a test for the success of general relativity.

(7) The curvature of a light ray and the slowing down of the speed of light in a gravitational field may also be predicted using Newtonian gravitation and the photon nature of light; they also are not tests for the success of general relativity.

(8) The weak field limit of general relativity yields special relativity, which is now known to be false.[(1)-(4)]

(9) The Chandrasekhar limit[(5)] prohibits super-massive bodies (black holes) which may account for the missing mass[(6)] needed to hold fast-moving galaxies in clusters and which may account for the origin of quasars and galaxies.

(10) The cosmological red shift is not derived by general relativity as a gravitational effect.

The gravitational theory proposed here is based upon the necessary logical extension of Newton's gravitation to include mass-energy equivalence. In particular, the mass equivalent of the gravitational field energy is included as part of the source mass. Poisson's equation for the Newtonian gravitational potential $\Phi$ is generalized to include the mass equivalent of the gravitational field-energy-per-unit-volume $W$,

$$W = -(\nabla\Phi)^2/8\pi G, \tag{1}$$

where $G$ is the universal gravitational constant, yielding

$$\nabla^2\Phi = -4\pi G\rho + (\nabla\Phi)^2/2c^2, \tag{2}$$

where $\rho$ is the material mass density and $c$ is the velocity of light (the round trip phase velocity in free space). It may be noted from the classical derivation of Eq. (1) that $W$ is just the self-energy-per-unit-volume of the material mass distribution $\rho$.

This result (2) may be linearized by introducing a new gravitational field potential $\Psi$ defined by

$$\Phi = -2c^2 \ln \Psi. \tag{3}$$

Substituting Eq. (3) into (2) yields the desired linear result as

$$\nabla^2\Psi = 2\pi G\rho\Psi/c^2. \tag{4}$$

The proposed theory is succinctly stated by Eq. (2), or its equivalent Eq. (4). The consequences derived from Eq. (2) or (4) are presented below.

## 2. GENERALIZATION TO INCLUDE TIME RETARDATION

Time retardation can be introduced by generalizing Eq. (2) to the wave equation

$$\nabla^2\Phi - \partial^2\Phi/c^2\partial t^2 = -4\pi G\rho - (\partial\Phi/\partial t)^2/2c^4 + (\nabla\Phi)^2/2c^2, \tag{5}$$

where the gravitational field energy has been taken as

$$(1/8\pi G)[(\partial\Phi/\partial t)^2/c^2 - (\nabla\Phi)^2], \tag{6}$$

the minus sign being taken in agreement with Eq. (1). Using Eq. (3) yields the wave equation for $\Psi$ as

$$\nabla^2\Psi - \partial^2\Psi/c^2\partial t^2 = (2\pi G\rho/c^2)\Psi. \tag{7}$$

This Eq. (7) can also be written in the integral form

$$\Psi(\mathbf{r}, t) = (G/2c^2)\int_{V'} (\rho_{\text{ret}}\Psi_{\text{ret}}/R)d^3r', \tag{8}$$

where retarded values occur in the integrand,

$$\rho_{\text{ret}} = \rho(\mathbf{r}', t - R/c) \text{ and } \Psi_{\text{ret}} = \Psi(\mathbf{r}', t - R/c), \tag{9}$$

and

$$R = |\mathbf{r} - \mathbf{r}'|. \tag{10}$$

It is clear that Eq. (7) predicts scalar longitudinal gravity waves of velocity $c$. For example, in regions where $\rho = 0$, Eq. (7) predicts free space gravity waves.

Only static source distributions will be considered in this paper where Eq. (4) is sufficient.

## 3. THE TOTAL MASS

Since the present theory extends the concept of mass to include the mass equivalent of the gravitational field energy itself, it is convenient to define a *total* mass $M$ in a volume $V$ as

$$M = \int_V \rho\Psi d^3r, \tag{11}$$

where $\rho$ is the material mass density. When $\Psi = 1$ and $\Phi = 0$, Eq. (11) yields the material mass in $V$, as it should.

It may be seen, using Eq. (4), that this definition (11) for the total mass satisfies Gauss's law; thus,

$$M = (c^2/2\pi G)\int_S (\partial\Psi/\partial\mathbf{n})dS, \tag{12}$$

where $S$ is the surface enclosing the volume $V$ and $\mathbf{n}$ is the outward drawn normal to the surface.

## 4. FIELD OF A SPHERE OF UNIFORM MATERIAL MASS

Solving Eq. (4) for the case when the material mass density $\rho$ is constant within a sphere of radius $R$ and zero outside subject to the boundary conditions that $\Psi$ and $\nabla\Psi$ are continuous across $r = R$, yields

$$\Psi = \begin{cases} \operatorname{sech}(\beta R)\sinh(\beta r)/\beta r & \text{for } r \leqq R, \\ 1 - GM/2c^2 r & \text{for } r \geqq R, \end{cases} \tag{13}$$

where $\beta$ and $M$ are constants defined by

$$\beta^2 = 2\pi G\rho/c^2 \text{ and } M = (2c^2R/G)[1 - \tanh(\beta R)/\beta R]. \tag{14}$$

It may be noted that $M$ is the total mass satisfying Eq. (11).

For the case when $\beta$ is small, which is true for ordinary material mass densities, the result (13) reduces to

$$\Psi \approx 1 - \Phi_0/2c^2 \tag{15}$$

where $\Phi_0$ is the ordinary classical Newtonian gravitational potential given by

$$\Phi_0 = \begin{cases} (GM_0/2R)(3 - r^2/R^2) & \text{for } r \leqq R, \\ GM_0/r & \text{for } r \geqq R, \end{cases} \tag{16}$$

where $M_0$ is the material mass of the sphere.

## 5. AN INTEGRAL EQUATION FOR THE GRAVITATIONAL POTENTIAL

For a prescribed static material mass density distribution $\rho$, the gravitational potential from Eq. (4) [and, thus, $\Phi$ from Eq. (3)] may be obtained in principle as readily as the gravitational potential in Newtonian theory. It is assumed that appropriate solutions to Eq. (4) are for $\Psi$ and $\nabla\Psi$ continuous everywhere.

It is useful to reformulate Eq. (4) as an integral equation. Considering the Green's function $\Gamma$ defined by

$$\nabla^2\Gamma = -4\pi\delta(\mathbf{r} - \mathbf{r}'), \tag{17}$$

where $\delta(\mathbf{r} - \mathbf{r}')$ is a delta function,

$$\Gamma = 1/|\mathbf{r} - \mathbf{r}'|. \tag{18}$$

Multiplying Eq. (4) by $\Gamma$ and Eq. (17) by $(\Psi - 1)$, subtracting, and integrating over all space, noting that $\Gamma$ and $\partial\Gamma/\partial r$ vanish on the sphere at infinity, the desired integral equation becomes

$$\Psi(\mathbf{r}) = 1 - (G/2c^2)\int \rho(\mathbf{r}')\Psi(\mathbf{r}')\Gamma(\mathbf{r}', \mathbf{r})d^3r'. \tag{19}$$

By substituting the entire right side of Eq. (19) back into (19) under the integral sign, using Eq. (18), and iterating the procedure yields the series solution

$$\Psi(\mathbf{r}) = 1 - \frac{G}{2c^2}\int \frac{\rho(\mathbf{r}_1)}{|\mathbf{r} - \mathbf{r}_1|}d^3\mathbf{r}_1 + \frac{G^2}{4c^4}\int \frac{\rho(\mathbf{r}_1)}{|\mathbf{r} - \mathbf{r}_1|}d^3r_1 \int \frac{\rho(\mathbf{r}_2)}{|\mathbf{r}_1 - \mathbf{r}_2|}d^3r_2 - \cdots . \tag{20}$$

It may be seen that the second term on the right of Eq. (20) is just the classical Newtonian potential $\Phi_0$ multiplied by $(-1/2c^2)$. Successive terms in the series are of the order of magnitude of successive powers of the small quantity $G/2c^2$. This series solution (20) reveals the important fact that the gravitational potential will be less than the classical Newtonian potential and that all the effects of gravitation will be less than the effects predicted by classical Newtonian theory. No singularities such as the Schwarzschild singularity can possibly arise. In fact, it may be readily deduced from Eq. (19) that

$$0 \leqq \Psi \leqq 1. \tag{21}$$

## 6. MOTION OF A PARTICLE IN A GRAVITATIONAL FIELD

The dynamics of a particle is specified by non-Newtonian mechanics where the momentum $\mathbf{p}$ is given by

$$\mathbf{p} = m\gamma\mathbf{v}, \tag{22}$$

where $m$ is the material mass of the particle, $\mathbf{v}$ is the velocity of the particle, and

$$\gamma = 1/\sqrt{1 - v^2/c^2}. \tag{23}$$

The total energy of a free particle including the rest energy of $mc^2$ is then given by

$$E = m\gamma c^2. \tag{24}$$

Non-Newtonian mechanics was established by careful experimentation.[(7),(8),(9)] It has been subsequently confirmed by countless accurate observations. It is not appropriate to attribute empirical non-Newtonian mechanics to special relativity with its numerous errors and internal inconsistencies.[(1)-(4)]

The force that a mass particle experiences in a gravitational field is taken as the gradient of the gravitational potential times the non-Newtonian mass $m\gamma$ to agree with classical Newtonian theory; thus,

$$\mathbf{F} = m\gamma\nabla\Phi = -2c^2 m\gamma\nabla \ln \Psi. \tag{25}$$

The motion of a material mass particle in a gravitation field using non-Newtonian mechanics is then given by Newton's second law as

$$d(m\gamma\mathbf{v})/dt = -2c^2 m\gamma\nabla \ln \Psi. \tag{26}$$

An energy integral of the motion can be immediately obtained by multiplying Eq. (26) by $\gamma\mathbf{v}$ and integrating with respect to time; thus,

$$\begin{aligned}\gamma\mathbf{v}\cdot d(m\gamma\mathbf{v})/dt &= c^2 m\gamma d\gamma/dt \\ &= -2c^2 m\gamma^2\mathbf{v}\cdot\nabla \ln \Psi = -2c^2 m\gamma^2 d(\ln \Psi)/dt.\end{aligned} \tag{27}$$

Integrating Eq. (27) yields

$$\gamma = K\Psi^{-2}, \tag{28}$$

where $K$ is a constant of integration, which may be identified with the total energy by letting $K = E/mc^2$. The desired energy integral then becomes

$$E = m\gamma c^2\Psi^2. \tag{29}$$

For a particle in free space where $\Psi = 1$, Eq. (29) yields Eq. (24), as it should. For a slowly moving particle in the far field of a small material mass $M_0$ gives

$$\gamma \approx 1 + v^2/2c^2 \text{ and } \Psi \approx 1 - \Phi_0/2c^2 = 1 - GM_0/2c^2 r. \tag{30}$$

In this case the total energy from Eq. (29) becomes

$$E \approx mc^2 + mv^2/2 - GmM_0/r, \tag{31}$$

the rest energy plus kinetic energy plus gravitational potential energy. This result (31) then further serves as a check on the correctness of Eq. (29).

## 7. PRECESSION OF THE PERIHELION OF MERCURY

For a particle moving in a central force field a further integral of the motion may be obtained in terms of the angular momentum. Taking the vector product of $\mathbf{r}$ and Eq. (26) divided by $\gamma$ yields

$$\mathbf{r} \times (1/\gamma)d(m\gamma\mathbf{v})/dt = -\mathbf{r} \times 2c^2 m\nabla \ln \Psi = 0; \tag{32}$$

since $\Psi$ is a function of $r$ only. Integrating Eq. (32) then yields

$$\mathbf{r} \times m\gamma\mathbf{v} = \mathbf{L}, \tag{33}$$

where $\mathbf{L}$, a constant of integration, is the angular momentum of the particle. This result (33) prescribes motion in a plane normal to $\mathbf{L}$. Choosing the radius $r$ and the angle $\vartheta$ in this plane, Eq. (33) becomes

$$m\gamma r^2\dot{\vartheta} = L, \tag{34}$$

where the dot over $\vartheta$ refers to time differentiation.

Using the energy integral (29) to eliminate $\gamma$ yields

$$r^2\dot{\vartheta} = (c^2L/E)\Psi^2. \tag{35}$$

Solving Eq. (29) for $v^2 = c^2(1 - \gamma^{-2}) = \dot{r}^2 + r^2\dot{\vartheta}^2$ and letting $\dot{r} = (dr/d\vartheta)\dot{\vartheta} = r'\dot{\vartheta}$ and using Eq. (35) to eliminate $\dot{\vartheta}$ yields an expression for $r$ as a function of $\vartheta$,

$$r'^2 + r^2 = (E^2/c^2L^2)r^4/\Psi^4 - (m^2c^2/L^2)r^4. \tag{36}$$

Making the substitution $r = 1/u$ yields

$$u'^2 + u^2 = (E^2/c^2L^2)\Psi^{-4} - m^2c^2/L^2. \tag{37}$$

For the present example of interest, the potential field $\Psi$ of the sun may be taken as

$$\Psi = 1 - GMu/2c^2, \tag{38}$$

from the second of Eqs. (13) and (14), assuming the sun has a uniform density, which should be adequate for present purposes. From the second of Eqs. (14) to second order smallness

$$M = M_0(1 - 3GM_0/5c^2R), \tag{39}$$

where $M_0 = 4\pi\rho R^3/3$ is the total material mass of the sun.

Expanding $\Psi^{-4}$ to second order smallness from Eq. (38) gives

$$\Psi^{-4} = 1 + (2GM/c^2)u + (5G^2M^2/2c)u^2. \tag{40}$$

Substituting this result (40) into Eq. (37) then yields an equation of the form

$$u'^2 + A^2(u - B)^2 - C^2 = 0, \tag{41}$$

where the constants $A$, $B$, and $C$ may be readily obtained. The solution to Eq. (41) is

$$u = B + (C/A)\cos A\vartheta, \tag{42}$$

where

$$A^2 = 1 - 5(GME/c^3L)^2/2. \tag{43}$$

The angle necessary to return to the same value of $u$ on the orbit is given by

$$\vartheta = 2\pi/A. \tag{44}$$

The precession in one Mercury year $\delta$ is then

$$\delta\vartheta = 2\pi/A - 2\pi = (5\pi/2)(GME/c^3L)^2. \tag{45}$$

For the present approximation it is sufficient to choose $E = mc^2$ and $M = M_0$.

This result (45) is about 40 percent of the anomalous precession. The discrepancy may arise from the failure to take time retardation into account. It might also arise from other causes. Predicting the result of such an isolated example, a single data point, does not constitute a proper test for any gravitational theory.

## 8. GRAVITATIONAL RED SHIFT

When a photon is created in a gravitational field-free region, rest energy, and perhaps kinetic energy, is converted into photon energy. When a photon is created in a gravitational field, the total mass-energy, including the gravitational energy, must be conserved. In a gravitational field-free region, an amount of energy $mc^2\gamma$ is converted into photon energy $h\nu$; thus,

$$h\nu = mc^2\gamma, \tag{46}$$

where $h$ is Planck's constant and $\nu$ is the photon frequency. Substituting $mc^2\gamma$ from Eq. (46) into Eq. (29), the total energy of a photon in a gravitational field becomes

$$E = h\nu\Psi^2 \text{ or } \lambda = (hc/E)\Psi^2. \tag{47}$$

As a photon passes from infinity where $\nu = \nu_0$ or $\lambda = \lambda_0$ and $\Psi = 1$ into a gravitational field $\Psi$, the frequency $\nu$ or wavelength $\lambda$ becomes

$$\nu = \nu_0/\Psi^2 \text{ or } \lambda = \lambda_0\Psi^2. \tag{48}$$

For experiments on the earth, the weak gravitational field limit may be taken, where $\Psi$ is given in terms of the classical Newtonian field $\Phi$, as

$$\Psi = 1 - \Phi/2c^2. \tag{49}$$

Conserving energy, using Eq. (47), a fractional change in frequency or wavelength is given by

$$\Delta\nu/\nu = -\Delta\lambda/\lambda = \Delta\Phi/c^2 \tag{50}$$

where a term varying as $1/c^4$ has been neglected. A photon passing out of a gravitational field is shifted toward the red, $\Delta\Phi$ being negative and $\Delta\lambda$ positive. This result (50) was verified experimentally using the Mössbauer effect.[10]

Actually the result (50) merely expresses the conservation of energy in a Newtonian gravitational field. The change in the energy of a photon $h\Delta\nu$ is equal to the change in gravitational energy $(h\nu/c^2)\Delta\Phi$, the mass equivalent of the photon energy $h\nu$ being $h\nu/c^2$. This trivial result (50) can hardly be viewed as a profound test of any gravitational theory other than Newtonian gravitation.

It is important to ask what happens to the energy lost by a photon $-h\Delta\nu$ as it climbs out of a gravitational potential energy well $-h\nu\Phi/c^2$. The energy lost by the photon can only become deposited as gravitational energy associated with the matter left behind, since only gravitational effects are involved. The consequences of this fact are far reaching. It means that energy of a form with about the lowest capability of creating thermodynamic order, i.e., thermal radiation, is converted to energy of the greatest capability of creating thermodynamic order, i.e., gravitational energy that can be converted directly into work.

To pursue the matter further, the case of a uniform sphere of low density $\rho$ and radius $R$ may be considered. The gravitational energy of the sphere is $-6GM_0^2/5R$, where $M_0 = 4\pi\rho R^3/3$ is the material mass of the sphere. Assuming the radiating photon deposits its energy loss by expanding the sphere, then $h\Delta\nu = (6GM^2/5R^2)\Delta R$. This constitutes a decrease in density. The red shift of photons can in general be interpreted as causing a reduction in the density of matter with an attendant increase in gravitational potential energy.

## 9. SLOWING OF THE SPEED OF LIGHT IN A GRAVITATIONAL FIELD

Since photons are radiated into phase space where the number of photons radiated per energy interval is proportional to the square of the frequency $\nu^2$, a flux of photons, being viewed as a continuous process of reradiation, must be proportional to $\nu^2\mathbf{v}$, where $\mathbf{v}$ is the velocity of the photons. Classical wave theory indicates the same conclusion. The Poynting's vector $\mathbf{S}$ and the energy density $E$ in scalar representation[11] are given by

$$\mathbf{S} = -\nabla U\partial U/\partial t, \text{ and } E = (\nabla U)^2/2 + (\partial U/\partial t)^2/2c^2, \tag{51}$$

where $U$ is the wave function and $c$ is the phase velocity. The time-averaging Poynting's vector, or net photon flux, for a traveling wave $U = A\cos[2\pi\nu(t - x/c)]$ is

$$\langle\mathbf{S}\rangle = \langle E\rangle\mathbf{v} = \nu^2\mathbf{v}K, \tag{52}$$

where $K$ is a constant. It should be noted that the velocity of energy propagation $v$, which is the photon velocity, is not in general equal to the phase velocity $c$.[12],[13]

Since energy is conserved for each individual photon, as discussed in the previous section, the steady-state flux of photons in a tube of flow must be conserved. In particular, the steady-state flux of photons at infinity in the absence of a gravitational field must equal the steady-state flux of photons in the same tube of flow when it passes into a gravitational field. Consequently,

$$\nu^2 v = \nu_0{}^2 c, \tag{53}$$

where $\nu_0$ is the frequency and $c$ the velocity of photons at infinity, and $\nu$ is the frequency and $v$ the velocity in a gravitational field. From Eqs. (53) and (48) then

$$v = c\Psi^4. \tag{54}$$

In the weak field limit valid for actual observations

$$\Psi^4 = 1 - 2\Phi/c^2, \tag{55}$$

where $\Phi$ is the classical Newtonian potential. This agrees with the general relativity prediction.[14] In principle this result (55) can be checked by observations.[15]

It should be noted that this result (55) follows simply from Newtonian gravitational theory and the behavior of photons. It thus does not constitute a test of any gravitational theory other than Newtonian theory.

## 10. DEFLECTION OF A LIGHT RAY IN A GRAVITATIONAL FIELD

The bending of a ray of light in a gravitational field produced by a spherical mass distribution such as the sun may be derived from the second of Eqs. (13) and (54) using Huygen's principle for the refraction of light. To within a sufficient approximation, the total angular deflection $\delta$ of a ray of light passing within a projected distance $r_0$ of the center of the sun is then given by

$$\delta = \int_{-\infty}^{\infty} [(\partial v_y/\partial x)/v_y]dy, \tag{56}$$

where $y$ is a coordinate through the center of the sun parallel to the original direction of the ray, and $x$ is a coordinate through the center of the sun transverse to the original direction of the ray. Since $v_x$ is always negligible compared with $v_y$, $v_y$ may be taken equal to $v$ as given by Eq. (54). Thus, Eq. (56) becomes

$$\delta = \int_{-\infty}^{\infty} 4[\partial(\ln \Psi)/\partial x]dy. \tag{57}$$

Using the second of Eqs. (13) for the case where $M \approx M_0$, the material mass, to first order in $M_0$, the material mass, to first order in $GM_0/2c^2r$, then $\partial(\ln \Psi)/\partial x = (GM_0/2c^2)x/r^3$. Thus,

$$\delta = (2GM/c^2 \int_{-\infty}^{\infty} [x/(x^2 + y^2)^{3/2}]dy. \tag{58}$$

Since for a small angular deflection $\delta$, $x = r_0$, Eq. (58) yields

$$\delta = 4GM_0/c^2r_0. \tag{59}$$

This agrees with the general relativity prediction[16] and with the rather uncertain observations.[17]

It may be noted that this result (59) can be obtained from Newtonian gravitational theory and the behavior of photons. Thus, the bending of a light ray around the sun does not constitute a test of any gravitational theory other than Newton's.

## 11. SUPER-MASSIVE BODIES

The present theory yields no limit for the mass of a gravitating body, such as the small Chandrasekhar limit[5] derived using general relativity. A small limit to the mass of a gravitating body is also implied by Newtonian theory. Increasing the material mass indefinitely eventually yields a gravitational self-energy (which is negative) equal to the rest energy of the matter, thereby producing a body of zero total gravitational mass and lacking any interaction with other bodies.

To examine the implications of the present theory, the particularly simple example of a gravitating sphere of uniform matter density $\rho$ may be considered. The total gravitational mass of such a sphere is given by the second of Eqs. (14). For a very massive body or super-massive body

$$\sqrt{2\pi G\rho}R/c = \beta R \rightarrow \infty; \tag{60}$$

so the second of Eqs. (14) yields

$$M = 2c^2R/G = (2c^2/G)(3/4\pi\rho)^{1/3}M_0^{1/3} \propto M_0^{1/3}. \tag{61}$$

Thus the material mass $M_0$ can increase indefinitely without any limitation on the total gravitation mass $M$. This general conclusion will not be altered if some realistic equation of state for the pressure as a function of the density for the matter is assumed. This result (61) thus indicates that the present theory admits the possibility of super-massive bodies.

A super-massive body may be envisioned as having a mass of the order of a galactic mass. It may be envisioned as being contained within a small volume, perhaps the size of the solar system. The high gravitational field at the surface of such a super-massive body would preclude the escape of radiant energy due to the extreme gravitational red shift. A super-massive body would be an effective sink for all particles directed toward the body. Such super-massive bodies would be black and would, therefore, not be directly observable.[18]

Super-massive bodies are convenient to explain certain observed astronomical phenomena. The origin of a galaxy or a quasar can be envisioned as arising from the collision (or near collision) of two super-massive bodies. The gravitational pull of one body on the other would result in tidal bulges in which the gravitational fields could be greatly reduced permitting the release of ordinary mass and radiation. Matter would then presumably stream into the region between the super-massive bodies where the gravitational field would be essentially zero. The subsequent recoil jetting of the partially depleted super-massive bodies away from each other might then account for the two spiral arms of a galaxy.

The high velocities of stars and galaxies in certain clusters indicate the presence of more mass than can be visually accounted for in order to hold the clusters together. Super-massive bodies, being black and small, could easily account for the missing mass when appropriately situated.

The red shifts of quasars and some condensed galaxies appear to be too great to be due solely to a cosmological red shift. There is much evidence indicating the existence of large red shifts apart from the cosmological red shift.[19] Anomalously high red shifts might be accounted for by the very large gravitational red shifts of super-massive bodies. Thus, quasars viewed as the result of the collision of two super-massive bodies would radiate light with a large red shift due to the gravitational field of the two super-massive bodies. Quasars, thus, need not be far away to exhibit large red shifts. The large red shift of some galaxies might also result from super-massive bodies being embedded in them. The apparent rotations of the plane of galaxies, as suggested by barred spirals, might result from the passing of a black super-massive body.

Super-massive bodies might also play a role in the large scale features of the universe, such as galactic clusters and strings of galaxies.

## 12. THE COSMOLOGICAL RED SHIFT

It is generally assumed, as explicitly stated by the cosmological principle, that at every point in the universe, the universe in the large will appear isotropic. Thus, it is generally assumed that the universe can have no origin. Yet there is, in fact, one unique point in the universe that may be viewed as the origin of the universe, and that is the point at infinity. This point can have unique properties, and it can be viewed from any ordinary point in the universe.

Assuming that the universe in the large has a uniform mass density, it is of some interest to obtain the gravitational field in the neighborhood of the point at infinity for a uniform mass density $\rho$. The gravitational field $\Psi$ is then given by the asymptotic form of Eq. (4); thus

$$d^2\Psi/dr^2 = \beta^2\Psi, \tag{62}$$

where $\beta^2 = 2\pi G\rho/c^2$. The bounded solution of Eq. (62) is

$$\Psi = \Psi_0 e^{-\beta r}, \tag{63}$$

where $\Psi_0$ is a constant of integration.

The cosmological red shift may be obtained by considering a photon passing through this field given by Eq. (63). Using the second of Eqs. (47) or (48) and Eq. (63), the fractional change in wavelength of the photon $z$ is

$$\begin{aligned} z &= (\lambda_{\text{observer}} - \lambda_{\text{source}})/\lambda_{\text{source}} \\ &= \exp[2\beta(r_{\text{source}} - r_{\text{observer}})] - 1, \end{aligned} \tag{64}$$

where $r_{\text{source}}$ and $r_{\text{observer}}$ are assumed to be in the asymptotic region. Abbreviating the notation, Eq. (64) may be written as

$$z = \Delta\lambda/\lambda = e^{2\beta r} - 1. \tag{65}$$

For an estimated density of the universe[20] of $\rho = 10^{-29}$ gm/cm$^3$ then $\beta = 7 \times 10^{-29}\text{cm}^{-1}$. For distances $r$ up to the order of $10 \times 10^9$ light-years, $\beta r \ll 1$, the red shift, as given by Eq. (65), may be approximated as a linear red shift

$$z = \Delta\lambda/\lambda = 2\beta r. \tag{66}$$

Using the estimated value of $\beta$, the Hubble constant becomes

$$H = 2\beta = 100 \text{ km/sec/Mpsec}. \tag{67}$$

Considering the large range of observational estimates of the Hubble constant[21] and the uncertainty in estimating the density of the universe, this value (67) may be regarded as satisfactory.

## 13. COSMOLOGY

The present result (66) and (67) for the cosmological red shift has profound implications for cosmology. The cosmological red shift predicted here is based solely upon a gravitational effect. This means that the usual interpretation of the observed cosmological red shift as a Doppler shift due to an expanding universe is untenable. Since the theory says the universe is not expanding, the big-bang theory also becomes untenable. In addition, the theory implies a steady-state universe that is not changing with time.

According to the present theory, the physical mechanism giving rise to the cosmological red shift is gravitation; so the energy lost by photons proceeding toward the earth from large distances must be deposited as gravitational potential energy. Considering the fact that local gravitational red shifts can be accounted for by assuming a local expansion of matter (Sec. 8 above), a similar mechanism may be assumed for the cosmological red shift. Matter distributed heterogeneously as condensed galaxies and stars has lower gravitational energy than matter evenly or homogeneously distributed as gas and dust. Thus, light passing through space tends to drive the matter in the universe toward more uniform or homogeneous distribution, thereby increasing the gravitational potential energy of the universe.

The cosmological red shift process is the opposite of the process forming local condensations such as stars and galaxies. Stellar formation is associated with decreasing local gravitational potential energy and the radiation of photons. The cosmological red shift phenomenon is associated with the absorption of photons and with an "evaporation" of local condensations of matter with a consequent increase in gravitational potential energy. Thus, in a steady-state universe these two processes may be assumed to be balanced against each other.

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**Résumé**

*L'équation de Poisson pour le potentiel gravitationnel de Newton est traitée afin d'y inclure l'équivalent massique du champ d'énergie lui-même considéré comme faisant partie de la masse proprement dite. Le temps-retard est introduit en transformant l'équation de Poisson en une équation d'onde initialement dépendante du temps. En négligeant le temps-retard, on peut prédire à peu près 40 pour cent de la part inexpliquée de la précession et du périhélie de Mercure. Le déplacement gravitationnel de la raie rouge, le ralentissement de la vitesse de la lumière et la courbure du rayon lumineux dans un champ gravitationnel procèdent de la gravitation newtonienne et du comportement des photons. Les effets gravitationnels sont généralement plus petits que ceux donnés par la gravitation newtonienne. Il n'y a pas de limite, telle que celle de Chandrasekhar, pour la dimension des objets en gravitation; comme il devient dès lors possible de prendre des corps super-massifs en considération, ils peuvent expliquer la masse "manquante" présente dans l'univers et l'origine des quasars et des galaxies. Le déplacement cosmologique de la raie rouge est vu comme un effet gravitationnel, la constante de Hubble prédite correspond raisonnablement bien avec les estimations tirées des observations. Dès lors, selon cette théorie, le déplacement de la raie rouge n'est pas dû à un effet Doppler; l'univers n'est pas en expansion; le "big-bang" n'a jamais eu lieu et l'univers se trouve dans un régime d'équilibre continu.*

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