On gravitational collapse

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Abstract: Gravitational collapse of diffuse material has been investigated using a new solution of Einstein's equations of general relativity. This replaces the theory of black-hole formation developed for the standard vacuum solution of Schwarzschild. The bodies which now form have reasonable physical properties, such as nuclear hard core density in collapsed stars, or 10^4kg/l in galactic centres, and only 1kg/l in quasars. Accreting material converts to kinetic energy and radiation, so that a singularity cannot be produced.

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1. Introduction

A recent paper has revealed that the observed precession of planet Mercury's orbit is no longer compatible with standard General Relativity theory, [1]. That is, the orthodox vacuum solution with its concomitant space-time curvature interpretation may not be physically meaningful. Consequently, black-holes cannot exist, so the end state of stellar evolution theory now needs to be reconsidered in the light of another solution of Einstein's Equations.

Some years ago [2], Paper 1, it was shown how Einstein's equations could be interpreted in straight-forward physical terms by explicit introduction of gravitational field energy as gravitons, analogous to the electromagnetic field. These gravitons of the field produce the gravitational force by direct interactions, all conducted in flat space-time. Metric tensor components then describe the variation in dimensions and time-rate or energy of particles in a field, not so-called continuum curvature. Agreement with the ideas found in Special Relativity theory and accelerated frames is thereby guaranteed, and gravity is no longer detached from other forces. The old problem of justifying the equality of space-time manifold curvature $R_{\mu\nu}$ and physical matter $T_{\mu\nu}$ is rendered obsolete. Consequently, mass particles and their field gravitons are expressions of the same material, (energy), existing in empty flat space-time.

2. Building a massive body from diffuse matter.

In Paper 1, Einstein's equations were solved for the exterior solution of the spherically-symmetric static field of energetic gravitons in polar coordinates. The line element was then found to be:

$$ds^2 = -\frac{dr^2}{(1 - GM/c^2 r)^2} - r^2 d\theta^2 - r^2 \sin^2\theta d\varphi^2 + \left(1 - \frac{GM}{c^2 r}\right)^2 dt^2 \quad . \tag{1}$$

Logically, it was argued that the gravitational field induces mass particles to fall by converting their own mass (potential energy) into kinetic energy. Upon impact, the particle KE is radiated away, leaving the particle with reduced rest mass:

$$m_r = m_o(1 - GM/c^2 r) \quad . \tag{2}$$

We can calculate how much free diffuse matter is required to build a body mass M up to its ultimate gravitational radius ($R_0 = GM_0/c^2$). If the final density is to be nuclear hard-core density ρ_n throughout, then let $M = (4/3)\pi\rho_n r^3$. And for an originally diffuse mass element dm, only:

$$dM = dm(1 - GM/c^2 r) \quad , \tag{3}$$

is added to M. Upon eliminating *r*, this may be integrated to find the total amount of diffuse mass required to build a body of mass M:

$$M_T = \int dm = \int_0^M \frac{dM}{[1-(M/M_0)^{2/3}]} \underset{M \to M_0}{\longrightarrow} \infty \quad . \tag{4}$$

Thus, it is impossible to build a body up to its gravitational radius because infalling matter is increasingly less effective at adding mass. Figure 1 illustrates the amount of diffuse matter necessary to build the body up to any particular mass M.

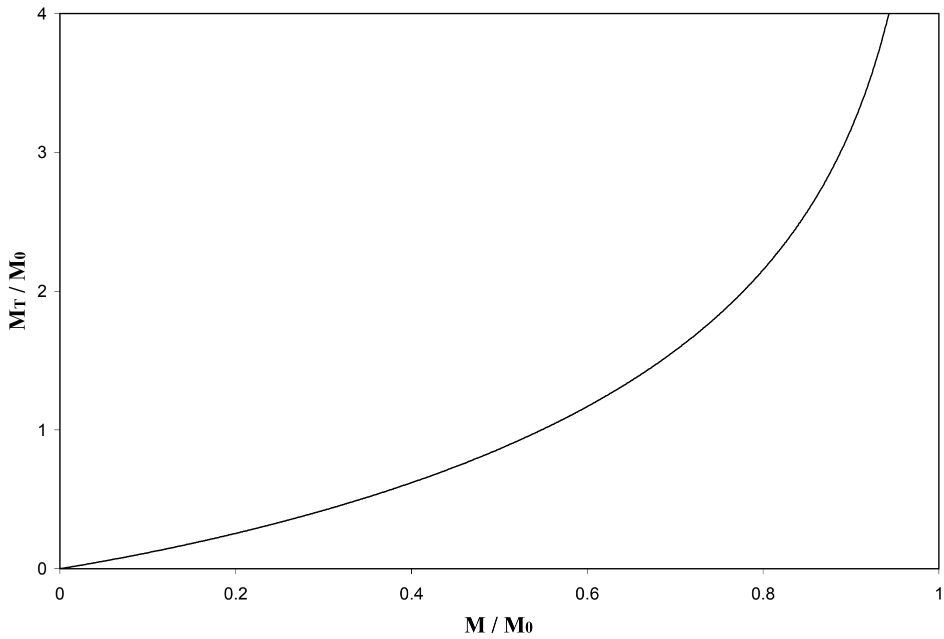

Figure 1 The total diffuse mass M_T necessary to build a body from zero to mass M, relative to the maximum possible body mass M_0 .

If during the building process the core material should collapse to a denser state, the mass to kinetic energy to radiation conversion will continue further and still prevent a singular surface from forming. This means that it is *impossible* to build the black-holes peculiar to the Schwarzschild solution. More energy is actually liberated by this process of accretion than that predicted by the Schwarzschild solution. Furthermore, in this theory, energetic γ-rays may be produced by total conversion of infalling matter, and these will subsequently leave the gravitational field *without* loss of energy.

The bulk density of collapsed bodies must vary greatly, from that of quasars, galactic centres, through white dwarfs, neutron stars, and quark stars. For bodies approaching their gravitational radius, their instantaneous masses may be related to their mean densities ρ_o by applying an approximate classical calculation, as follows. Let :

$$R \approx GM/c^2, \text{ and } M = (4/3)\,\pi\rho_o R^3, \quad (5)$$

then:

$$M \approx c^3\left[G^3(4/3)\pi\rho_o\right]^{-1/2}. \quad (6)$$

Thus, body mass must *decrease* with increasing density because infalling matter converts to free radiation more and more as it compacts. It follows that a body of large mass with relatively low density must be supported by radiation pressure at high temperature. As it burns-away, its mass will decrease and density increase. Collapse will only cease when the core material gas pressure is able to resist self-gravity, see Figure 2. A final body of nuclear density has a mass around $1.1M_\Theta$, while another of quark density (say 10^{22}kg/l) has four times Jupiter's mass. Consequently, collapsing bodies can act like photon factories, unless they collapse violently and blast their material into space.

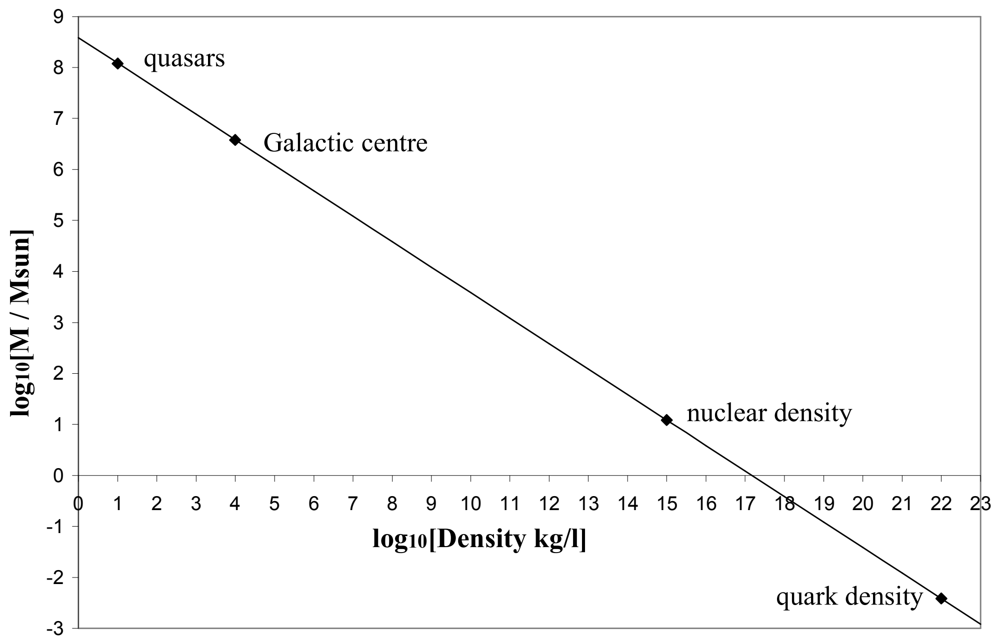

Figure 2 Variation of body mass (in Solar mass units) with density, for bodies near to their gravitational radius.

3. Interior properties of a massive body

The interior properties of a collapsed body, near to its gravitational radius, may be calculated using the new solution of Einstein's equations, (see Paper 1, Section 16). For example, a dense body of mass $3.6\times10^6 M_\Theta$ but low luminosity has been predicted at the centre of our galaxy, see [3-5]. It could be named a 'black-corps', which may be near to its gravitational radius ($R \approx GM/c^2 \approx 5.3 \times 10^6$km), with average density around 1.1×10^4 kg/l. This density is very high and implies that the material would behave like a fluid in hydrostatic equilibrium. It is commonly believed that quasars contain black-holes of up to $10^8 M_\Theta$, but these would be black-corps with lesser density around 10 kg/l.

The line element for the interior of a spherically-symmetric static body consisting of a "perfect fluid" will be expressed in isotropic form as:

$$ds^2 = -e^{\mu}\left(dr^2 + r^2 d\theta^2 + r^2 \sin^2\theta d\varphi^2\right) + e^{\nu} dt^2 \quad . \qquad (7)$$

For the energy-momentum tensor components we shall take the mechanical *local* hydrostatic pressure p_o and constant *local* mass density ρ_{oo}:

$$T_0^{11} = T_0^{22} = T_0^{33} = p_o \quad \text{and,} \quad T_0^{44} = \rho_{oo} \quad . \qquad (8)$$

Solution of Einstein's equations then yields the spatial metric tensor component:

$$e^{-\mu/2} = (1 + kr^2/4), \quad \text{for} \quad k = 8\pi\rho_{oo}/3 \quad , \qquad (9)$$

and temporal metric tensor component:

$$e^{\nu/2} = \left[\frac{3e^{\mu_m/2} - 1 - e^{\mu/2}}{3e^{\mu_m/2} - 2}\right] \quad , \qquad (10)$$

where $e^{\mu_m/2}$ pertains to the maximum radius r_m at the surface. Both these equations automatically designate the centre of the fluid sphere as the coordinate reference frame of special relativity. We see that on going from the surface towards the centre of the body, a material element is compressed isotropically according to Eq.(9), and slows down internally according to Eq.(10), due to loss of potential energy (mass). The local (pressure/density) ratio increases, on going from the surface inwards:

$$\frac{p_o}{\rho_{oo}} = \left[\frac{e^{\mu/2} - e^{\mu_m/2}}{3e^{\mu_m/2} - 1 - e^{\mu/2}} \right] \quad . \tag{11}$$

Figure 3 illustrates the variation of central pressure of a body (where $e^{\mu/2} = 1$), in terms of its actual size r_m relative to its theoretical gravitational radius R_0 .

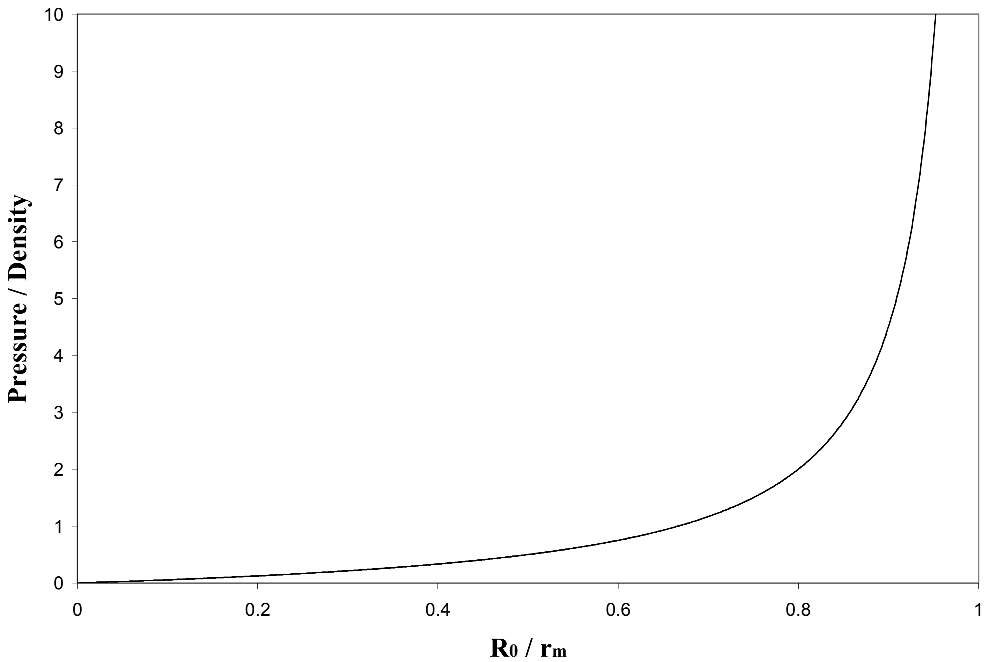

Figure 3 Pressure / density ratio at the centre of a massive body in hydrostatic equilibrium. A body of mass M and maximum radius r_m has a theoretical gravitational radius $R_0 = GM / c^2$.

These results are interesting because the body material behaves sensibly, even if an *exterior* observer would lose sight of the ultimate black-corps. In the most extreme case, the time-rate at the surface may approach infinity relative to the centre time-rate, if according to Eq.(10) we have:

$$3e^{\mu_m/2} - 2 = 0 \quad . \tag{12}$$

After introducing Eq.(9) and practical units, this means:

$$\left(\frac{G}{c^2} \right) \frac{4\pi}{3} \rho_{oo} r_m{}^2 = 1 \quad , \tag{13}$$

so a test particle would lose all its mass on falling from the surface to the centre. This equation is compatible with Eq.(5) although ρ_{oo} is the locally measured density, which corresponds with a *reduced* coordinate (real) density. Confirmation of this comes from considering the particle energy which decreases with $e^{\nu/2}$ towards zero relative to the surface, whereas particle size can only decrease with $e^{-\mu/2}$ by a factor of 3/2.

According to Eq.(11) the local pressure experienced by particles increases inwards and could cause them to rupture then collapse suddenly to a denser state. The release of radiation energy would probably cause some outer material to be blown away, while inner material would be compressed by the explosion, as predicted in a super-nova event.

4. Conclusion

The new solution of Einstein’s equations has been employed to describe how gravitational collapse of diffuse material may produce very dense bodies of low luminosity. Mass converts to kinetic energy during the contraction, and is lost from the system as radiation upon impact with the stationary core. Black holes cannot exist so, at last after 75 years of wasted labour, the "stellar buffoonery" ridiculed by Eddington and Einstein has been hurled into the abyss for "hideous fantasies"; freeing the lives of bright physicists to pursue inspired praiseworthy research, increasing true knowledge.

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