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Binary Star System Decay by Graviton Interaction

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Abstract

The action of gravitons in a binary star system is modelled as the locus of points on an ellipse synchronous to the elliptic orbit of the binary star. In their interaction between the masses in the system the rotational energy of the gravitons is reduced by gravitational redshift, which accounts for the decay of the binary star orbital period. This model is able to fit a broad range of eccentricities of binary pulsar orbits and orbital period decay comparable to the General Relativistic gravitational wave model.

Keywords

Binary Stars, Gravitons, Orbital Period Decay, Correction Function

1. Introduction

The purpose of this paper is to introduce a model for the action of the gravitons in a binary star system described in [1], a paper which has a section on binary pulsars based on a comparison to the equation for the decay of a binary star system developed in [2], but we did not give a complete model for the action of the gravitons. This new model describes the rotational phase of gravitons which interact between the masses, where the graviton phase is a locus of points on an ellipse around the central mass, with an eccentricity and period identical to the binary star system ellipse. In this model the gravitons interact directly between the masses in orbit, losing energy in the system by gravitational redshift. We will reanalyze the set of binary pulsars from the previous paper as well as make comparisons to the General Relativity (GR) model. We will also give predictions for two millisecond binary pulsars. We make a detailed comparison of the graviton model with the GR gravitational wave model and show how our model mathematically corresponds to it, although some physical aspects are disparate.

2. Rotational Energy of Gravitons in a Binary Star System

Consider a binary star system composed of a companion star of mass m in orbit around a primary star of mass M. By Kepler's second law, the companion star in an elliptical orbit will sweep out an equal area in equal time around the primary star, expressed by

$$\left(\frac{r^2}{2}\right)\frac{\mathrm{d}\phi}{\mathrm{d}t}=\frac{\pi AB}{T}, \tag{1}$$

where r is the instantaneous distance between the stars, ϕ is the angle r makes with the line thru the stars at perigee, A and B are the semi-major and semi-minor axes, respectively, and T is the orbital period. We assume that gravitons are responsible for the force between the stars. We define the graviton origin ellipse which encloses the center of mass of the system and has the same eccentricity and the same angular speed as the binary star ellipse. The origin ellipse describes the motion of the line of gravitons interacting between the two stars in the system, having the same period T as the orbit ellipse and expressed by

$$\left(\frac{\mathfrak{r}^2}{2}\right)\frac{\mathrm{d}\phi}{\mathrm{d}t}=\frac{\pi\mathfrak{a}\mathfrak{b}}{T}, \tag{2}$$

where $\mathfrak{r}$ is the distance from the center of mass to the origin ellipse, $\mathrm{d}\phi$ is the small angle swept out in time $\mathrm{d}t$, $\mathfrak{a}$ and $\mathfrak{b}$ are the semi-major and semi-minor axes of the origin ellipse, respectively, and T is the orbital period of the binary star system. Multiplying Equation (2) by the angular frequency $\omega=2\pi/T$ and simplifying we get,

$$\mathfrak{h}\omega=\mathfrak{h}\left(\frac{2\pi}{T}\right)=\left(\frac{2\pi\mathfrak{l}^2}{\left(1-\varepsilon^2\right)^{3/2}T}\right)\left(\frac{2\pi}{T}\right), \tag{3}$$

where the graviton specific angular momentum $\mathfrak{h}=\mathfrak{r}^2\,\mathrm{d}\phi/\mathrm{d}t$ and $\mathfrak{l}^2/\left(1-\varepsilon^2\right)^{3/2}=\mathfrak{a}\mathfrak{b}$, where $\mathfrak{l}$ is the semi-latus rectum of the graviton origin ellipse and ε is the ellipse eccentricity, equal to the binary star system eccentricity. The radial distance $\mathfrak{r}$ is given by

$$\mathfrak{r}=\frac{\left(1-\varepsilon^2\right)\mathfrak{a}}{1+\varepsilon\cos(\phi)}. \tag{4}$$

The graviton origin ellipse semi-latus rectum $\mathfrak{l}$ is defined in terms of the Schwarzschild radius R_s of the combined masses,

$$\mathfrak{l}=\sqrt{\sigma(\varepsilon)}R_s=\frac{2\sqrt{\sigma(\varepsilon)}G(M+m)}{c^2}, \tag{5}$$

where the correction function $\sigma(\varepsilon)$ is defined,

$$\sigma(\varepsilon)=\alpha\mathrm{e}^{-\beta\varepsilon}+p+q\varepsilon^2, \tag{6}$$

where the parameters α, β, p and q are determined by experiment and c is the speed of light in vacuum. **Figure 1** shows the relationship of the binary star ellipse and the graviton origin ellipse.

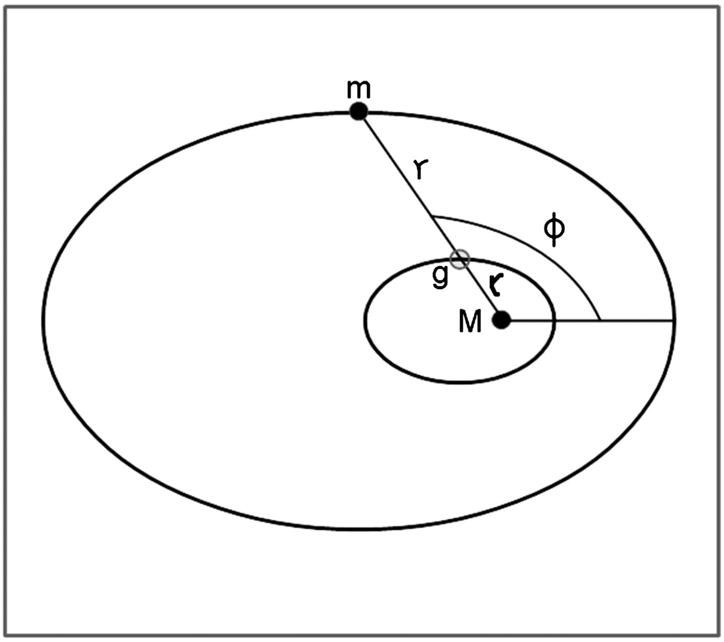

Figure 1. Binary star system ellipse (outer) and graviton origin ellipse (inner). *M* is the primary mass, *m* is the companion mass, *r* is the distance between the masses, $\mathfrak{r}$ is the distance from *M* to the graviton rotational energy point of interaction between the masses and *f* is the rotation angle of the ellipses. The ellipses are not drawn to scale.

We define the graviton rotational energy Ξ in the center of mass system of the masses *M* and *m*,

$$\Xi = \mathfrak{M}\mathfrak{h}\omega, \tag{7}$$

where

$$\mathfrak{M} = \frac{(Mm)^2}{(M+m)^3} = \frac{\mu Mm}{(M+m)^2}, \tag{8}$$

is the graviton rotational relativistic mass (not a rest mass since gravitons travel at speed *c*) and where $\mu = (Mm)/(M+m)$ is the reduced mass of the system. Since the gravitons having rotational energy Ξ are in free fall in the gravitational field of the binary star system, over a small time δt under the field acceleration $G(M+m)/r^2$, the graviton net rotational energy will change due to gravitational redshift by the amount,

$$\delta\Xi = -\Xi\left(\frac{\delta v}{c}\right) = -\left(\frac{\mu Mm}{(M+m)^2}\right)\mathfrak{h}\omega\left(\frac{G(M+m)\delta t}{cr^2}\right), \tag{9}$$

where we substituted from (7) for Ξ and the change in the free fall velocity $\delta v = \left[G(M+m)/r^2\right]\delta t$ where the minus sign implies a reduced (redshifted) graviton energy[1], since the gravitons are moving in the same direction as the velocity δv, and where the distance *r* is given by,

[1]We remark that in the original definitions given in (7) and (9), the graviton rotational mass was defined as the reduced mass $\mu = Mm/(M+m)$ and the gravitational acceleration field was defined as $GMm/(M+m)r^2$, but these have now been defined in the physically correct form.

$$r = \frac{\left(1-\varepsilon^2\right)A}{1+\varepsilon\cos(\phi)}. \quad (10)$$

3. Rate of Change of the Orbital Period

To obtain the time rate of change of the orbital period T, we use Kepler's third law,

$$G(M+m)T^2 = 4\pi^2 A^3, \quad (11)$$

which upon differentiating with respect to the time t and simplifying yields the rate of change of the orbital period,

$$\frac{\mathrm{d}T}{\mathrm{d}t} = \left(\frac{3}{T}\right)\left(\frac{4\pi^2 A^4}{G^2 Mm(M+m)}\right)\left(\frac{\mathrm{d}E}{\mathrm{d}t}\right), \quad (12)$$

where the total orbital energy $E = -GMm/(2A)$. Substituting from Equations (3) and (5) into Equation (7) we get the graviton rotational energy,

$$\Xi = \left(\frac{\mu Mm}{(M+m)^2}\right)\left(\frac{4\sigma(\varepsilon)}{\left(1-\varepsilon^2\right)^{3/2}}\right)\left(\frac{2\pi G(M+m)}{c^2 T}\right)^2. \quad (13)$$

Dividing Equation (9) by δt and substituting for Ξ from (13) gives,

$$\frac{\delta\Xi}{\delta t} = -\left(\frac{\mu Mm}{(M+m)^2}\right)\left(\frac{4\sigma(\varepsilon)}{\left(1-\varepsilon^2\right)^{3/2}}\right)\left(\frac{2\pi G(M+m)}{c^2 T}\right)^2\left(\frac{G(M+m)}{cr^2}\right). \quad (14)$$

Then, substituting $\mathrm{d}E/\mathrm{d}t = \delta\Xi/\delta t$ from (14) into Equation (12) gives,

$$\frac{\mathrm{d}T}{\mathrm{d}t} = -\left(\frac{3}{T}\right)\left(\frac{4\pi^2 A^4}{G^2 Mm(M+m)}\right)\left(\frac{(Mm)^2}{(M+m)^3}\right)\left(\frac{4\sigma(\varepsilon)}{\left(1-\varepsilon^2\right)^{3/2}}\right) \times\left(\frac{2\pi G(M+m)}{c^2 T}\right)^2\left(\frac{G(M+m)}{cr^2}\right). \quad (15)$$

In making fits to binary star data we will take an average of the radial distance r where $\cos\left(\phi\left(t-t_0\right)\right)=0$ for $\phi\left(t-t_0\right) = n\pi/2, n=1,3,5,\cdots$. Thus, the radial distance $r=\left(1-\varepsilon^2\right)A$ in (15). Finally, using Kepler's third law, (11), we substitute for A in terms of T into Equation (15) and simplify to obtain,

$$\frac{\mathrm{d}T}{\mathrm{d}t} = -24\pi\left(\frac{\sigma(\varepsilon)}{\left(1-\varepsilon^2\right)^{7/2}}\right)\left(\frac{(M+m)^2}{Mm}\right)^{2/3}\left(\frac{2\pi GMm}{c^3(M+m)T}\right)^{5/3}. \quad (16)$$

Equation (16) is equivalent in form to the derivation given by [2], which was derived from General Relativity with gravitational wave (GW) emission for energy decay. We describe this GW relation in the next section and compare the two methods in a subsequent section.

4. The Energy Loss Due to Gravitational Wave Emission

We give a brief derivation of binary star orbital decay due to GW emission based on [3]. Gravitational waves are emitted by a binary star system due to the time rate of change of the quadrupole moment for the binary, where the quadrupole moment for the simple case of a *circular orbit* is expressed by,

$$Q_{ij} = \frac{1}{2}\mu r^2 I_{ij}, \tag{17}$$

where $\mu = Mm/(M+m)$ is the reduced mass, r is the separation of the masses and I_{ij} is a 3×3 traceless matrix, given by,

$$I = \begin{pmatrix} \cos(2\omega t)+\frac{1}{3} & \sin(2\omega t) & 0 \\ \sin(2\omega t) & \frac{1}{3}-\cos(2\omega t) & 0 \\ 0 & 0 & -\frac{2}{3} \end{pmatrix}. \tag{18}$$

The strain due to the wave caused length change δd_{ij} at a distance d_L from the system [4] is given by,

$$h_{ij} = \frac{\delta d_{ij}}{d_L} = \frac{1}{d_L}\left(\frac{2G}{c^4}\frac{\mathrm{d}^2 Q_{ij}}{\mathrm{d}t^2}\right). \tag{19}$$

At a sufficient distance d_L from the source we can use a linearized approximation of Einstein's equations. The rate of change of the strain is given by

$$\dot{h}_{ij} = \frac{2G\dddot{Q}}{d_L c^4}, \tag{20}$$

where we have used the dot notation for the time derivative. Then, the power (luminosity) $\mathrm{d}E_{GW}/\mathrm{d}t$ of the wave is proportional to the square of $\dot{h}_{ij}$ integrated over the surface of the volume of space, expressed by

$$\left(\frac{16\pi G}{c^3}\right)\frac{\mathrm{d}E_{GW}}{\mathrm{d}t} = \iint |\dot{h}|^2\,\mathrm{d}S = \frac{16\pi G^2}{4\pi c^8 d_L^2}\iint\left(\dddot{Q}_{ij}\dddot{Q}_{ij}\right)\mathrm{d}S = \frac{48\pi G^2}{15c^8}\sum_{i,j=1}^{3}\left(\dddot{Q}_{ij}\dddot{Q}_{ij}\right) \tag{21}$$

where

$$|\dot{h}|^2 = \sum_{i,j=1}^{3}\left(\dot{h}_{ij}\dot{h}_{ij}\right) \tag{22}$$

and the integration over the sphere gives an area of $4\pi d_L^2$, cancelling that value in the numerator of (21). From (17) and (18) the summation in (21) becomes

$$\sum_{i,j=1}^{3}\left(\dddot{Q}_{ij}\dddot{Q}_{ij}\right) = 8^2\mu^2(1/4)r^4\omega^6\left(2\cos^2(2\omega t)+2\sin^2(2\omega t)\right) = 32\mu^2 r^4\omega^6, \tag{23}$$

and by substituting this result into (21) and simplifying yields,

$$\frac{\mathrm{d}E_{GW}}{\mathrm{d}t} = \frac{32G}{5c^5}\mu^2 r^4\omega^6. \tag{24}$$

Using the notation $P_b = T = 2\pi/\omega$ for the orbital period and r in place of A for the circular orbit in (12) and substituting for $\mathrm{d}E/\mathrm{d}t$ with the negation of (24) because the GW emission causes an energy loss to the orbit, we get,

$$\frac{dP_b}{dt}=\left(\frac{-6\pi r}{GMm\omega}\right)\left(\frac{dE_{GW}}{dt}\right)=-\left(\frac{6\pi r}{GMm\omega}\right)\left(\frac{32G(Mm)^2 r^4\omega^6}{5c^5(M+m)^2}\right)$$
$$=-\left(\frac{192\pi}{5}\right)\left(\frac{(M+m)^2}{Mm}\right)^{2/3}\left(\frac{2\pi GMm}{c^3(M+m)P_b}\right)^{5/3}, \tag{25}$$

where we used Kepler's law to transform $r^5\omega^5 \sim (1/P_b)^{5/3}$. Putting in the dependence on the orbit eccentricity ε from [2] for an elliptical orbit, we put (25) into the familiar form,

$$\dot{P}_b=-\left(\frac{192\pi}{5}\right)\left(\frac{1+(73/24)\varepsilon^2+(37/96)\varepsilon^4}{(1-\varepsilon^2)^{7/2}}\right)\left(\frac{(M+m)^2}{Mm}\right)^{2/3}\left(\frac{2\pi GMm}{c^3(M+m)P_b}\right)^{5/3}. \tag{26}$$

Application to PSR B1913+16 and Other Binaries

We look at the report on B1913+16, the Hulse-Taylor binary pulsar [5]. This astronomical endeavor spanned 30 years of approximately yearly observations of the binary system. The data for the system is as follows: primary mass $M=1.4408\pm0.0003M_{\odot}$, companion mass $m=1.3873\pm0.0003M_{\odot}$, $P_b=0.322997462727\pm(5\times10^{-12})\,\text{day}$, $\dot{P}_b=(-2.4211\pm0.0014)\times10^{-12}\,\text{s}\cdot\text{s}^{-1}$, $\varepsilon=0.6171338\pm0.0000004$, where M is the primary mass and m is the companion mass, $M_{\odot}=1.988470\times10^{30}\,\text{kg}$ is the solar mass, P_b is the binary orbital period, $\dot{P}_b$ is the orbital period change and ε is the orbital eccentricity. The initial orbital period for B1913+16 is $T_0=P_b=0.322997462727\,\text{day}$. For the gravitational constant we use the value $G=6.67430\times10^{-11}\,\text{m}^3\cdot\text{kg}^{-1}\cdot\text{s}^{-2}$ and $c=299792458\,\text{m}\cdot\text{s}^{-1}$ for the speeds of gravity (graviton) and light (photon) in vacuum. To make a good fit of (16) to the binary pulsar systems we are examining, we determined best fit parameter values of $\alpha=0.4928$, $\beta=56.5$, $p=1.6$ and $q=5.12072$, which makes the leading factor $24\pi\sigma(\varepsilon)$, where the previous study [1] had a leading constant factor of 32π. **Figure 2** shows the correction function $\sigma(\varepsilon)$ with the specified parameters (α,β,p,q) and the GR correction function from (26),

$$\sigma_{GR}(\varepsilon)=1+(73/24)\varepsilon^2+(37/96)\varepsilon^4. \tag{27}$$

Notice that the correction function $\sigma(\varepsilon)>1$, always being above the horizontal value 1 line in **Figure 2**. From this fact it can be shown that the semi-major axis $\mathfrak{a}$ and the semi-minor axis $\mathfrak{b}$ of the graviton origin ellipse are always greater than the Schwarzschild radius R_s of the combined masses $M+m$.

Substituting these experimental parameters and astronomical values for B1913+16 into (16) yields,

$$\frac{dT}{dt}=-2.40715\times10^{-12}\,\text{s}\cdot\text{s}^{-1}, \tag{28}$$

which is a good match to the experimental corrected value [5] of

$$\dot{P}_b=(-2.4086\pm0.0052)\times10^{-12}\,\text{s}\cdot\text{s}^{-1}, \tag{29}$$

and is also close to the GR theoretical value,

$$\dot{P}_{bGR} = -2.40219 \times 10^{-12}\,\mathrm{s} \cdot \mathrm{s}^{-1}. \tag{30}$$

In Table 1 and Table 2 we list nine PSR's, [5]-[13] and [14]. In Table 3 we show the error in each prediction, the error computed by

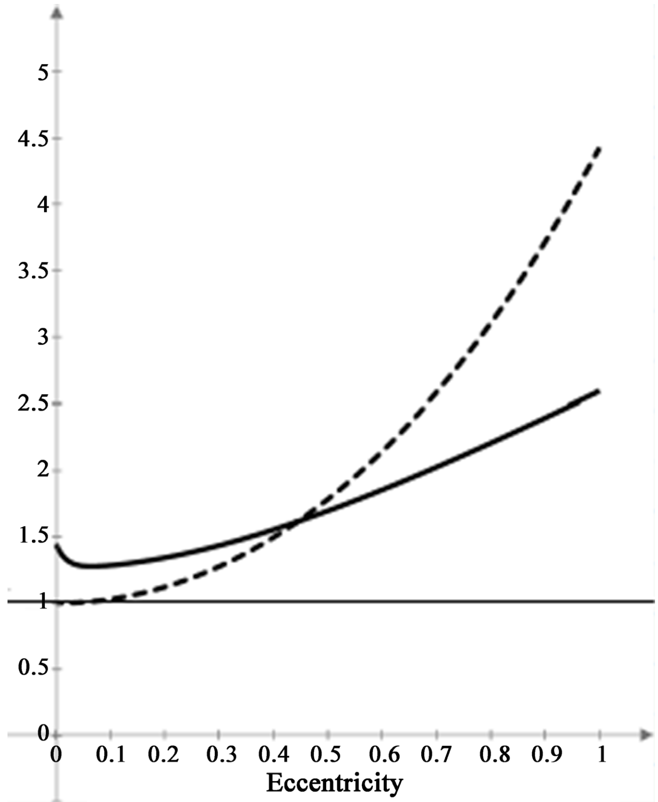

Figure 2. Correction function (solid line) with best fit parameter values of $\alpha = 0.4928$, $\beta = 56.5$, $p = 1.6$ and $q = 5.12072$. GR correction function (dashed line). Horizontal line drawn at 1 for reference.

Table 1. PSR binary systems studied. Column description: 1: PSR name; 2: Primary (pulsating) star mass; 3: Companion star mass; 4: Period (day) Pb or T; 5: Orbit eccentricity.

PSR	$M(M_\odot)$	$M(M_\odot)$	$P_b(T)$ (day)	Eccen
B1913+16	1.4408	1.3900	0.3230	0.6171
B1534+12	1.3332	1.3452	0.4207	0.2737
J1756−2251	1.341	1.230	0.3196	0.1806
J0737−3039	1.3381	1.2489	0.1023	0.0878
J1906+0746	1.291	1.322	0.1660	0.0853
J1141−6545	1.27	1.02	0.20	0.17
J1012+5307	1.72	0.165	0.6047	1.2×10^{-6}
J0621−1002	1.70	0.97	8.3187	2.5×10^{-3}
J2222−0137	1.831	1.319	2.4458	3.8092×10^{-4}

Table 2. PSR binary systems studied (continued). Column description: 1: PSR name; 2: dP_b/dt (observed intrinsic value); 3: dP_b/dt (general relativity computation); 4: dT/dt (due to graviton gravitational redshift).

PSR	dP_b/dt intr (10^{-12} s·s^{-1})	dP_b/dt GR (10^{-12} s·s^{-1})	dT/dt (10^{-12} s·s^{-1})
B1913+16	−2.4086	−2.4022	−2.4072
B1534+12	−0.174	−0.1924	−0.1940
J1756−2251	−0.234	−0.2169	−0.2178
J0737−3039	−1.252	−1.2478	−1.2519
J1906+0746	−0.5650	−0.5645	−0.5665
J1141−6545	−0.403	−0.3911	−0.3927
J1012+5307	-1.5×10^{-2}	-1.1581×10^{-2}	-1.5147×10^{-2}
J0621−1002	<−5	-7.5859×10^{-4}	-9.6194×10^{-4}
J2222−0137	-1.43×10^{-2}	-0.8088×10^{-2}	-1.0526×10^{-2}

Table 3. Prediction errors of binary systems studied. Column description: 1: PSR name; 2: dP_b/dt (general relativity computation error); 3: dT/dt (due to graviton gravitational redshift error). The errors are computed by Equation (31).

PSR	dP_b/dt GR Err	dT/dt Err
B1913+16	2.6603×10^{-3}	0.6026×10^{-3}
B1534+12	0.1060	0.1148
J1756−2251	0.0732	0.0692
J0737−3039	3.3266×10^{-3}	0.0528×10^{-3}
J1906+0746	0.8592×10^{-3}	2.6798×10^{-3}
J1141−6545	0.02949	0.02567
J1012+5307	0.22795	0.00983
J0621−1002	1.0	1.0
J2222−0137	0.4344	0.2639
Mean Err	0.1097 ± 0.0231	0.0608 ± 0.0084

$$Err = \left| \frac{\dot{P}_p - \dot{P}_i}{\dot{P}_i} \right|, \quad (31)$$

where $\dot{P}_p$ is the predicted period decay and $\dot{P}_i$ is the measured intrinsic period decay. Excluding PSR J0621-1002 which has a poor intrinsic $\dot{P}_b$ measurement, for the PSR prediction errors given in Table 3, the mean error and unbiased standard deviation of the mean error between the observed intrinsic $\dot{P}_b$ values and this paper's predicted dT/dt values is $dT/dt\,MeanErr = 0.0608 \pm 0.0084$. For a comparison with the standard GR GW emission theory, the mean error and unbiased standard deviation of the mean error is $\dot{P}_{bGR}\,MeanErr = 0.1097 \pm 0.0231$.

Table 4. PSR binary systems with new predictions. Column description: 1: PSR name; 2: Primary (pulsating) star mass; 3: Companion star mass; 4: Orbit eccentricity.

PSR	$M(M_\odot)$	$M(M_\odot)$	$P_b(T)$ (day)	Eccen
J1949+3160	1.34	0.81	1.9495374	4.3124×10^{-5}
J1950+2414	1.496	0.280	22.19137127	0.07981173

Table 5. PSR binary systems with new predictions. Column description: 1: PSR name; 3: dP_b/dt (general relativity computation); 4: dT/dt (due to graviton gravitational redshift). dP_b/dt (observed intrinsic value) not yet determined.

PSR	dP_b/dt GR (10^{-12} s·s^{-1})	dT/dt (10^{-12} s·s^{-1})
J1949+3160	$(-6.02 \pm 0.66) \times 10^{-3}$	$(-7.88 \pm 0.48) \times 10^{-3}$
J1950+2414	$(-4.48 \pm 0.49) \times 10^{-5}$	$(-4.50 \pm 0.27) \times 10^{-5}$

In Table 4 and Table 5 we present predictions for two binary star systems [15] for which the intrinsic $\dot{P}_b$ are not yet determined: PSR J1949+3160, a millisecond pulsar and a white dwarf companion, and PSR J1950+2414, also a millisecond pulsar with a possible low mass white dwarf companion. The estimated deviations of the predicted values are determined using the standard deviation of the mean error found in the preceding analyses.

5. Comparison of the Methods

This paper's approach attempts to use the gravitational redshift mechanism as the cause of the orbital decay found in binary star systems, a mechanism which has no GW emission. Our model emulates the traditional (GW) equations. The goal was to have the graviton energy redshift during free fall in the gravitational field of the binary star account for the observed orbital decay of the binary system. We struck upon the idea of a circulating equation $\Xi = \mathfrak{M}\mathfrak{h}\omega$ for the gravitons which surround the nucleus of the binary system, where the position of the orbiting body is tracked in phase by the graviton rotational energy of relativistic mass $\mathfrak{M}$. This graviton energy travels at velocity c from the central mass toward the orbiting body and with respect to the frame which is in free fall in the field between the masses, the graviton energy will be redshifted, thus reduced in energy. This mechanism for energy loss is a relativistic effect without emission, just as the case where light loses energy by gravitational redshift of its frequency when traveling away from the surface of a star. This is contrary to the mechanism of GW emission due to rotating binary stars where the wave carries away energy from the system.

Although the addition of a correctional function $\sigma(\varepsilon)$ was found necessary to make a better equality of the graviton model equation to the astrophysical data, this is a brute force approach even though this model strives to be compliant with the theory of General Relativity as formulated by Einstein, more precisely to its linearized approximation. At this stage, having compared our phenomenological approach to the standard GR method, we can go a step further in our graviton theory by actually equating it to the GR wave emission equation, giving to that equation a new interpretation of a gravitational redshift energy loss which emits no radiation.

Equate (9) and (21) in the form $-\delta\Xi/\mathrm{d}t = \delta E_{GW}/\mathrm{d}t$, expressed by,

$$-\frac{\delta\Xi}{\mathrm{d}t} = \mathfrak{M}\mathfrak{h}\omega\left(\frac{G(M+m)}{cr^2}\right) = \frac{\delta E_{GW}}{\mathrm{d}t} = \frac{G}{5c^5}\sum_{i,j=1}^{3}\left(\dddot{Q}_{ij}\dddot{Q}_{ij}\right), \tag{32}$$

where $\mathfrak{M}$ is the graviton rotational relativistic mass defined in (8). Moving the acceleration rate from the left side to the right side of (32), the graviton energy Ξ surrounding the nuclear mass $(M+m)$ takes the form,

$$\Xi = \frac{\mu Mm}{(M+m)^2}\mathfrak{h}\omega = \frac{r^2}{5(M+m)c^4}\sum_{i,j=1}^{3}\left(\dddot{Q}_{ij}\dddot{Q}_{ij}\right). \tag{33}$$

From (3) and (23) with the dependence on the orbit eccentricity ε from [2] for an elliptical orbit, which also converts radial distance r to semi-major axis $a = A$, substituting all this into (33) we get,

$$\begin{aligned}\frac{\mu Mm}{(M+m)^2}\mathfrak{h}\omega &= \frac{\mu Mm}{(M+m)^2}\left(\frac{\mathfrak{l}^2\omega}{\left(1-\varepsilon^2\right)^{3/2}}\right)\omega \\ &= \frac{\left(\left(1-\varepsilon^2\right)a\right)^2}{5(M+m)c^4}\left(\frac{\sigma_{GR}(\varepsilon)}{\left(1-\varepsilon^2\right)^{7/2}}\right)32\mu^2 a^4\omega^6.\end{aligned} \tag{34}$$

Now, using Kepler's third law for $\left(a^3\omega^2\right)^2 = \left(G(M+m)\right)^2$ in (34), with some simplification, yields,

$$\left(\frac{\mu\mathfrak{l}^2}{\left(1-\varepsilon^2\right)^{3/2}}\right)\omega^2 = \frac{32\mu}{5c^4}\left(\frac{\sigma_{GR}(\varepsilon)}{\left(1-\varepsilon^2\right)^{3/2}}\right)\left(G(M+m)\right)^2\omega^2. \tag{35}$$

Then, substituting for $\mathfrak{l}$ from (5) into (35) and simplifying we get,

$$\left(\frac{2\sqrt{\sigma(\varepsilon)}G(M+m)}{c^2}\right)^2 = \frac{32\sigma_{GR}(\varepsilon)}{5c^4}\left(G(M+m)\right)^2. \tag{36}$$

Finally, from (36) we are left with the relationship of the correction function $\sigma(\varepsilon)$ to the GR correction function $\sigma_{GR}(\varepsilon)$,

$$\sigma(\varepsilon) = (8/5)\sigma_{GR}(\varepsilon), \tag{37}$$

where $\sigma_{GR}(\varepsilon)$ is given by (27). Substituting (37) for $\sigma(\varepsilon)$ into (16) we obtain an orbital period decay equation from our graviton model identical to the standard GW model (26).

6. Conclusions

We presented a model to describe the rotational energy of gravitons in a binary star system. We have based it on an analogy to the General Relativity theory GW energy loss in a binary star system. Our approach enabled an adaptive correction to the graviton rotational energy which minimized the error in the prediction of the decay of the orbital period against the experimental value. Although the gain in accuracy is just a 5% reduction in the prediction error compared to GR, it does suggest that a graviton theory is a viable approach.

There are ongoing projects in the search for continuous low frequency GW's from known binary pulsars that are far from merging, where the orbital periods are of order > 0.1 day, and the GW frequencies will be $f < 2\left(1/0.1\times 86400\right)\approx 1.2\times 10^{-4}\text{ Hz}$. The LIGO/Virgo detectors can only go down to about 20 Hz [16]. Analysing day long or week long recorded data streams lowers the detection frequency to the range where these continuous GWs could be detected [17], but no detections have been made thus far. Research into continuous GW emission from binary pulsars is ongoing and the LISA telescope will look for these types of signals directly in the 0.1 mHz to 1 Hz range [18]. In a related field, regarding continuous GW emission from isolated neutron stars (pulsars), the latest research in the data of the LIGO/Virgo third observing run (O3) have made no detections [19]. Although there have been GW detections made of relativistically high energy binary blackhole mergers and binary neutron star mergers, these are not the type of low speed binary star events addressed in this discourse. As there has as yet been no detection of gravitational waves from these low speed sources, we deem this as ample justification to consider the thesis we have put forth.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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