Protogravity: a quantum-theoretic precursor of actual gravity

I explore the possibility that gravity is not the result of a curved geometry, or of any other extraneous force or effect, but has its origin with quantum mechanics in the wave structure of matter and radiation.

My contention will be that gravity is essentially a consequence of the manner in which the wave structure of a elementary particle must adapt to a change of inertial frame.

A particle may experience a range of changes as it moves. For a massive particle, these are the changes in length, time and simultaneity described by the Lorentz transformation and, at what will emerge here as the more fundamental level, the corresponding changes in wavelength, frequency and phase defined for quantum mechanics by the de Broglie wave.

These changes are the origin in special relativity of the twin effect - the slower aging of the twin who undertakes a return trip as compared with that of her brother who stays at home. The derivation of the twin effect from the de Broglie wave will be important here and can be briefly stated. This wave has the form,

$$\psi_{dB} = e^{i(\omega_E t - \boldsymbol{\kappa}_{dB}\cdot\mathbf{r})},$$

where ω_E and κ_{dB} are, respectively, the Einstein frequency and the de Broglie wave vector. An orbiting particle thus suffers a loss in phase per orbit,

$$\Delta\varphi = \oint \omega_0 dt - \oint [\omega_E dt - \kappa_{dB} ds],$$

(ω_0 being the frequency of the particle at rest), leading to a reduced proper time,

$$\tau = \oint (1 - \frac{v^2}{c^2})^{\frac{1}{2}}\, dt,$$

implying for the orbiting particle a slowing of time, a diminished frequency and a correspondingly reduced energy.

An orbiting object thus has from the twin effect a binding energy, and it is this binding energy that I have referred to above as protogravity. This binding influence is not as yet the gravity experienced here on Earth. A stationary object also feels the influence of gravity, and an orbiting object experiences dilations of time, not only from its motion about a gravitating mass, but from its proximity to that mass.

Yet we have from this protogravity a binding force sufficient in itself to explain the tendency of matter to favour bound rather than unbound motion in the early universe. And as I will show from a consideration of the further constraints imposed by conservation of energy and the principle of relativity this proto-gravity is also able to explain the important Schwarzschild metric, and in so doing, the effects of gravity so far as these can be ascertained with reasonable certainty from the Earth.

In this explanation, the twin effect will provide the mechanism of gravitational attraction, while conservation and the principle of relativity will determine the relative strength of this mechanism from place to place. The dilation of time experienced by an object that is stationary with respect to a gravitating mass will be explained, as Einstein himself suggested, by its reduced energy and the Planck-Einstein relation, $E = \hbar\omega$, which relates energy E to frequency ω (where $\hbar$ is Planck's constant). The further dilation experienced by an object that is moving within the influence of gravity will then follow from the requirement of the principle of relativity that moving and stationary particle have the same interactions and dynamic relationships within that influence as they do when beyond it.

Why should this protogravity be regarded as a *quantum-theoretic* precursor of actual gravity? It is because (as shown by the derivation above) the twin effect follows from the evolution of phase described by the de Broglie wave in the same way as the Schrödinger evolution follows from the evolution of that same de Broglie wave in quantum mechanics.

As is also indicated by the derivation above, the equivalence of inertial and gravitational mass can then be seen as a consequence of a common origin in wave structure.

While I have taken this proposal only so far as the Schwarzschild metric, the laws and relationships on which I have relied, that is to say, conservation of energy, the principle of relativity and the Lorentz transformation, have the status in physics of meta-principles. They are fundamental laws of universal application, likely to have the same relevance, in other situations.

But as currently understood, these three meta-principles are themselves unexplained brute properties of the given universe. To tie the three together in a thoroughly wave-theoretic interpretation of gravity, something more than the de Broglie wave will be required. I will rely on that alternative understanding of the de Broglie wave, according to which it is not a wave in its own right, but the modulation of an underlying wave structure having, in the rest frame of the particle, the form of a standing wave. This, I should say is not a new interpretation of the de Broglie wave. Indeed, an anticipation of this conception of the wave may be discerned in de Broglie's famous thesis of 1923.

In this explanation of gravity, the gravitational constant G would be a measure of the degree to which matter and radiation, or more generally energy, is bound to other matter and energy. As others have proposed, including, variously, Jacobson, Padmanabhan and Verlinde, gravity would thus have thermodynamic significance. G would be akin to an intensive thermodynamic parameter, its apparently unchanging value in the present epoch having been determined by the circumstances of the early universe.

If gravity can be explained from particle wave structure, no further reconciliation should then be necessary, either with quantum mechanics or with the other fundamental forces.

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