Photon-Graviton Recycling as Cause of Gravitation

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Abstract. Previously, the author proposed that graviton energy and photon energy are everywhere being interconverted at fractional rates proportional to the Hubble constant H_0. Evidence for the postulated graviton decay was suggested to lie in observable planetary heating and expansion. The greatest quantity of gravitational potential energy associated with a mass resides in its interactions with the most distant matter of the visible universe. Assuming that this graviton energy is also decaying to photons, then long wavelength electromagnetic radiation is being generated almost uniformly at every point in space. A universe in equilibrium requires that this radiation is reconverted to gravitons at the same relative rate, closing the energy cycle. Supposing that photons are reconverted to gravitons through absorption by matter, a simple mechanism for universal gravitation can be developed. In a mechanism analogous to Le Sage's and Brush's theories of gravity, bodies mutually screen each other from a portion of the radio photon background and consequently are pushed towards each other. It is shown that Newton's law is reproduced and some possible connections to the General Theory of Relativity are discussed. Lastly, it is suggested that the luminosities of neutron stars, white dwarfs and black holes may be primarily due to graviton decay therein.

Keywords: Le Sage gravity, planetary heating, tired light, static universe, expanding earth hypothesis, black holes

Introduction

The question of what physical process underlies gravitation has a dual response in the General Theory of Relativity (GTR). In the geometric interpretation, it is the bending of spacetime itself which induces gravitational accelerations, *i.e.*, there is no need to search for a deeper cause. In the field interpretation, which was favoured by Einstein, gravity is a force not fundamentally different from the other forces, and very likely connected to the latter. However, almost a century of searching for a mechanism of quantum gravity has failed to reveal such an association.

Working within a static universe context (*i.e.*, without the postulate of universal expansion), the author has previously suggested that the graviton energy in gravitating systems is being converted directly or indirectly to photons and heat at a fractional rate proportional to H_0 (Edwards, 2006, hereafter Ref 1). Empirical evidence for this graviton decay was suggested to lie in the observed heat emissions from planets and in the quite possible expansion of the Earth (for discussions of the expanding Earth theory, see Wesson, 1978; Weijermars, 1986; Scalera and Jacob, 2003). In a static universe, a necessary corollary of this central premise is that graviton energy is at the same time being continuously regenerated from photon energy at the same fractional rate, such that the total gravitational energy in the universe, as well as the gravitational constant G, are not diminished over time. In this respect, the model differs fundamentally from earlier suggestions by Dirac (1937) and others that G decays at a fractional rate proportional to H_0. Observational evidence for the latter notion has been for the most part negative (Uzan, 2003).

In static cosmologies, the cosmological redshift has some alternative explanation than expansion. One of the earliest alternative mechanisms to be proposed was that of Zwicky (1929), who postulated that the cosmological redshift could be due to a gravitational interaction of light with other bodies along the photon trajectory. Subsequently, numerous other static models employing a 'tired light' mechanism were proposed (Assis, 1992, 1993; Jaakkola, 1991, 1993, 1996; Crawford, 1999). The depletion of a photon's energy in space in such models can be expressed as

$$\frac{\dot{E}}{E} = -H_0 , \tag{1}$$

where E is the initial photon energy. While some strands of evidence support the expanding universe model, a variety of other tests have tended to favour static models (Assis, 1992, 1993; Assis and Neves, 1995; Jaakkola, 1991, 1993, 1996; Edwards, 1998; Crawford, 1999; Lopez-Corredoira, 2003).

Of the evidence given for universal expansion, the discovery of time dilation in the light curves of Type Ia supernovae has been cited as perhaps most conclusive (Leibundgut *et al*., 1996). As mentioned in Ref 1, however, time dilation appears to be associated with diverse kinds of redshifts and may perhaps be inevitably associated with redshifts whatever their cause. Thus, if it can be demonstrated that a *specific* tired light mechanism can adequately explain the cosmological redshift in all respects, then there is a reasonable likelihood that it will be found to incorporate time dilation as well. This consideration would also affect interpretations of the Tolman galaxy surface brightness tests in a direction which would further support static models. The surface brightness of galaxies would be diminished by an extra factor of $(1+z)^{-1}$ due to time dilation, bringing the total reduction to $(1+z)^{-2}$. The extra factor significantly reduces the discrepancy between the Tolman prediction for the tired light case and recent findings by Lubin and Sandage (2001).

Static cosmologies, in which expansion is not assumed, implicitly require a detailed balance of energy transformations and so the question of the fate of the lost photon energy in the cosmological redshift must be addressed. By contrast, it is not generally supposed that conservation of photon energy necessarily holds in expanding universe models (Harrison, 1995). Energy conservation with respect to the cosmological redshift has previously been conceptualized in some static models through interconversion of photon energy and graviton energy (Jaakkola, 1991, 1993, 1996; Ref 1). In this case, the 'lost' energy from photons in the cosmic redshift reappears as graviton energy and another process converts graviton energy back to photon energy. Jaakkola (1996) noted that the range of gravity would also be finite in this case and that the Seeliger-Neumann paradox (of gravitational instability) in static models would thus find a solution. In this vein, some recent Le Sage-type models of gravitation have been proposed in which background electromagnetic waves push bodies together (Adamut, 1982; Jaakkola, 1991, 1996; Edwards, 2002a; for other models and discussion, see Edwards, 2002b).

The greatest pool of gravitational potential energy in the universe resides in the interactions of bodies with the universe as a whole. Thus, it would be expected that there should be a cosmological manifestation of the proposed energy conversions, which in Ref. 1 were discussed only with respect to a planet's internal gravitational potential energy. Given that the graviton energies associated with these distant interactions must individually be miniscule, the photons arising from decay of these gravitons must be in the form of extremely long wavelength radio waves. It is here proposed that it is the interaction of primarily these radio emissions with gravitons which gives rise to gravitation. In this preliminary study, we will develop only the Newtonian gravitational expression using this model.

Basic Nature of Gravitons and Gravitation

In the present paper, as in Ref. 1, it is assumed that the gravitons exchanged by all masses are in essence photon-like. The simplest possibility which can be envisaged here is that gravitons are a kind of virtual photon which is exchanged between the masses of gravitating systems. As such they would share significant properties with the virtual photons that are continuously exchanged by atomic charges. An identification of gravitons as virtual photons would connect with a view of the universe as a quantum system analogous to the atom. In this regard, it has been suggested, for example, that the solar system has a quantum organization similar to the atom and that galaxies have a quantized distribution in space (Arp, 1993, Chap. 8, and references therein).

Since gravitons are being exchanged between all the masses of the visible universe, they may collectively be conceptualized as 'filaments' of virtual photons connecting the masses. The cosmic graviton lattice defined by these filaments would then correspond in this preliminary picture to the spacetime of GTR. A further connection between GTR and quantum physics can be envisaged wherein the graviton lattice is also the medium for, or equivalent to, the matter waves of quantum physics.

With this general picture in mind, alternative explanations for both the cosmological redshift and gravitation become apparent. In their passage through space, photons interact to a certain extent with the background graviton lattice and in the process lose a small fraction of their energy to that lattice. This lost photon energy, which is converted to graviton energy, accounts for the cosmological redshift of light. At the same time, the gravitons interacting with photons are jostled slightly out of their virtual states, with the result that some graviton energy is converted to new photons. In gravitation, two masses will thus see a general deficit of background photons in the direction of each other and so will be pushed together.

Decay of Gravitons to Radio Photons

Our quantitative treatment of gravitation begins with consideration of the amount of gravitational potential energy that exists in the universe. As in Ref 1, the quantity of energy tied up in the gravitons exchanged between two bodies is assumed to be equal to the magnitude to the gravitational potential energy ($-U$) of the gravitational system. Under our central postulate, the expression for the conversion of graviton energy in a system to photon energy, E, is then

$$\frac{dE}{dt} = -UH_0 . \qquad (2)$$

The quantity U is not changed by this graviton decay *per se*, since gravitons are simultaneously being reconstituted in gravitational systems. As discussed in Ref. 1, one possible manifestation of the supposed graviton decay is planetary heating and expansion.

If graviton energy is decaying at the rate given in (2), then the most significant consequences should be found at the cosmological level. In this connection, Tryon (1973) speculated on how the universe may have arisen "out of nowhere" without violation of the energy conservation. Tryon showed that the gravitational potential energy U_U of a mass m with respect to the whole universe was

$$U_U \approx -mc^2 . \qquad (3)$$

The gravitational potential energy of the newly formed matter cancels the rest energy of this matter, thus retaining universal conservation of energy. Tryon conceptualized his relation within a standard cosmology premised on universal expansion. Recently, Overduin and Fahr (2001, 2003) provided an updated derivation and discussion of this equation within the standard cosmology context. These authors also pointed out that Tryon's idea was actually suggested much earlier by Haas (1936) and Jordan (1947). Haas had noted that the postulate of universal expansion was not needed to develop the relation in (3). In general, these concepts mesh with the earlier notion of Mach that the inertial mass of a body rests in its interactions with the distant stars. The identification of gravitons as virtual photons would also be consistent with Tryon's hypothesis, since it is well-established in QED that virtual photons increase the mass of their atomic systems.

We next consider how a cosmic background of long wavelength photons is derived in the model. The gravitons that are associated with a mass are decaying to photons at a fractional rate proportional to H_0. As mentioned above, the loss of graviton energy is associated with the cosmological redshift of light and is consistent with the premise that gravitons are a form of virtual photonic energy. It is thus necessary to incorporate the tired light effect in the expression for the gravitational potential energy of a distant mass. While (1) gives the instantaneous rate of a photon's energy loss, the progressive loss of energy in its passage through space is expressed as

$$E(r) = E_0 e^{-\alpha_L r} , \qquad (4)$$

where E_0 is the initial photon energy and α_L is the mean absorption coefficient of light along the path between the source and the observer (Assis, 1992). Given that $E = hv = hc/\lambda$, we can express (4) in the form of a redshift law

$$z(r) = \frac{\lambda(r) - \lambda_0}{\lambda_0} = e^{-\alpha_L r} - 1 \cong \alpha_L r \, , \tag{5}$$

where λ_0 and $\lambda(r)$ are the wavelength of the light at the source and observer respectively. Since $z \cong H_0 r/c$, the above expression then yields

$$\alpha_L \cong \frac{H_0}{c} . \tag{6}$$

(Assis, 1992).

Equations (4), (5) and (6) may then be used to incorporate the tired light effect in the model. Including the attenuation factor from (4), the summation of the gravitational potential energies that a mass m possesses with respect to all the masses M_i in the universe is then given by

$$U_U = -\sum_0^\infty \frac{GM_i m}{r_i} \exp\left(-\alpha_L r_i\right), \tag{7}$$

where the values r_i are the respective distances to all the masses M_i. If matter, chiefly in the form of galaxies, is considered to be distributed approximately evenly in space, the above expression can be evaluated using the gravitational potential energy of concentric shells of matter of thickness dr centred about m, each of constant density ρ. We then have

$$U_U = -\int_0^\infty \frac{4\pi G\rho m r^2 e^{-\alpha_L r}}{r} dr = -4\pi G\rho m \int_0^\infty r e^{-\alpha_L r} dr$$

$$U_U = -\frac{4\pi mG\rho}{{\alpha_L}^2}. \tag{8}$$

If we substitute for α_L from (6) and use a typical value for ρ, we find that $U_U \approx -mc^2$, as in the Tryon relation (3). The gravitational potential energy that a mass has with respect to the whole universe therefore attains a finite value and the Seeliger-Neumann paradox in static models is resolved.

If the gravitons associated with m are being degraded to photons due to the cosmological redshift, then from (2) and (8), the rate of photon production from these gravitons, L_U, is given by

$$L_U = \frac{4\pi mG\rho}{{\alpha_L}^2} H_0. \tag{9}$$

Since the large scale distribution of matter in a static universe is approximately uniform, then a consequence of (9) is that photons are being generated everywhere in space at about the same rate. As already mentioned, the largest contribution to U_U originates from a mass's interactions with the very most distant objects in the visible universe. Since the graviton energy associated with a specific distant mass is miniscule, however, the product photons of the graviton decay must be radio waves of very long wavelength. We will designate these waves as radio wave background radiation, or RWBR. The great range of possible graviton energies implies that the RWBR, unlike the CMBR, would not possess a uniform, blackbody spectrum.

Absorption of Radio Photons by Masses Causing Gravitation

As already discussed, the cosmological redshift of light is assumed to be due to an interaction between photons and gravitons, the latter being associated with the other masses along the photon trajectory. In this process, all photons, including RWBR photons, are attenuated in their passage through space. We now connect these energy losses to gravitation. The attenuation of the photon flux due to interaction with the matter-associated gravitons can be envisaged as a quasi-screening effect similar to that postulated in Le Sage-type or, especially, Brush-type theories (for discussions, see Edwards, 2002b). Unlike these theories, however, we do not stipulate that the photon flux need pass directly through masses in order for absorption to occur. As noted above, absorption instead has a long-range character, since photons are being absorbed into the entire cosmic lattice of gravitons associated with any given mass. The lattice can perhaps be visualized as a vast antenna system intercepting photons and converting a portion of their energy into graviton energy and mass. Expressed in a different way, we could view the model as being more closely Le Sage-like or Brush-like if the masses were identified with their graviton filament arrays vastly extended out into space.

In the present model, absorption of photon energy by a system of masses increases the graviton energy that the masses exchange with each other. Photon absorption by each mass of the system will project shadows in the photon background flux onto the other component masses and so each mass will experience a force towards the other masses. Around a particular mass m the distant galaxies are arranged symmetrically and so the forces on m due to screening by distant matter on average cancel each other. The symmetrical distribution of forces around mass m is disturbed, however, if a local mass M_2 is introduced. Similarly to the distant galaxies, M_2 induces an attenuation of photons that would otherwise have impinged on m. The mass m thus perceives a deficit with respect to the total photon flux originating from the direction of M_2. Since the density of the graviton filament array emanating from a mass varies in an inverse square manner with the distance from that mass, a distant mass will effectively subtend a smaller screening angle at m than a nearby one. The attenuation factor will be proportional to r^{-2}.

Let us suppose that the separation between m and M_2 is sufficiently small that the attenuation of the flux within the masses and in the space between them can be neglected. We can then determine the amount of screening of the background photon flux at m due to the presence of M_2. Let us designate the attenuation rates due to distant matter and due to M_2 as A_U and A_2 respectively. We have supposed that the absorption of photon energy by a mass at a distance r is proportional to the mass of the body and inversely proportional to r^2. The ratio of the photon attenuation rate due to M_2 to the rate due to all the distant masses of the universe is then given by

$$\frac{A_2}{A_U} = \frac{\left(\dfrac{M_2}{R_2^2}\right)}{\sum_0^\infty \dfrac{M_i}{r_i^2} e^{-\alpha_L r_i}}. \tag{10}$$

In this expression, the term in the denominator on the right side once again includes an exponential term reflecting the diminishing effect of more distant masses. Simplifying as in (8), we can express the term in the denominator on the right side as

$$\sum_0^\infty \frac{M_i}{r_i^2} e^{-\alpha_L r_i} = \int_0^\infty \frac{4\pi r^2 \rho}{r^2} e^{-\alpha_L r} dr = \frac{4\pi\rho}{\alpha_L}. \tag{11}$$

By simple geometry the quantity of energy that the distant masses screen off from m is equal to the energy which m screens from the distant masses. The latter energy must in turn be equal to the rate at which m is absorbing photons and increasing the graviton energy it exchanges with the distant masses. Under the conditions of general equilibrium supposed in a static universe, the rate at which RWBR photon energy is produced from gravitons is in general equal to the rate at which photon energy is converted back to graviton energy. We may therefore write $A_U = L_U$. Substituting (11) in (10) and also for A_U we obtain

$$A_2 = L_U\left(\frac{\alpha_L M_2}{4\pi\,\rho R_2^2}\right). \tag{12}$$

Further substituting for L_U from (9), the rate at which photon energy is blocked from m due to the presence of M_2 is then

$$A_2 = \frac{GmM_2H_0}{\alpha_L R_2^2}. \tag{13}$$

Finally substituting from (6) for α_L and noting that the momentum of a quantum of radiation with energy E is E/c, the attractive force on m due to the attenuation of photon flux by M_2 is then

$$F = -\frac{GmM_2}{R_2^2}, \tag{14}$$

thus recovering Newton's law.

The strength of the attraction oddly does not depend directly on any of the factors ρ, H_0 or α_L. The reasons for this are straightforward. If ρ, for example, were greater, then U_U would also increase. The greater density of gravitons would lead, however, to higher values for H_0 and α_L, which would then reduce U_U through (8). In addition, the derivation does not shed light on whether the gravitation constant G

depends on any of these factors. This is to be expected given that G enters at the very beginning of the derivation and passes through unchanged.

Graviton Decay as a Repulsive Force in Compact Stars and Black Holes

In the model, the gravitational potential energy specific to any two interacting masses is decaying to RWBR photons. If the latter photons are directed back towards the two masses along the same trajectories as the original gravitons, they would exert a repulsive force between the two bodies. For masses separated by a distance that is small compared to the visible universe, it is easy to show that this force would be small compared to the Newtonian force. For such masses the tired light term can be neglected in an approximation and the repulsive force is given by $(GMm/R)(H_0/c)$, where the factor of c again converts the photon energy to momentum. Equating this with the attractive Newtonian force (14), we find that the two forces balance only under the condition $R \sim c/H_0 \sim 10^{28}$ cm, *i.e.*, at such a large distance that the tired light effect would in fact be significant. In most two-body situations, the repulsive force can thus be neglected.

For a single mass, however, decay of internal gravitational potential energy can have significant effects. In Ref. 1, it was suggested that planetary heating and expansion could result from such a process. While the effects of graviton decay would be masked by stellar fusion in main sequence stars, they could be dramatic in very large or dense objects, such as neutron stars or black holes. Stars are unstable if their luminosity surpasses the Eddington luminosity, L_E, given by

$$L_E \cong 1.3\times 10^{38}\left(\frac{M}{M_S}\right)(\text{erg s}^{-1}), \tag{15}$$

where M and M_S are the object's mass and the solar mass respectively. Using a non-relativistic approximation for U, the luminosity arising from decay of graviton energy in a star or black hole (L_G) is given by

$$L_G = -UH \approx \frac{GM^2}{R} H_0 \ (\text{erg s}^{-1}). \tag{16}$$

For a black hole with one solar mass and a Schwarzschild radius of 3 km, graviton decay would thus give rise to $L_G \sim 10^{36}$ erg s^{-1}. From (15) it is seen that this luminosity would be below the Eddington luminosity for such an object. However, black holes with greater than 5-10 solar masses and with similar radii would have luminosities approaching or exceeding L_E and would therefore be unstable.

Similarly, the model places restrictions on the mass and radius of supermassive black holes. The candidate object for a supermassive black hole at the centre of the Milky Way, Sagittarius A*, is considered to have a mass of 3.7 million solar masses and a radius in the vicinity of 1 AU = 1.5 $\times 10^{13}$ cm. In this case, $L_G \sim 10^{43}$ erg s^{-1}, while $L_E \sim 10^{44}$ erg s^{-1}. A supermassive black hole with this mass and radius would thus be stable with respect to the graviton decay luminosity most of the time, but could be subject to mass losses should L_G increase slightly (through accretion or a decrease in radius). Graviton decay could thus account for the bipolar particle jets associated with such objects.

It is noteworthy that in the above examples L_G is fairly close in value to L_E. A possible inference to be drawn is that the observed luminosities may be attributed to the model process. Similar inferences might also be drawn for the observed luminosities of white dwarfs and neutron stars.

Cosmic Energy Balance and the CMBR

One of the successes of the Big Bang model was in its early prediction of a cosmic microwave background radiation (CMBR). A number of authors have pointed out that the static universe model also can also account for the CMBR (*e.g.*, Assis and Neves, 1995). In the latter case, however, the precise mechanism whereby the precise 2.7 deg K spectrum of the CMBR is attained has proved elusive. In particular, since most starlight is redshifted to the energy level of the CMBR without apparently ever contacting matter directly, it cannot be supposed that the CMBR is just serially reradiated starlight.

The present hypothesis suggests an alternative possibility. Starlight emitted into space interacts with the cosmic graviton lattice. Through the postulated redshift process, the energy of starlight photons is gradually converted to graviton energy. Gravitons, however, are continually being degraded to RWBR photons according to (2). We thus have photon energy being injected into space at the rate of $\rho_G H_0$ (erg cm^{-3}), where ρ_G is the average density of gravitational potential energy in the universe. Since the RWBR photons are generated in approximately equal energy densities at all points in space, with only local deviations in the vicinity of large masses, they would eventually give rise in their interactions with matter to a radiation field with a very smooth thermal spectrum, which we tentatively identify with the CMBR. Gravitons are in turn regenerated by subsequent conversion of photons, including both RWBR and CMBR photons, back to gravitons via the model redshift.

If the gravitons and photons of the universe are indeed being interconverted at the same fractional rate, and if the universe is in a state of general equilibrium, then we may write

$$\frac{\dot{\rho}_G}{\rho_G} = \frac{\dot{\rho}_E}{\rho_E} = \pm H_0 \,, \tag{17}$$

where ρ_E is the cosmic density of photon energy. The right side of the equation expresses the premise that gravitons and photons are being regenerated at the same rate as they are being degraded.

Since under equilibrium conditions the rates of graviton production and photon production are the same, an obvious test of the model is that ρ_G and ρ_E should be nearly equal. If they were not the ratio of graviton to photon energy in the universe would change over time. The cosmic density of graviton energy ρ_G is obtained by replacing m in (8) with the cosmic matter density ρ, *i.e.*,

$$\rho_G = -\frac{4\pi G \rho^2}{\alpha_L^2} \,. \tag{18}$$

If we suppose that the principal form of matter in the universe is baryonic, *i.e.*, that the problems that suggest dark matter as a solution may yet be explainable by other means, then we have $\rho \cong 1.5 \times 10^{-31}$ gm cm^{-3}. With $\alpha_L = H_0/c$ and for $H_0 = 2.2 \times 10^{-18}$ sec^{-1}, we then have $\rho_G = 4 \times 10^{-12}$ erg cm^{-3}. The largest known contribution to ρ_E is given by the CMBR $\cong 4 \times 10^{-13}$ erg cm^{-3}. Thus, for this value of ρ, we need specify only that the energy density of the RWBR is about an order of magnitude larger than the CMBR. This higher density of RWBR photons compared to the CMBR photons merely reflects that most of the RWBR photons are absorbed by matter at the graviton level (*i.e.*, through the graviton filaments), rather than at the electronic level. While this is a large energy density for the RWBR background, it should be noted that evidence of an intense radio wave background at a wavelength of 144 m, apparently originating from the edge of the visible universe, was earlier found by Reber (1968).

Discussion

In this paper, it has been postulated that gravitons consist of some form of electromagnetic energy similar to virtual photons and that gravitons cumulatively establish a quantum lattice connecting all masses. Photons incident on the filaments of this lattice impart energy to the gravitons, while at the same time losing a portion of their original energy. This loss of energy corresponds in the model to the cosmological redshift in a static universe. The model avoids the problem of blurring of distant sources in tired light models, since the weakening of light does not occur through direct interactions with atoms but rather through a diffuse graviton lattice.

It has also been shown that a Newtonian gravitational model of the Le Sage type can be developed on these premises. The mode of absorption of photon energies is not precisely as in electromagnetic analogues of Le Sage's theory, since absorption of background photon fluxes by a mass is mediated by its graviton filament array, which extends across the visible universe. This novel mode of screening may explain some of the difficulties in detecting gravitational screening in laboratory or eclipse experiments (for discussions on the difficulties of Le Sage's model as well as some possible solutions see, Edwards, 2002b).

The central thesis of the model, interconversion of photon and graviton energy, also has potential explanatory power in geological and astrophysical processes. The geological ramifications were discussed in Ref. 1, especially in respect to possible Earth expansion, while in astrophysics the model may help explain the observed luminosities of neutron stars, white dwarfs and black holes.

As mentioned earlier, an identification of gravitons with the matter waves of quantum physics can also be drawn. The photonic elements of the graviton lattice can possibly be viewed as highly coherent waves which collectively establish the lattice by virtue of their mutual interference. The loss of energy from gravitons would then simply imply a loss of energy from the coherent wave lattice to the random photon background. The conversion of RWBR photons back to gravitons, again mediated by matter and its associated graviton lattice, would restore the lattice energy. The cosmological redshift in this case would increase the entropy of radiation on one hand while decreasing it on the other, leaving the total entropy of the universe constant.

Lastly, it was also suggested above that the graviton lattice could delineate the 'spacetime' of GTR. In this case, the greater densities of the graviton lattice near masses might be connected to spacetime curvature. This could account for gravitational lensing, for example, since photons passing near masses could be refracted in the denser lattice there.

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