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THE MOST VIABLE GRAVITATIONAL THEORY

by

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SUMMARY

Abundant geophysical, astrophysical and cosmological evidence is explainable most readily by consequences of an Einstein desideratum for Mach's Principle: Cavendish parameter G should increase as one approaches a massive body (exact opposite of Brans-Dicke hypothesis, but a feature of Einstein-Hlavaty asymmetric, non-metric theory). A corresponding physically viable (95% probability) scalar-tensor theory predicts (as did Milne, in exact opposition to Dirac) that G increases in time, and that complete gravitational collapse is impossible: black holes do not exist; quasars are merely compact pulsating stars. A new critical test aboard the Helios satellite and nuclear applications are proposed.

NOTE. For brevity, most historical references, literature references to related work, documentation of assumed facts, and mathematical details have had to be omitted; this 1400-word essay is a summary of EXHIBIT A, which itself is a condensed, synthesizing summary of APPENDICES 1-4, all of which are unpublished and specially written in support of the present essay.

Newton's Law of Gravity (in conjunction with his Galilean-invariant Laws of Dynamics) explained Kepler's three Laws of Planetary Motion by a single, simple hypothesis and, as applied to our solar system's dynamical astronomy by Laplace, Lagrange and Poisson, led to a comprehensive celestial mechanics which was remarkably successful, except that, as noted by Leverrier and confirmed by Simon Newcomb, a minute residual precession of the perehelion of Mercury remained unexplained.

The Lorentz-invariant Maxwell Equations were equally successful with electromagnetism. Many experiments (e.g., Michelson-Morley, Kennedy-Thorndike, Ives-Stilwell, Hahn-Meitner, Rossi-Hall, Pound-Rebka, etc.) have established beyond doubt the necessity for a Lorentz-invariant modification of Newtonian kinematics and dynamics, as developed in the Special Relativity theory of Poincaré and Einstein (including a dynamics finalized by Planck), which can be treated most economically via the spacetime formalism of Minkowski.

In 1916, Einstein succeeded in incorporating a generalization of Newtonian gravity into this conceptual framework, by regarding the pseudo-Riemannian metric of spacetime as non-flat (with a curvature tensor determined by a brilliant generalization of the D'Alembert-Poisson wave equation), and immediately demonstrated the viability of this theory by an incredibly accurate prediction of the residual precession of Mercury. Also, prior to Hubble's observational discovery (in conjunction with Lemaitre's predictions) of the expansion of the universe, Friedmann had, a decade earlier, discovered three possible homogeneous, isotropic, but necessarily <u>expanding</u> solutions of the field equations of Einstein's General Relativity (GR), which in retrospect exhibit further the awesome predictive power of GR. In 1934, Milne and McCrea demonstrated [cf. Appendix 2] the <u>exact</u> identity of the Einstein-Friedmann equations and the Newtonian gravitational dynamics of an initially homogeneous, isotropic, radially expanding collection of point-

particles, thus imparting still further credibility to GR as a viable generalization of Newtonian gravitational theory.

However, GR is not the only possible extension of Newtonian gravity to a locally Minkowskian spacetime manifold. In GR, the Cavendish parameter G is assumed to be a fundamental constant of nature. But in theories of the Jordan-Brans-Dicke (JBD) type, one has, besides the ten Einstein gravitational potentials defining the metric tensor, an extra scalar field whose reciprocal provides the local value of G. This scalar field satisfies an additional D'Alembert-Poisson wave equation, whose right-hand side is proportional to the trace of the energy-momentum tensor, i.e., the mass density of matter, via a non-dimensional coupling coefficient conventionally written as $8\pi/(3 + 2\omega)$.

In JBD (and its generalizations by Bergmann and Wagoner), one assumes that $-3/2 < \omega < +\infty$. This has several observable consequences which must be checked against reality to see if the JBD hypothesis that $(3 + 2\omega) > 0$ is physically viable. In the first place, as one's test particle approaches a ponderable mass, G decreases, i.e., $(\delta G/G) < 0$. In the second place, as time increases, G decreases, i.e., $(\dot{G}/G) < 0$. In the third place, the Eddington-Robertson parameter γ of the PPN formalism (which determines the amount of spacetime curvature near a ponderable mass, and is normalized to $\gamma = 1$ in GR) is given by $\gamma = (\omega + 1)/(\omega + 2) = 1 - [1/(\omega + 2)] < 1$. Finally, GR is recovered as $\omega \to +\infty$.

In 1937, Dirac suggested that $G \propto 1/t$, i.e., that $(\dot{G}/G) < 0$. For this reason, the adherents of JBD have (in the present author's opinion, too uncritically) always assumed that $-3/2 < \omega < +\infty$.

In contrast, the presently advocated theory [Appendix 3] is based upon the hypothesis that $-\infty < \omega < -2 < 0$; one now recovers GR as $\omega \to -\infty$, instead of as $\omega \to +\infty$. The full complement of physical differences between this theory and JBD are numerous and profound, though apparently hitherto unnoticed [e.g. in

this theory black holes are impossible!]. The most obvious differences are those displayed in the following table.

Present Theory	JBD
$-\infty < \omega < -2$	$-3/2 < \omega < +\infty$
$(\dot{G}/G) > 0$ (MILNE)	$(\dot{G}/G) < 0$ (DIRAC)
$(\delta G/G) > 0$ (EINSTEIN)	$(\delta G/G) < 0$ (DICKE)
$(\text{PPN:})\gamma > 1$	$(\text{PPN:})\gamma < 1$
recover GR as $\omega \to -\infty$	recover GR as $\omega \to +\infty$

The objective of the present essay is to summarize the wealth of available support for the proposition that all known geophysical, astrophysical and cosmological evidence confirms the present theory and contradicts both GR and JBD (to at least two standard deviations), i.e., there is less than 5% probability that experimental reality is in accord with either GR or JBD, and there is more than 95% probability that the present theory is the only currently viable metric gravitational theory.

From geophysics it is known that the Earth's inertia tensor J and core radius r satisfy $\frac{1}{6}\,\mathrm{tr}(\dot{J}J^{-1}) = \dot{r}/r = -(0.1)(\dot{G}/G) = -\varepsilon$, say. There are three separate geophysical anomalies proving that $\varepsilon > 0$. Firstly, the Earth's core is mysteriously losing heat at an unexplained 35 ergs/cm^{2}sec (difference between observed value of 50 erg/cm^{2}sec, predicted value of 15 ergs/cm^{2}sec). But shrinkage $[(\dot{r}/r) < 0]$ would involve compression, friction and loss of heat to the crust. (In effect, the expanding universe is braking itself by doing work on the Earth's core.) Secondly, there is a residual, unexplained, observed acceleration of the Earth's rate of rotation, of about 7×10^{-11} parts per year, mathematically equivalent [cf. Exhibit A] to $\mathrm{tr}(\dot{J}J^{-1}) < 0$. Finally, application of the shrinkage concept to the Sun would provide an energy source additional

to nuclear transmutation, and so necessitate lowering the postulated central temperature T otherwise considered to be consistent with the observed luminosity L; this would explain the "impossible" anomalous observed solar electron neutrino flux, without such "desperate measures" [Trimble and Cowan, 1973] as Fowler's ad hoc hypothesis that T is presently below its average value.

There are at present, twenty-four known experimental attempts to measure γ, by four classes of solar system astrophysical experiments: deflection of light waves, precession of perihelion, radar-echo time-delay, and deflection of radio microwaves. A comprehensive statistical analysis of these experiments [Appendix 1] yields $\gamma = 1.10 \pm 0.05$, i.e., if the observation errors are random and normal, there is less than a 5% probability that either GR or JBD is physically viable.

This result should not seem so surprising when it is recalled [Exhibit A] that one of Einstein's four desiderata for the incorporation of Mach's Principle in GR included $(\delta G/G) > 0$, the exact opposite of JBD's basic hypothesis. (Furthermore, the Einstein-Hlavaty asymmetric, non-metric "final unified field theory" also involves $(\delta G/G) > 0$, a confirmatory point apparently hitherto unnoticed.) Similarly, the interpretations of Mach's Principle by Milne and by Sciama both lead to $(\dot{G}/G) > 0$.

Finally, another hitherto unnoticed physical paradox of GR, that of matter escaping from a black hole by radial motion [Appendix 2], shows that the observed hyperbolicity of the universe ($q < \frac{1}{2}$: Sandage, 1974; Gunn, 1974) is physically incompatible with GR or JBD or any theory which does not involve the 1935 Milne hypothesis $(\dot{G}/G) > 0$ in the form $G \alpha c^3 t/M$ as $t \to + \infty$, where M denotes essentially the constant rest-mass of the visible universe. But in the present theory, Milne's relation can be proved rigorously in the case $q < \frac{1}{2}$, $k = -1$ (as a consequence of the present covariant metric

gravitational theory, which is derived from a Lagrangian variational principle), as well as the fact that $0 < (\dot{G}/G) \approx 3 \times 10^{-13}$ [Appendix 4]. Furthermore, in GR no stable star can have a radius $R < (9/8)r_{LS}$, where r_{LS} is the Laplace-Schwarzschild black-hole radius, and so the surface of no star, no matter how compact, can emit light having a red-shift $z > 2$, whereas, in the present theory, the surface of a compact star can emit light of red-shifts $o < z < +\infty$; this implies that the red-shifts of quasars are not anomalous unless Mach's Principle is ignored.

Thus, all available geophysical, astrophysical, and cosmological evidence supports the present theory and refutes what in expert opinion were the most viable alternatives. Therefore, we should take seriously the present theory's implications in as yet unobserved parameter-regimes. In particular, black holes are impossible, and both G and a new anti-gravitational centrifugal repulsion become infinite near an impenetrable r_{LS}. The strong nuclear force's repulsion is, therefore, a natural aspect of gravity without any need for ad hoc "strong gravity" hypotheses, such as are current in nuclear physics. Also, two test-particles near the r_{LS} of a third ponderable mass attract infinitely strongly (an explanation of the quark's triplet nature?).

Finally, a Cavendish experiment performed onboard the Helios satellite (aphelion 1 AU, perihelion 1/3 AU) would [Appendix 3] provide a new critical test of the present theory, by comparing the relative values of G at perihelion and aphelion.

$$G_{per}/G_{aph} = \begin{cases} 1 + 0.9 \times 10^{-9}, & \text{present theory} \\ 1, & \text{GR} \\ 1 - 1.3 \times 10^{-9}, & \text{JBD} \end{cases}$$

HELIOS SATELLITE-BORNE
CRITICAL TEST OF PRESENT THEORY

Thus the present theory satisfies Sir Karl Popper's celebrated criterion for prime viability of a scientific theory, namely, that it is readily falsifiable, if false.

BIOGRAPHICAL SKETCH

Robert W. Bass is a Professor of Physics and Astronomy at Brigham Young University, and a long-time student of the theory of relativity and gravitation.

Born in 1930, he graduated from Johns Hopkins University (B. A. in Physics, Phi Beta Kappa) in 1950 and received a Rhodes Scholarship. After being privileged to discuss his plans in person with the late Albert Einstein, he sought admission to Wadham College with the intention of ultimately doing graduate work under the great British cosmologist, E. A. Milne; unfortunately, Milne died before Bass arrived at Oxford.

Receiving an M. A. Oxon in 1950, he returned to Johns Hopkins and received a doctorate in mathematics in 1955 under the late Aurel Wintner (author of The Analytical Foundations of Celestial Mechanics). Subsequently he did three years of post-doctoral research at Princeton University, including one year in topological dynamics and nonlinear mechanics under the late Research Professor Emeritus, Solomon Lefschetz, and two years at the Princeton Plasma Physics Laboratory.

In 1958, Bass published the principal special case of what is now known as Pontriagin's Maximum Principle (for which the Soviet Academician received the Lenin Prize in 1960). In 1960, at the IAF in Stockholm, Bass announced a new "Principle of Least Mean Absolute Potential Energy", which, it was shown in 1971, provides a purely dynamical explanation for Bode's Law of Planetary Distances. Also in 1960, at the first meeting of the International Federation of Automatic Control, held in Moscow, Bass served as Chairman of the session on nonlinear stability and Vice Chairman of the session on discontinuous feedback systems. In 1961, he was voted "Outstanding Young Scientist of the Year" by the Maryland Academy of Sciences.

Bass's decade in the aerospace industry included positions as Chief Scientist, Aeronca Manufacturing Corp.; Head, Advanced Studies Staff, Hughes Aircraft Company; and Assistant to the Chief Engineer, Advance Flight Mechanics, McDonnell Douglas Corp.

On June 13, 1974, Bass presented a half-hour invited address to the semi-annual meeting of the American Physical Society, concerning his new design of a "shatterproof magnetic bottle" for controlled thermonuclear fusion plasma confinement. At present, he is Chief Technical Consultant to an eleven-profesor group at BYU which is undertaking an experimental test of Bass's magnetic bottle, called the Topolotron because it is based on principles of "topological stability" introduced in 1937 by Andronov and Pontriagin but never hitherto applied to plasma physics.

In 1957, jointly with Louis Witten, Bass published a "Remark on Cosmological Models " (Reviews of Modern Physics, vol. 29, pp. 452-453), which contained the first published mention of the theorem (since elaborated by others) that under certain conditions spacetime must contain a closed time-like line.

Dr. Robert W. Bass holds a model of the inside surface of the unique "magnetic bottle" Topolotron of which he is the principal inventor. The abstract mathematics of celestial mechanics and solar system stability, which Bass also researches, is almost identical to the theory underlying the design of "magnetic bottles" for the peaceful utilization of the power of the hydrogen bomb. Successful controlled fusion power would eliminate the crises of energy, pollution, and overpopulation. BYU has filed patent applications on the Topolotron in the USA and nineteen foreign countries.

Bass Researches Plasma Physics, Celestial Mechanics, and Gravitational Astrophysics

In addition to his main research work as Chief Technical Consultant to the BYU Fusion Power Steering Committee, Robert W. Bass has recently published and is preparing for publication several new results on the dynamic stability of planetary motions, and on the fundamental nature of gravity, such as whether or not the Cavendish gravitational "constant" G is really a constant of nature, or whether it may increase or decrease as time increases.

Bass's "Principle of Least Mean Absolute Potential Energy" (1958), a variant of which was independently discovered in 1970 by M. Ovenden, gives a dynamic explanation of the relative mean distances of the planets, a problem that has intrigued astronomers since the days of Kepler. Titius and Bode pointed out that, after a constant displacement is subtracted, each planet is about twice as far from the Sun as its predecessor. Bass's theory enables a more accurate prediction, utilizing only the values of the planetary masses, their order from the Sun, and the total energy and total angular momentum.

Mach's Principle implies that G is not a constant but is determined by the distribution of matter in the universe. Jordan, Brans, and Dicke have tried to incorporate this in Einstein's theory of gravitation (General Relativity), by including an additional wave equation whose source is the mass density and whose solution is the reciprocal of G. There is in the JBD theory an undetermined dimensionless coupling constant ω, $-(3/2) < \omega < +\infty$, which allows G to decrease slowly as time increases. Bass has shown that by taking $-\infty < \omega < -2$, which means that G increases with time, the latest and allegedly most precise versions of all four solar system experiments on "parameterized post-Newtonian" metric gravitational theories, as well as the latest cosmological data of Sandage and Gunn, can be fit better (i.e., within fewer standard deviations) by taking $\omega = -35$, than by either General Relativity or the original form of the JBD theory.