Gravitation Essay

APPENDIX 3B

COMPLETE GRAVITATIONAL COLLAPSE IS IMPOSSIBLE: BLACK HOLES DO NOT EXIST

by

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ABSTRACT

A quantitative elaboration of powerful anti-black-hole arguments previously presented by Einstein, Rosen, and Hoyle shows that when Mach's Principle is taken into account (via a modified Jordan-Brans-Dicke type of scalar-tensor formalism), in the manner unambiguously required by the experimental evidence that the Eddington-Robertson parameter $\gamma > 1$, the Laplace-Schwarzschild radius defines a barrier impenetrable by mass particles [in fact, gravitational attraction reverses polarity and becomes infinitely repulsive there] and so complete gravitational collapse is impossible.

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May 2, 1975

ERRATA AND CORRIGENDA

1. Exhibit A

   a. Page 2, bottom line: strike out first factor 2.

   b. Page 8, line 8: insert [Our Maximum Likelihood estimate is $\gamma = 1.02 \pm 0.01$.]

   c. Page 14, next to bottom line: version[22].

2. Appendix 1

   a. Abstract, line 7: replace "weakens" by "changes" and ± 0.06 by ± 0.01; in next line replace 60% by 95%.

   b. Page 3: delete factors (1/N) from (6) and (7),

   c. Page 4, equation (8): replace $\pm 0.20 > 1.01$ by $\pm 0.06 > 1.15$; in (10): replace $\pm 0.088 > 0.92$ by $\pm 0.062 > 0.95$.

   d. Page 5, equation (11): replace $\pm 0.059 > 0.96$ by $\pm 0.018 > 1.004$; equation (12): replace $\pm 0.029 > 0.98$ by $\pm 0.011 > 0.99$; equation (13): replace $\pm 0.06 > 0.96$ by $\pm 0.01 > 1.01$; two lines below (13) replace 60% by 95%.

   e. Page 8: replace $\pm 0.20 > 1.01$ by $\pm 0.06 > 1.15$.

   f. Page 10: replace $\pm 0.088 > 0.92$ by $\pm 0.062 > 0.95$.

   g. Page 11: replace $\pm 0.059 > 0.96$ by $\pm 0.018 > 1.004$.

   h. Page 12: replace last column by 0.06, 0.015, 0.062, 0.018 and replace $\pm 0.029 > 0.98$ by $\pm 0.011 > 0.99$.

   i. Page 14: replace ± 0.055 by $\pm 0.011 > 1.006$.

3. Appendix 3A

   a. Page 2, equation (7): insert minus sign before right-hand side.

4. Appendix 3B

   a. Insert reference 11:

      A. Einstein, "Stationary systems with spherical symmetry consisting of many gravitating masses," Annals of Mathematics, Ser. 2, vol. 40 (1939), pp. 922-936.

As documented elsewhere, abundant geophysical, astrophysical ($\gamma > 1$), and cosmological ($q < \frac{1}{2}$) evidence necessitates, with 95% probability, that standard General Relativity (GR) must be modified, in a manner similar to, but in essence exactly opposite, to the Jordan-Brans-Dicke (JBD) theory, to include a variable Cavendish parameter G satisfying the two postulates

(1a) $(\delta G/G) > 0$, (1b) $(\dot{G}/G) > 0$.

Here (1a) means that the value of G measured by two test-particles increases as the test-particles approach a ponderable mass, e.g., the Sun; a critical test onboard the Helios satellite (perihelion 1/3 AU, aphelion 1 AU) would be

(2)
$$\frac{G_{per}}{G_{aph}} = \begin{cases} 1 + 0.9 \times 10^{-9}, & \text{present theory;} \\ 1 \qquad , & \text{GR;} \\ 1 - 1.3 \times 10^{-9}, & \text{JBD.} \end{cases}$$

Similarly, (1b) means that G increases as cosmic time t increases, e.g., there is a Milne-type relation

(3)
$$G \quad \alpha \quad c^3 t/M$$

where M denotes essentially the rest-mass of the visible universe.

The object of the present article is to demonstrate that, in the present theory, Mach's Principle requires that gravitational attraction must reverse polarity and become unbounded centrifugal repulsion just outside the Laplace-Schwarzschild radius.

This result could have been anticipated from standard GR. In fact, neither Einstein, nor his 1935 collaborator, Rosen, believed in the possibility of so-called black holes. Many examples in physics and engineering are known wherein an equation valid in certain regimes has acceptable mathematical solutions that are physically meaningless: witness the common occurrence of quadratic equations of which one root is physically meaningful and the other root is irrelevant. In 1969 fully aware of such interesting modern mathematical developments as the

Kruskal diagram, Rosen published several powerful arguments that the Laplace-Schwarzschild radius r_{LS} represents a real physical singularity. (The usual statements that $R_{\lambda\mu\nu\sigma}$ is well-behaved near r_{LS}, and that particle and photon trajectories are regular at r_{LS}, are irrelevant because they involve merely local considerations, whereas what goes wrong at r_{LS} is global in nature and cannot be discovered from strictly local investigations). In particular, Rosen showed that curves $r = \text{constant} < r_{LS}$ are both time-like and space-like, hence non-physical.

It should also be noted that in the 1972 Henry Norris Russell Lecture, before the American Astronomical Society, Sir Fred Hoyle reiterated his known skepticism about the physical reality of black holes as follows: "Recently the words 'black hole' have become an astronomical cliché. But is the conventional picture of a black hole at all correct? It seems to me that this classical picture is likely to be just as inapposite as was the classical picture of individual atoms in the first decade of the present century. ... We argue today that an aggregate of matter with dimensions close to the Schwarzschild radius will radiate, either gravitationally or electromagnetically, and will eventually collapse into a black hole. Former experience should warn us against this much too classical concept. The difficulty with attempts to formulate a quantum theory of large aggregates has hitherto been, however, that so long as the masses of particles are fixed and autonomous to themselves [i.e., so long as Mach's Principle is ignored] the situation remains classical. This stranglehold on the problem is broken, at any rate in principle, when masses are taken to arise from the interactions of particles." [Italics added.]

In his concluding sentence, Sir Fred is obviously alluding to Mach's Principle. Since the present theory involves a new version of Mach's Principle, the present article may be regarded as a quantitative elaboration upon Hoyle's argument.

Likewise, Rosen's second argument against black holes involves the limiting relation between GR and scalar-tensor theories. In the usual JBD theory, GR is recovered as the dimensionless coupling coefficient $\omega \to +\infty$. In the present theory, however (as demanded by the experimental indications that $\gamma > 1$) we shall assume that

(4) $$-\infty < \omega < -2 < 0$$

and shall investigate the relationship between this theory and GR as $\omega \to -\infty$. In this (modified) sense, the present paper may also be regarded as a quantitative elaboration upon Rosen's second argument.

In the present theory, $\mathcal{G}$ denotes the value of G that would be present near a star's location if the star were absent. Then the (PPN) measured value of G would be

(5) $$\hat{G} = \left(\frac{2|\omega| - 4}{2|\omega| - 3}\right) G$$

where the true G in the field equations would be

(6) $$G = \mathcal{G}\,\frac{(1 + \beta/r)^{\delta}}{(1 - \alpha/r)^{\gamma}} =$$

$$= \mathcal{G}(1 + \frac{\varepsilon}{r} + \cdot\cdot\cdot)\ ,\ (r \to +\infty)\ .$$

[Recall that here α, β, γ, δ are not the PPN parameters.] In the notation of our prior article, and of Weinberg (1972), we may consider the geodesic equation of a material particle in terms of the test-particle's proper-time τ,

(7) $$d\tau^2 = B^2(r)\ dt^2\ ,$$

in which case, as usual

(8) $$r^2\,\frac{d\phi}{d\tau} = J\ ,$$

(9) $$\left(\frac{dr}{d\tau}\right)^2 = -\frac{1}{A(r)} + \frac{1}{A(r)B(r)} - \frac{J^2}{r^2 A(r)}\ .$$

Hence if $\mu > 0$ is the mass of the test-particle, (8)-(9) imply that

(10) $$\tfrac{1}{2}\mu\left\{\left(\frac{dr}{d\tau}\right)^2 + r^2\left(\frac{d\phi}{d\tau}\right)^2\right\} + V(r) \equiv \text{constant } (=0),$$

where

(11) $$V = \mu\phi$$

and

(12) $$2\phi \overset{d}{=} \frac{1}{A(r)} - \frac{1}{A(r)B(r)} + \frac{J^2}{r^2}\left(\frac{1}{A(r)} - 1\right) .$$

From (12) it is clear that ϕ is the potential of a radial force field generalizing the Newtonian potential, which can be verified explicitly as follows. If we let

(13) $$|\omega| \to +\infty ,$$

then

(14) $$B \to 1 - \frac{2GM}{r}, \quad (r \geqq 2GM = r_{LS}) ,$$

(15) $$A \to 1 + \frac{1}{(1 - \frac{2GM}{r})} \cdot \left(\frac{2GM}{r}\right) \equiv (1 - \frac{2GM}{r})^{-1} ,$$

so that

(16) $$AB \to 1$$

and (12) becomes, as expected

(17) $$2\phi \to \phi_\infty \overset{d}{=} -\frac{2GM}{r} - \frac{2GMJ^2}{r^3} .$$

Hence, <u>the radial acceleration of a test particle is, as</u> $|\omega| \to +\infty$,

(18) $$-\phi'_\infty = -\frac{GM}{r^2} - \frac{3GMJ^2}{r^3} .$$

where the second term in (18) is the well-known GR correction to Newtonian gravity which produces, e.g., the anomalous precession of the perihelion of Mercury. Hence <u>the present theory agrees perfectly in the limit with GR as</u> $|\omega| \to +\infty$. (Note that in this limit it is <u>not</u> G but the <u>constant</u> G which appears; hence our later result that

(19) $$G \to +\infty \text{ as } r \to (r_{LS} + 0)$$

does not imply a discrepancy with GR as some casual readers of a prior draft of this paper have claimed.)

However, between GR and the present theory there is a startling difference [which seemingly could not have been foreseen from (19)] in that for any finite value of $|\omega|$, no matter how large, in proper time the centrifugal acceleration of a test particle [i.e., the gravitational REPULSION (!)] becomes infinite as $r \to (\tilde{r}_{LS} + 0)$ $(\approx r_{LS} + 0)$. In fact, from (12)

(20) $$2\phi = \left(1 + \frac{J^2}{r^2}\right)\left\{\frac{(1+\beta/r)^{2[\delta(|\omega|-1)+1]}(1-\alpha/r)^{2[1-\gamma(|\omega|-1)]}}{(1+\eta/r)^2}\right\} + $$

$$- \frac{J^2}{r^2} - \frac{(1+\beta/r)^{2[\delta(2|\omega|-3)+2]}(1-\alpha/r)^{2[1-\gamma(2|\omega|-3)]}}{(1+\eta/r)^2} ,$$

so that the radial acceleration becomes

(21) $$-\phi' = [1-\gamma(2|\omega|-3)]\left(\frac{\alpha}{r^2}\right)\frac{(1+\beta/r)^{2[\delta(2|\omega|-3)+2]}}{(1+\eta/r)^2(1-\alpha/r)^{1-2[1-\gamma(2|\omega|-3)]}} +$$

$$- [1-\gamma(|\omega|-1)]\left(\frac{\alpha}{r^2}\right)\left(1+\frac{J^2}{r^2}\right)\left\{\frac{(1+\beta/r)^{2[\delta(|\omega|-1)+1]}(1-\alpha/r)^{1-2\gamma(|\omega|-1)}}{(1+\eta/r)^2}\right\} +$$

$$+ \frac{J^2}{r^3}\left\{\frac{(1+\beta/r)^{2[\delta(|\omega|-1)+1]}(1-\alpha/r)^{2[1-\gamma(|\omega|-1)]}}{(1+\eta/r)^2} - 1\right\} .$$

Note that, for large $|\omega|$,

(22a) $$1 - \gamma(|\omega| - 1) \to 1 - \left(\frac{|\omega| - 1}{2|\omega| - 2}\right) = \tfrac{1}{2} > 0 ,$$

(22b) $$1 - \gamma(2|\omega| - 3) \to \frac{1}{(2|\omega| - 2)} > 0 \quad ,$$

whence, also

(22c) $$1 - 2\,[1 - \gamma(2|\omega| - 3)] \to 1 - \frac{2}{(2|\omega| - 2)} =$$

$$= 1 - \left(\frac{1}{|\omega| - 1}\right) = \left(\frac{|\omega| - 2}{|\omega| - 1}\right) > 0 \quad , \; (|\omega| > 2) \quad ,$$

while

(23) $$1 - 2\gamma(|\omega| - 1) \to 1 - \frac{2(|\omega| - 1)}{(2|\omega| - 2)\left\{1 + \frac{4\tau}{(2|\omega| - 2)^2}\right\}^{\frac{1}{2}}} =$$

$$= 1 - \frac{1}{[1 + \{(3|\omega| - 4)/(2|\omega| - 2)^2\}^2]^{\frac{1}{2}}} \to$$

$$\to 1 - \frac{1}{(1 + 3/4|\omega|)^{\frac{1}{2}}} > 0 \quad .$$

Since, furthermore,

(24) $$\beta << \alpha \; , \quad \eta << \alpha \quad (|\omega| >> 2) \; ,$$

we may legitimately write (21), in the case J = 0, as (for large $|\omega|$)

(25) $$-\phi' = -\frac{GM}{r^2}\left(1 - \frac{\tilde{r}_{LS}}{r}\right)^{1 - (1 + 3/4|\omega|)^{-\frac{1}{2}}} +$$

$$+ \frac{1}{(|\omega| - 1)}\frac{GM}{r^2} \cdot \frac{1}{\left(1 - \frac{\tilde{r}_{LS}}{r}\right)^{1 - (|\omega| - 1)^{-1}}} + \cdots$$

$$= -\frac{GM}{r^2}\left\{\left(1 - \frac{\tilde{r}_{LS}}{r}\right)^{1 - (1 + 3/4|\omega|)^{-\frac{1}{2}}} - \frac{1}{(|\omega| - 1)\left(1 - \frac{\tilde{r}_{LS}}{r}\right)^{1 - (|\omega| - 1)^{-1}}}\right\} .$$

Hence the <u>radial gravitational force is attractive, zero, or repulsive according</u>

as

$$(26)\quad \left(1 - \frac{\tilde{r}_{LS}}{r}\right)^{2 - (1 + 3/4|\omega|)^{-\frac{1}{2}} - (|\omega| - 1)^{-1}} \begin{Bmatrix} \geq \\ = \\ < \end{Bmatrix} \frac{1}{(|\omega| - 1)}$$

i.e., according as (for large $|\omega|$)

$$(27)\quad \left(1 - \frac{\tilde{r}_{LS}}{r}\right)^{1 - 5/8|\omega|} \begin{Bmatrix} \geq \\ = \\ < \end{Bmatrix} \frac{1}{(|\omega| - 1)}$$

i.e., as

$$(28)\quad r \begin{Bmatrix} \geq \\ = \\ < \end{Bmatrix} \tilde{\tilde{r}}_{LS} \stackrel{d}{=} \frac{\tilde{r}_{LS}}{\left[1 - \dfrac{1}{(|\omega| - 1)^{1 + 5/8|\omega|}}\right]} > \tilde{r}_{LS} \quad .$$

Also

$$(29)\qquad - \phi' \rightarrow + \infty \quad \text{as} \quad \tilde{\tilde{r}}_{LS} > r \rightarrow (\tilde{r}_{LS} + 0) \ ,$$

despite the fact that

$$(30)\qquad G \rightarrow + \infty \quad \text{as} \quad \tilde{\tilde{r}}_{LS} > r \rightarrow (\tilde{r}_{LS} + 0) \ ;$$

that is, the gravitational interaction changes from attractive to repulsive near and just outside the Laplace-Schwarzschild radius $\tilde{r}_{LS}$, and actually becomes infinitely repulsive as that radius is approached externally!

Hence no particle of mass $\mu << M$ can penetrate the Laplace-Schwarzschild horizon of a mass M, for $|\omega|$ sufficiently large.

Evidently the physical significance of this rigorous mathematical result is that complete gravitational collapse is impossible when Mach's Principle is taken into account in the manner required by the experimental evidence that the Eddington-Robertson parameter $\gamma > 1$.

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