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Gravitational Radiation

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Abstract

This paper addresses gravitational radiation based on a previously developed model.[1]

1. Introduction

Einstein (*c*. 1915) publishes the general theory of relativity, according to which gravitation is due to the *curvature* which matter creates in the field of space-time geometry. The field of space-time geometry *is* the gravitational field. The theory predicts the existence of gravitational waves in the space-time geometry field. Astronomic collisions and interactions among celestial bodies notwithstanding, so far there is no evidence of gravitons or waves in the field of space-time geometry.

The orbits of the binary pulsars PSR 1913+16 are shrinking. It is conjectured that the shrinking of the orbits are due primarily to the emission of gravitational waves from the pulsars. However, the observations of the pulsars for the past 30 years have shed no light on the form and nature of the gravitational waves.

General relativity predicts that gravitational waves are quadrupole and higher multipole waves, travel at the speed of light, have two degrees of polarization, and act as shear waves. This paper arrives at a starkly different picture of gravitational radiation.

2. Gravitational radiation from accelerating mass

We address gravitational radiation from an accelerating mass. As gravitational Maxwell's equations are not known, we derive Larmor's formula following J. J. Thomson's treatment of electromagnetic radiation from an accelerating charge.[2]

Fig. 1, in momentum space, shows a mass m with momentum $\vec{p}$ at $t = 0$, which accelerates at $\vec{a}$ for dt ($<< t$) and gains speed by $d\upsilon$ to υ. Changes propagate at a finite speed (b), so, later at time t, there is a transverse momentum field $\vec{P}_t$ of $\vec{p}$ in addition to the radial momentum field $\vec{P}_r$. Radial momentum field $\vec{P}_r$ drifts with the mass at speed υ and propagates radially at speed b. Transverse momentum field $\vec{P}_t$ changes from zero to amplitude P_t and back to zero in dt; this is *gravitational radiation pulse* propagating outwardly at speed b.

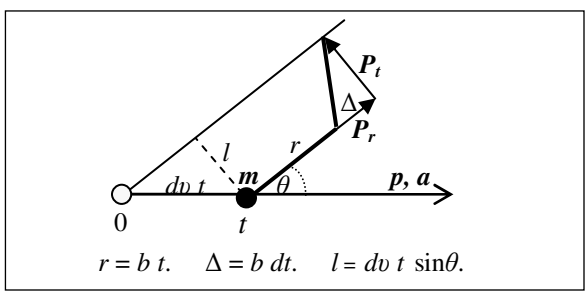

Figure 1. Mass m and its momentum field vectors

The ratio of transverse to radial momentum fields is:

$$\frac{P_t}{P_r} = \frac{l}{\Delta} = \frac{d\upsilon\, t \sin\theta}{b\, dt}, \tag{1}$$

where the radial momentum field P_r is:

$$P_r = G_d \frac{p}{r^2} \cos\theta \tag{2}$$

In contrast, in electrodynamics, the factor $\cos\theta$ does not arise.

Substituting (2) into (1), where $dv/dt = a$, we get:

$$P_t = \frac{G_d \; p \; a \sin 2\theta}{2\, b^2 \; r} \tag{3}$$

Radial P_r varies with $1/r^2$, transverse P_t with $1/r$. That is, transverse P_t survives over radial P_r at great distances.

We define g*ravitational Poynting intensity I*:

$$I \;=\; b\, P_t^2 / G_d \tag{4}$$

Substituting (3) into (4), we get gravitational intensity (watt/m^2):

$$I \;=\; \frac{G_d \; p^2 \, a^2}{4\, b^3} \, \frac{\sin^2 2\theta}{r^2} \tag{5}$$

The intensity falls off as $1/r^2$ and its angular variation is shown in Fig. 2 (a), which in turn shows that gravitational radiation accelerates a mass at 45^0 to its propagation direction and, so, has *four* degrees of polarization.

In contrast, the angular variation of electromagnetic pulse intensity is shown in Fig. 2 (b), which in turn shows that electromagnetic waves accelerate charges at 90^0 to their propagation direction and have *two* degrees of polarization.

Gravitational power (Ω) emitted is given by integrating the intensity (5) over all directions in Fig. 2 (c).

$$\Omega = \int_0^{2\pi} \int_0^{\pi} I \; r^2 \sin\theta \, d\theta \, d\varphi \tag{6}$$

If $\vec{p}$ and $\vec{a}$ are orthogonal, the magnitude of $\vec{p}$ stays constant, and its direction changes but only uniformly. Thus, a mass in a circular orbit does not gravitationally radiate, because no momentum-field pulse develops. A mass in motion in an eccentric orbit or an arbitrary trajectory gravitationally radiates – by the tangential component of the acceleration. In contrast, a charge *even* in a circular orbit emits electromagnetic radiation power.

Carrying out the integration in (6), we get gravitational Larmor's formula:

$$\Omega = (8\pi G_d / 15 b^3) \left(\vec{p} \cdot \vec{a}\right)^2 \tag{7}$$

Gravitational radiation power (Ω) is proportional to $(\vec{p} \cdot \vec{a})^2$. The first term $\approx 10^{-50}$ s/joule. A mass with *motive* power of $p\,a \approx 10^{25}$ watts emits *gravitational radiation* power of about 1 watt, which then falls of as $1/r^2$. In contrast, a charge emits electromagnetic radiation power proportional to $e^2 a^2$.

Fig. 2 (d) depicts a mass m in an elliptical orbit around another mass M. The elliptical orbit is given by semimajor axis length A and eccentricity ε. From (7), gravitational power Ω emitted from a point (r, θ) on the orbit is given by:

$$\Omega\,(A, \varepsilon, \theta) = K_1 \, K_2 \, (1 - 4\varepsilon \cos\theta + 6\varepsilon^2 \cos^2\theta - 4\varepsilon^3 \cos^3\theta + \varepsilon^4 \cos^4\theta) \sin^2\theta \tag{8}$$

where physical parameter $K_1 = (8\pi G_d/15 b^3)\,(G^3 M^3 m^2)$ and geometrical parameter $K_2 = \varepsilon^2/(A^5\,(1-\varepsilon^2)^3)$.

Total gravitational power Ω_{total} per orbital period is given by integrating Ω in (8) along its circumference:

$$\Omega_{total} \;= 2 \int_0^{\pi} \Omega(A, \varepsilon, \theta)\, d\theta \;= K_1 \, K_2 \, \pi \left(1 + \frac{3\varepsilon^2}{2} + \frac{\varepsilon^4}{8}\right) \tag{9}$$

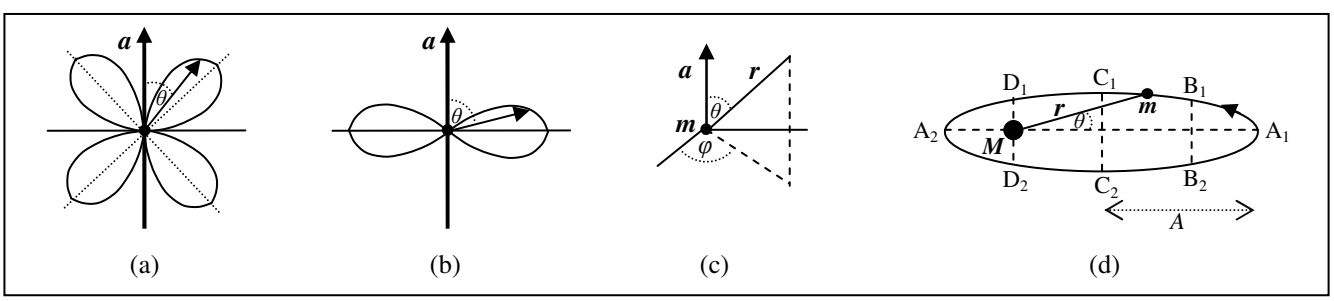

Figure 2. Variations in the intensity and power of gravitational radiation

Masses have primordial speed u (1.191 x 10^8 m/s). It is conjectured that masses in the universe have an acceleration of about 10^{-10} m/s^2. From (7), the sun, by this primordial motion, emits gravitational radiation power of about 10^7 watts, which arrives at the earth at about 10^{-17} watt/m^2.

3. Gravitational radiation from the binary pulsars PSR 1913+16

Each neutron star has a mass $m = 2.759 \times 10^{30}$ kg; each elliptical orbit is given by $A = 1.95 \times 10^{9}$ m and $\varepsilon = 0.617131$. [3] From (8), the variation of Ω with θ is plotted in Fig. (3), which shows the emission of gravitational radiation power in a pair of pulses at peaks of 7.01×10^{25} watts at $\theta = \pm 129^{0}.7$ at approximately 3.2×10^{3} secs interval per orbital period. From (9), the total gravitational power emission per orbital period is 1.564×10^{26} watts, which according to general relativity is 7.35×10^{24} watts.

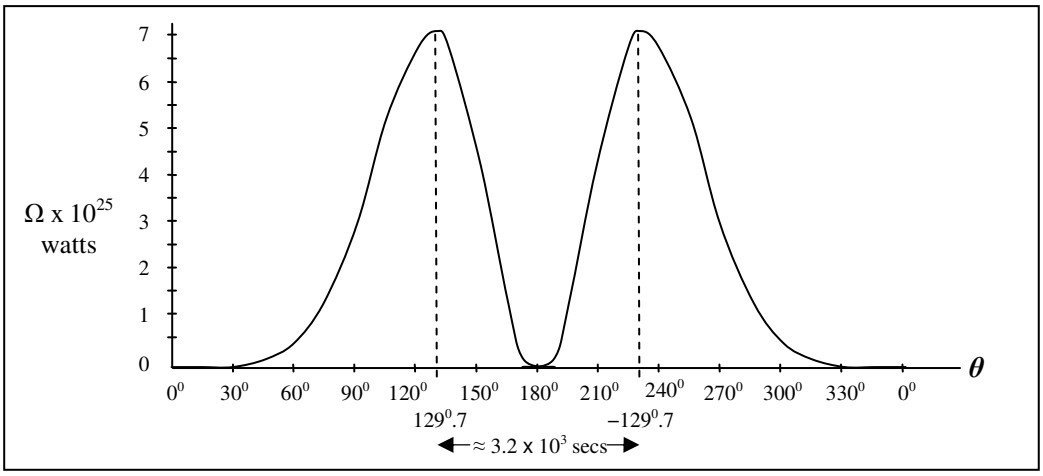

Figure 3. Gravitational radiation power from PSR 1913+16 pulsars

4. Remarks

No theory – be it relativities, quantum mechanics, or post-modern speculations (string theories, supersymmetry, hidden dimensions, quantum gravity, branes, *et al.*) – matters until and unless it can explain the details of gravitational radiation (that is, its emission mechanism, propagation mechanism, structure, speed, and polarization). Maxwell taught us so in electrodynamics.

More than one theory can explain the predictions of general relativity, such as the gravitational bending of light, the orbital precession of Mercury, the gravitational redshift of light, and the gravitational slowing down of the speed of time. But *one and only one* theory can explain the details of gravitational radiation. So far, gravitational waves as predicted by general relativity have not been detected. LIGO (Laser Interferometer Gravitational Observatory) and LISA (Laser Interferometer Space Antenna) seem to have taken more than enough time to detect gravitational radiation. Why? Could it be that gravitational radiation from the cosmos is too weak to arrive at Earth; or could it be that they are looking at the wrong picture. How long we must wait? We have proposed an alternate picture of gravitational radiation. We hope experimentalists would try to confirm or falsify it.

REFERENCES

1. R. P. Singh, A Constructive Model of Gravitation, *General Science Journ*al, 2012.

2. M. S. Longair, *High Energy Astrophysics*, Cambridge, 1981.

3. PSR B1913+16, *Wikipedia*, 2012; http://en.wikipedia.org/wiki/PSR_ B1913%2B16.