

DYNAMICS, RELATIVITY AND THE EQUIVALENCE PRINCIPLE IN THE 'ONCE-GIVEN' UNIVERSE

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I discuss the main results and experimental support of the paradigm of Cosmic Relativity in which all of dynamics and relativistic effects are gravitational effects of the matter-energy in the universe. The large gravito-magnetic effect of the matter in the universe, in relative motion to the laboratory observer, is directly demonstrated in an experiment. These results lead us to the Centenary Einstein Equation, with cosmic gravity included as its integral element.

1 Introduction and the Core Paradigm

All fundamental theories of physics were formulated well before we gained any knowledge about the real universe. In particular, theories of dynamics, relativity and quantum mechanics were formulated explicitly with empty space as their arena. However, all experimental tests in physics are unavoidably in the presence of cosmic matter and its gravity. Hence, an empirically and logically rigorous reconsideration becomes essential by examining the gravitational effects of the matter in the universe on bodies in motion relative to the cosmic frame. The results of such a study is staggering, to say the least, pointing to a fundamentally new paradigm for dynamics and relativity with several new predictions.^{1,2} The resulting theory, called Cosmic Relativity, has the matter filled cosmic frame and its gravity defining a preferred absolute frame and the universal and monotonically decreasing temperature of the cosmic microwave background radiation defining the absolute time. All relativistic physical effects are then gravitational effects due to the motion relative to the single preferred frame of the matter-filled universe. Of course, only the Galilean transformations (GT) are consistent with such an absolute frame because motion relative to the cosmic frame causes large matter currents and the relevant metric becomes anisotropic. However, GT correctly reproduces all the essential relativistic effects, like time dilation, with the velocity relative to the cosmic frame as the relevant parameter, instead of relative velocities between observer frames. This new paradigm has the strength that it is fully consistent with all known experiments and has significant new predictions. Law of dynamics and the equivalence principle follow as consequences.³ Since gravity of the real 'once-given' universe determines all dynamical and relativistic effects without added postulates, there is no more freedom in the theory or its parameters. It then demands a significant modification of the

Einstein's equation because the equation (as all other equations of dynamics and fields in physics) is operative and tested in the eternal presence of cosmic gravity. The resulting 'Centenary Einstein's Equation' encodes the gravitational presence of cosmic matter by including its energy momentum tensor as an integral non-removable part. We now examine the key results and tests, including a direct demonstration of the large gravitational effect of cosmic matter on the dynamics of a gravitational current loop.

2 Main results

Description of fundamental physical quantities by observers in motion is characterized by the metric of space and time. Empty space and its metric remains homogenous and isotropic in every moving frame and the only coordinate transformation that is consistent with this feature is the Lorentz transformation (LT). The metric $diag \{-1, 1, 1, 1\}$ goes to $diag \{-1, 1, 1, 1\}$ under LT. This is the very basis of the special theory of relativity. However, in reality, space is filled with the charge of gravity, or mass-energy, nearly at the critical density in our spatially flat universe. Motion results in a large gravitational current, thus generating anisotropy of order v/c . To reflect this, the metric should also become anisotropic, which is impossible with Lorentz transformations. Therefore, the real universe is maximally Lorentz violating in the sense of the anisotropy due to the motion-induced vector-like gravitational potential. The Doppler dipole anisotropy of the temperature of the cosmic microwave background enables fairly precise determination of one's motion relative to the cosmic frame. A uniform current of gravitational mass generates a gravitational vector potential (which is in fact a part of the full 10-component symmetric tensor), $A_i/c = g_{0i} = v_i/c$. The fact that there are no locally measurable physical effects of a constant vector potential field is then the statement of the principle of relativity and it is strongly tied to the observed homogeneity of the matter-energy distribution. Surprisingly, the Galilean transformations correctly gives us, along with the observed anisotropy, the most important relativistic feature of motion – time dilation! To illustrate this we work with a limited version of the actual Robertson-Walker metric, ignoring the very slow time evolution. Under GT, the metric coefficients transform from $\{g_{00} = -1, g_{0i} = g_{i0} = 0, g_{ii} = 1\}$ to $\{g_{00} = -(1 - v^2/c^2), g_{0i} = g_{i0} = v/c, g_{ii} = 1\}$. Nonzero g_{i0} , a gravito-magnetic potential, gives the observed anisotropy.

The constant c is the absolute velocity of light in the cosmic frame. One may verify that the spatial metric and the correct length contraction also follows from this. I also mention that an experiment that compares the genuine one-way velocity of light relative to a slowly moving observer indeed shows that light behaves as Galilean as familiar waves like sound, with first order relative velocity $c \pm v$.¹

This can also be treated in the language of gravitational potentials. It is well known that the Newtonian gravitational potential Φ_u at a point in this universe of size Hubble radius or so, evaluated using the observed matter-energy density, is numerically close to c^2 . Hence, even a phenomenological claim that all relativistic effects and due to the gravity of the universe with motional relativistic factor $1/\gamma = (1 - v^2/\Phi_u)$ is empirically accurate. In moving frames, the relativistic potential will have velocity dependent 'vector potential' component

$$A_i = \frac{v_i \Phi_u}{c} \left(1 - v^2/c^2\right)^{-1/2} = \gamma \frac{v_i \Phi_u}{c} \quad (1)$$

leading to several large gravito-magnetic effects.

The gravitational consequences of the cosmic matter and its current for the physics of moving bodies is enlightening. Though g_{i0} is homogeneous in a uniformly moving frame, which implies the principle of relativity, if there an acceleration g_{i0} becomes time dependent and the physical effect is a reactive force on the accelerated system,

$$F_i = -m_g \frac{dA_i}{cdt} = -\frac{m_g \Phi_u}{c^2} \left(\gamma a_i + \gamma^3 v_i (\vec{v} \cdot \vec{a})\right) \quad (2)$$

Another way of writing this is to note that the vector potential modifies the momentum (enabling generalizing to quantum theory) as $p' = p - m_g A_i$. We see that accelerating a body requires overcoming this cosmic gravito-magnetic reaction and hence a force F_i which is the full relativistic form of Newton's law of dynamics and the conventional inertial mass is just $m_i = m_g \Phi_u / c^2$.

Hence the ratio m_i/m_g is universal. The equivalence principle is a necessary implication of cosmic gravity. Therefore, Newton's law of dynamics and the equivalence principle have the same physical content and one implies the other through their cosmic gravity connection.³ Newton's law is a relativistic gravito-magnetic consequence of cosmic matter and the analogue in electrodynamics is the Lenz's law.

Needless to emphasize that both the centrifugal and the Coriolis forces follow as consequences of cosmic gravity, as had been speculated by E. Mach. Also, the Sagnac phase Φ_S turns out to be a gravitational phase, independent of the shape of the loop, similar to the electromagnetic Aharonov-Bohm phase.

$$\Phi_S = \frac{m_g}{\hbar} \oint A_g \cdot dx = \frac{m_g (\nabla \times \vec{v}) \cdot d\vec{S}}{\hbar} = \frac{2m_g \vec{\Omega} \cdot \vec{S}}{\hbar} \quad (3)$$

The large cosmic gravito-magnetic field in every rotating frame, amounting to $B_g = c\nabla \times g_{0i} = 2\Omega$ becomes very important for spin physics because spin (the fundamental gravito-magnetic moment) couples to a gravito-magnetic field with energy $s \cdot B_g/2$. Cosmic relativity takes the view that since spin is the current of gravitational charge, all spin-dependent effects in fundamental physics should be traceable to the gravitational interaction. This turns out to be crucial for a variety of physical phenomena including spin-statistics connection, hyperfine spectra, spin transport in chiral biomolecules and the fractional quantum Hall effect.^{4,5}

The 'gravitational field' F_i generated in an accelerated frame is fundamentally different from the usual Newtonian field $F_N = -\nabla\Phi$ because F_i appears only during motion relative to the cosmic frame. The 'weightlessness' during free fall is a force balance determined by

$$\nabla\Phi = -\frac{dA_i}{dt} \quad (4)$$

This has the important consequence that in an accelerated frame the motional gravitational field from time dependent g_{0i} does not lead to gravitational time dilation. Hence, the redshift in an accelerated frame is a Galilean consequence of the preferred frame and Galilean relative velocity, and not the gravitational time dilation.

3 Demonstrable experimental evidence

The enormous relativistic gravitational effect of cosmic gravity can be directly demonstrated in a simple, yet immensely important, experiment analogous to Ampere's experiment on current-current interaction. The interaction of a small loop of electrodynamic current i with a another larger loop of current I with effective magnetic field B can be written as $E = \mu \cdot B$ where $\mu = \pi i r^2$. The electromagnetic torque on the test current loop is $\tau = \mu \times B$. With even a slight angle between μ and B this torque will flip the loop if the direction of the current I is opposite to that in the test loop. The physical effect is the same when the small current loop is inside a rotating charged sphere.

It is easy to generate a current loop of the charge of gravity by rotating a small massive disc (gyrodisk) with $L = m\vec{v}_d \vec{r}_d$. It is equally easy to generate a large gravitational current and a gravito-magnetic field by rotating the laboratory relative to all the matter in the universe, if Cosmic Relativity is fundamentally correct. The amazing result is there to verify easily – the rotating disk flips when the external cosmic gravitational current is flipped in sign by changing the direction of the rotation of the laboratory, acted upon by real force; there is indeed a large torque, $\tau = cL \times (\nabla \times g_{0i})/2 = L \times \Omega$, that promptly flips the disk when the two currents are in

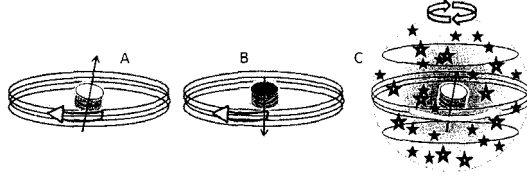


Figure 1 – Panels A and B indicate how a small current loop or magnet flips its direction when the current in the larger loop is in a direction opposite to that of the test loop current. Panel C: When a spinning disk is taken into a frame slowly rotating relative to the matter in the universe (indicated by dual arrows on top), the spinning disk flips due to the large gravitomagnetic force, when the current of the cosmic matter in the frame is in the same direction as the current in the spinning disk.

the same direction (in contrast to opposite currents in electrodynamics). It is most important to note that the physical flips can happen only with a transfer of energy and angular momentum from an external source through one of the two long range interactions known to physics. Since we have an electrically neutral spinning disk, it has to be gravity! The force arises from the interaction of the gravitational current in the disk i_d and the relativistic cosmic current generated I_c by rotating the frame. Quantitatively, the maximum force is

$$F_I = \frac{G i_d I_c}{c^2 R^2} \simeq \frac{G m_d \bar{v}_d M_u (\Omega R_u)}{c^2 R_u^2} = \frac{\Phi_u L}{c^2 \bar{r}_d} \Omega \quad (5)$$

from which the torque $\tau = L \times \Omega$ follows when the cosmic gravitational potential $\Phi_u \simeq c^2$. There is no escape from this conclusion.

Conventional physics has the experiment in the Schwartzchild metric of the earth, a solution of the vacuum Einstein equation $R_{ik} = 0$, where the gravito-magnetic effects are way too small to detect. This experiment falsifies the conventional picture and decisively demands the need to rewrite the paradigm to include the real physical effect of cosmic gravity. This can be done only by modifying the Einstein equation itself, with cosmic relativity as the new basis. Fortunately this is easy, maintaining the Bianchi identities and the consistency with all known experimental tests. The resulting Centenary Einstein's equation is

$$R_{ik} - \frac{1}{2} g_{ik} R + \Lambda_{g_{ik}} - \frac{8\pi G}{c^2} T_{ik(U)} = \frac{8\pi G}{c^2} T_{ik} \quad (6)$$

The extra piece on the left is the energy momentum tensor of the universe, included as the non-removable integral part of the equation itself.

In conclusion, new experimental tests in a variety of situations involving motion of massive bodies relative to the matter-filled universe demands a paradigm change in the fundamental theories of dynamics and relativity. This is answered by Cosmic Relativity, in which all relativistic effects and the law of dynamics are demonstrably identified as cosmic gravitational effects.

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