

Experimental Verification of a Classical Model of Gravitation

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A previously proposed model of gravitation is evaluated according to recent tests of higher order gravitational effects such as for gravito-electromagnetic phenomena and the properties of binary pulsars. It is shown that the model complies with all the tests.

1 Introduction

In previous articles [1–3] in this journal we presented a model of gravitation, which also led to a unified model of electro-magnetism and the nuclear force. The model is based on a Lagrangian,

$$L = -m_0(c^2 + v^2) \exp R/r, \quad (1)$$

where

$m_0 =$ gravitational rest mass of a test body moving at velocity \mathbf{v} in the vicinity of a massive, central body of mass M ,

$\gamma = 1/\sqrt{1 - v^2/c^2}$,

$R = 2GM/c^2$ is the Schwarzschild radius of the central body.

The following conservation equations follow:

$$E = mc^2 e^{R/r} = \text{total energy} = \text{constant}, \quad (2)$$

$$\mathbf{L} = e^{R/r} \mathbf{M} = \text{constant}, \quad (3)$$

$$L_z = M_z e^{R/r} = e^{R/r} m_0 r^2 \sin^2 \theta \dot{\phi}, \quad (4)$$

= z-component of $\mathbf{L} = \text{constant}$,

where

$$m = m_0/\gamma^2 \quad (5)$$

and

$$\mathbf{M} = (\mathbf{r} \times m_0 \mathbf{v}), \quad (6)$$

is the total angular momentum of the test body.

It was shown that the tests for perihelion precession and the bending of light by a massive body are satisfied by the equations of motion derived from the conservation equations.

The *kinematics* of the system is determined by assuming the local and instantaneous validity of special relativity (SR). This leads to an expression for gravitational redshift,

$$\nu = \nu_0 e^{-R/2r} \quad (\nu_0 = \text{constant}), \quad (7)$$

which agrees with observation.

The model is further confirmed by confirmation of its electromagnetic and nuclear results.

Details of all calculations appear in the doctoral thesis of the author [4].

1.1 Lorentz-type force

Applying the associated Euler-Lagrange equations to the Lagrangian gives the following Lorentz-type force:

$$\dot{\mathbf{p}} = \mathbf{E} m + m_0 \mathbf{v} \times \mathbf{H}, \quad (8)$$

where

$$\mathbf{p} = m_0 \dot{\mathbf{r}} = m_0 \mathbf{v}, \quad (9)$$

$$\mathbf{E} = -\hat{\mathbf{r}} \frac{GM}{r^2}, \quad (10)$$

$$\mathbf{H} = \frac{GM(\mathbf{v} \times \mathbf{r})}{c^2 r^3}. \quad (11)$$

1.2 Metric formulation

The above equations can also be derived from a metric,

$$ds^2 = e^{-R/r} dt^2 - e^{R/r} (dr^2 + r^2 d\theta^2 + r^2 \sin^2 \theta d\phi^2). \quad (12)$$

Comparing this metric with that of GR,

$$ds^2 = \left(1 - \frac{R}{r}\right) dt^2 - \frac{1}{1 - \frac{R}{r}} dr^2 - r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2, \quad (13)$$

we note that this metric is an approximation to our metric.

2 Higher order gravitational effects

Recent measurements of higher order gravitational effects have placed stricter constraints on the viability of gravitational theories. We consider some of these.

These effects fall in two categories: (i) Measurements by earth satellites and (ii) observations of binary pulsars.

2.1 Measurements by earth satellites

These involve the so-called gravito-electromagnetic effects (GEM) such as frame-dragging, or Coriolis effect, and the geodetic displacement. Surveys of recent research are given by Ruffini and Sigismondi [5], Soffel [6] and Pascual-Sánchez et.al. [7] A list of papers on these effects is given by Bini

and Jantzen [8], but we refer in particular to a survey by Mashhoon. [9]

Mashhoon points out that for a complete GEM theory, one requires an analogue of the Lorentz force law. Assuming slowly moving matter ($v \ll c$) he derives a spacetime metric of GR in a GEM form (see (1.4) of reference [9]). Assuming further that measurements are taken far from the source, ($r \gg R$) (see (1.5) of reference [9]), he derives a Lorentz-type force (see (1.11) of reference [9]),

$$\mathbf{F} = -m\mathbf{E} - 2m\frac{\mathbf{v}}{c} \times \mathbf{B}, \quad (14)$$

where m in this case is a constant.

This equation is analogous to (8). The latter equation, however, is an *exact* derivation, whereas that of Mashhoon is an approximate one for weak gravitational fields and for particles moving at slow velocities. This difference can be understood by pointing out that GR, as shown above, is an approximation to our model. This implies that all predictions of GR in this regard will be accommodated by our model.

2.2 Binary pulsars

Binary pulsars provide accurate laboratories for the determination of higher order gravitational effects as tests for the viability of gravitational models. We refer to the surveys by Esposito-Farese [10] and Damour [11, 12].

The Parametric-Post-Newtonian (PPN) formulation provides a formulation whereby the predictions of gravitational models could be verified to second order in R/r . This formulation, initially developed by Eddington [13], was further developed by especially Will and Nordtvedt [14, 15]. According to this formulation the metric coefficients of a general metric, $ds^2 = -g_{00}dt^2 + g_{rr}dr^2 + g_{\theta\theta}r^2d\theta^2 + g_{\phi\phi}r^2\sin^2\theta d\phi^2$, can be represented by the following expansions (see eqs. 1a and 1b of reference [10]):

$$-g_{00} = 1 - \frac{R}{r} + \beta^{PPN} \frac{1}{2} \left(\frac{R}{r}\right)^2 + O\left(\frac{1}{c^6}\right), \quad (15)$$

$$g_{ij} = \delta_{ij} \left(1 + \gamma^{PPN} \frac{R}{r}\right) + O\left(\frac{1}{c^4}\right). \quad (16)$$

Recent observations place the parameters in the above equations within the limits of [16]:

$$|\beta^{PPN} - 1| < 6 \times 10^{-4}, \quad (17)$$

and [17]

$$\gamma^{PPN} - 1 = (2.1 \pm 2.3) \times 10^{-6}. \quad (18)$$

We note that the coefficients of (12) fall within these limits. This implies that the predictions of our model will agree with observations of binary pulsars, or with other sources of higher order gravitational effects.

3 Other effects

Eqs. (2) and (5) show that gravitational repulsion occurs between bodies when their masses are increased by converting radiation energy into mass. We proposed in ref. [1] that this accounts for the start of the Big Bang and the accelerating expansion of the universe. It should be possible to demonstrate this effect in a laboratory.

Conversely, the conversion of matter into radiation energy ($v \rightarrow c$) as $r \rightarrow R$ describes the formation of a black hole without the mathematical singularity of GR.

4 Conclusion

The proposed model gives a mathematically and conceptually simple method to verify higher order gravitational effects.

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References

1. Wagener P.C. A classical model of gravitation. *Progress in Physics*, 2008, v. 3, 21–23.
2. Wagener P.C. A unified theory of interaction: gravitation and electrodynamics. *Progress in Physics*, 2008, v. 4, 3–9.
3. Wagener P.C. A unified theory of interaction: Gravitation, electrodynamics and the strong force. *Progress in Physics*, 2009, v. 1, 33–35.
4. Wagener P.C. Principles of a theory of general interaction. PhD thesis, University of South Africa, 1987. An updated version will be published as a book during 2009.
5. Ruffini R.J. and Constantino S. Nonlinear gravitodynamics: The Lense-Thirring effect. A documentary introduction to current research. World Scientific Publishing, 2003.
6. Soffel M.H. Relativity in astrometry, celestial mechanics and geodesy. Springer-Verlag, 1989.
7. Pascual-Sánchez J.F., Floria L., San Miguel A. and Vicente R. Reference frames and gravitomagnetism. World Scientific, 2001.
8. Bini D. and Jantzen R.T. A list of references on spacetime splitting and gravitoelectromagnetism. In: Pascual-Sánchez J.F., Floria L., San Miguel A. and Vicente R., editors. Reference frames and gravitomagnetism. World Scientific, 2001, 199–224.
9. Mashhoon B. Gravitoelectromagnetism: a brief review. In: Iorio L. editor. Measuring gravitomagnetism: a challenging enterprise. Nova Publishers, 2007, 29–39; arXiv: gr-qc/0311030.
10. Esposito-Farese G. Binary-pulsar tests of strong-field gravity and gravitational radiation damping. arXiv: gr-qc/0402007.
11. Damour T. Binary systems as test-beds of gravity theories. arXiv: gr-qc/0704.0749.
12. Damour T. Black hole and neutron star binaries: theoretical challenges. arXiv: gr-qc/0705.3109.
13. Eddington A.S. Fundamental theory. Cambridge Univ. Press, Cambridge, 1946, 93–94.

14. Nordvedt Jr. K. and Will C.M. Conservation laws and preferred frames in relativistic gravity. II: experimental evidence to rule out preferred-frame theories of gravity. *Astrophys. J.*, 1972, v. 177, 775–792.
 15. Will C. M. Theory and experiment in gravitational physics. Revised edition, Cambridge Univ. Press, Cambridge, 1993.
 16. Will C. M. *Living Rev. Rel.*, 2001, v. 4; arXiv: gr-qc/0103036.
 17. Bertotti B., Iess I., and Tortora P. A test of General Relativity using radio links with the Cassini Spacecraft. *Nature*, 2003, v. 425, 374–376.
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