Stellar Collapse*

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The phenomenon of stellar collapse is considered from the viewpoint of the neo-Newtonian ballistic theory of light. The restrictions of the special theory of relativity are thus removed. The theory predicts that a collapsing star will expand again, and continue to alternately expand and collapse at a rate depending on the mass and greatest radius of the star. On each cycle material will be lost, including photons which appear to distant observers as the emissions of a pulsar. It is concluded that pulsars are oscillating stars, that these eventually "evaporate"away completely, and that there is no such object as a black hole.

I. Introduction

Some years ago I posed the question whether black holes exist (Waldron 1983a). My conclusion at that time was that they do not, because the vast amount of gravitational energy liberated as a burnt-out star collapses would cause the body to explode before it contracted to the Schwarzschild limit. I sent my paper to a number of leading cosmologists, many of whom were kind enough to reply to me. Mostly, their replies were little to the point, but one or two made replies which led me to think further on the question. It is these further thoughts which are presented in the present paper.

Black holes are thought to exist because, it is said, a star collapses until all its matter is contained within the Schwarzschild radius, and then no matter, no energy, can escape because the velocity of escape from the Schwarzschild radius is the velocity of light, c, and nothing can travel faster than c according to the special theory of relativity (STR), which is a development of the wave theory of light.

However, a considerable number of scientists do not accept STR, and there has been a large amount of effort applied to seeking alternative explanations of the phenomena of modern physics. If STR is rejected, then it is likely that the wave theory of light must also be rejected, and we are then forced to develop the ballistic theory of light. Over several decades the ballistic theory has proved very successful in explaining many experimental facts in optics, electromagnetism, gravitation, and cosmology, though some questions remain unanswered in terms of this theory. This does not mean that the theory has failed in these cases, but that there has not yet been time to investigate them. One such question, to be discussed below, is what happens to a collapsed star after it collapses. The study leads to a new view of the nature of a pulsar and to the conclusion that black holes indeed do not exist.

II. The Ballistic Theory

Before embarking on the study of collapsing stars it will be helpful to give a brief outline of the fundamental principles of the ballistic theory. The attempt has been made to develop a theory from classical principles without using Einstein's invariance postulate, which is rejected because it is incompatible with the principle of relativity. Thus Newton's three laws of motion are taken as a foundation and are regarded as inviolable. The whole edifice of classical mechanics and statistical mechanics is erected on them, and survives unchanged in the ballistic theory. But the forces which operate within that framework are modified. Coulomb's law is replaced by a law which includes a factor containing the relative velocity of the two interacting charges (Waldron 1981a, 1984); when this relative velocity falls to zero, the force law reduces to Coulomb's law. It is worth remarking here that Coulomb's law was based on experimental observations on charges *at rest* in the laboratory, so this new law does not contradict Coulomb; it goes into a region about which Coulomb was silent, and agrees in the circumstances Coulomb's law was designed to fit. An analogous modification is made to Newton's law of gravitation (Waldron 1984, 1989). No reason is offered as to why the force laws should take the forms they do; they have been arrived at simply by requiring that they lead to correct calculations of experimental results. This is, after all, the way in which Coulomb's law and Newton's law were arrived at.

A model of the photon (Waldron 1983b) is developed according to which a photon is a material particle which is ejected from its source with velocity c with respect to that source. After ejection it moves in straight lines and interacts with other matter in accordance with Newtonian mechanics. It has mass, and though overall electrically neutral, it contains equal amounts of positively and negatively charged matter which give it a dipole moment. The photon rotates, and the varying orientation of the dipole enables a phase to be associated with it, accounting for the wave-like properties of light and other electromagnetic radiation.

The cosmological redshift cannot be explained by Doppler shift according to the ballistic theory, so an explanation is sought on the basis of an unstable photon. This leads to a picture of a stable, non-expanding universe, without beginning or end. Hubble's constant then appears as related not to the rate of expansion of the universe but to the decay rate of the photon (Waldron 1981b, 1985).

III. Stellar Collapse

When the last bit of nuclear fuel burns out in a star, there is nothing to sustain it against its gravitational self-attraction and it collapses. Let us first study the collapsing process within the framework of the ballistic theory; some discussion will be developed and conclusions drawn in the next section.

We assume that at time $t = 0$, when the last sustaining nuclear reaction is completed and the star is just on the point of collapse, the density of material in the star is $\mathbf{r}(r, t)$, *i.e.*, $\mathbf{r}$ is a function of radius r and time t, being spherically symmetrical and zero for $r > r_0$. Then an element dr_2 at radius r_2 has mass $4\mathbf{p}\mathbf{r}(r_2)\ r_2^2\ dr_2 = dm_2$, and an element dr_1 at radius r_1 has mass $4\mathbf{p}\mathbf{r}(r_1)\ r_1^2\ dr_1 = dm_1$, where $r_1 < r_2$. For its attractive force on bodies outside itself, the shell at r_1 can be replaced by a point mass at $r = 0$. Thus the attractive force of the element dm_1 on the element dm_2 is

$$dF_2 = -G dm_1 \frac{dm_2}{r_2^2},$$

i.e.,

$$dF_2 = G_0 16\mathbf{p}^2 r_1^2 \mathbf{r}(r_1)\, \mathbf{r}(r_2)\, dr_1 dr_2$$

The total force on dm_2 due to the whole of the material within the shell r_2 is

$$F_2 = -16\mathbf{p}^2 G \mathbf{r}(r_2)\, dr_2 \int_0^{r_2} \mathbf{r}(r_1)\, r_1^2 dr_1$$

This force causes an acceleration given by

$$F_2 - dm_2 r_2''$$

Hence

$$r_2'' = \frac{-4p\,G}{r_2^2}\int_0^{r_2} r\,(r_1)\,r_1^2\,dr \tag{1}$$

Further progress requires some estimate of the function r(r1). For an accurate treatment this should be something like reality, but to discover the gross features of the collapse a considerable error is tolerable and so, for simplicity, $r(r)$ will be taken as constant with r. So we put $r\,(r_1)$ equal to $r(t)$ in eqn. (1) and integrate. Hence

$$r_2'' = -\frac{4p}{3} G\,r\,r_2 \tag{2}$$

If m_2 is the total mass within radius r_2, then $r = 3m_2/4pr_2^3$ and eqn (2) becomes

$$r_2^2 r_2'' = -Gm_2 \tag{3}$$

The solution of eqn (3) is

$$t = \sqrt{\frac{r_{2o}^3}{2GM_2}}\left(\tan^{-1}\sqrt{\frac{r_{2o}}{r_2} - 1} + \sqrt{\frac{r_{2o}}{r_2} - \frac{r_2^2}{r_{2o}^2}}\right) \tag{4}$$

where r_{2o} is the value of r_2 when the star is at it fullest extension, at $t = 0$.

Now write R for the total radius of the star, and R for the value of R at $t = 0$, and write $R_S = 2GM/c^2$ for the Schwarzschild radius, where $M = m(r_2)$ is the total mass of the star when $r_2 = R$. Eqn (4) can then be written

$$t = \sqrt{\frac{R_0^3}{R_2 c^2}}\left(\frac{R}{R_0}\sqrt{\frac{R_0}{R} - 1} + \tan^{-1}\sqrt{\frac{R_0}{R} - 1}\right) \tag{5}$$

where t is the time taken for the surface of the star to collapse from radius R_0 to R. It will collapse to the Schwarzschild radius in a time t_0 given by writing R_S for R. If we denote R_0/R_S by n, and express the mass M as m times the sun's mass, eqn (5) yields

$$t_0 = 9.854\times10^{-4}\, m\sqrt{n}\left(\sqrt{n-1} + n\tan^{-1}\sqrt{n-1}\right)\text{ seconds} \tag{6}$$

For sufficiently large m, this can be written

$$t_0 = 9.854\times10^{-6}\times\frac{p}{2}\, m n^{3/2}\text{ seconds} \tag{7}$$

In view of the approximations already made, the difference between the values given by eqns (6) and (7) can be ignored. Some typical values of t_0 are given in Table I.

A first integration of eqn (3) gives

$$r_2' = -\sqrt{\frac{2Gm_2}{r_{2o}}\left(\frac{r_{2o}}{r_2} - 1\right)}$$

whence

$$R' = -c\sqrt{\frac{R_S}{R_0}\left(\frac{R_0}{R} - 1\right)} \tag{8}$$

So the speed of the surface of the star, when it reaches the Schwarzschild radius ($R = R_S$), is

$$R' = -c\sqrt{1 - \frac{1}{n}} \tag{9}$$

Having reached $R = R_S$, the further time required for the radius to fall to zero, supposing this were possible and that the speed given by eqn (9) were maintained, is

$$\left|\frac{R_S}{R}\right| = \frac{2GM}{c^3\sqrt{1-\frac{1}{n}}} = \frac{m\times 9.854\times 10^{-6}}{\sqrt{1-\frac{1}{n}}} \text{ seconds} \tag{10}$$

i.e. about $m\times 10^{-5}$ seconds.

But in fact R could never fall to zero because a point would be reached at which all the particles (neutrons?) of which the star was composed would be so close together as to be virtually in contact, as far as 'contact' has any meaning for elementary particles. If we denote this ultimate minimum radius by R_c, then collapse to within R_S is only possible if $R_S > R_c$. A simple calculation shows that this condition is satisfied for values of m greater than a critical value lying somewhere between about 1 and 10, depending on the value assumed for the radius of a neutron in a mass of close-packed neutrons. (*Values of R_c and m will depend on which subatomic particle is chosen as the constituent of the collapsed star.-Ed.*)

As the star collapses, gravitational potential energy is converted into the kinetic energy of inward motion of the material of the star. A straightforward Newtonian calculation shows that when the star of mass M and initial radius R_0 falls to a radius R, the total kinetic energy acquired is

$$W(R) = 0.3\left(1-\frac{R}{R_o}\right)Mc^2 \tag{11}$$

Knudsen (1950) gives a relation between the R.M.S. velocity V of a gas of particles of molecular weight L, having a Maxwell-Boltzmann velocity distribution, and the temperature q K of the gas:

$$LV^2 = 249.555\times 10^6\, q \tag{12}$$

On this basis, if the energy $W(R)$ were converted into heat, the temperature at radius R would be

$$q = \left(1 - \frac{R}{R_0}\right) 2.16 \times 10^{12}\ \mathrm{K} \tag{13}$$

IV. Discussion

According to orthodox thought, based on the relativity theories of Einstein, a burnt-out star will start to collapse, much as envisaged in this paper. The possibility of collapsing to within the Schwarzschild radius depends on m being greater than about 1.4, and this is in keeping with the result obtained above in section III. So far there is no conflict between the two theories.

But when one asks what happens to the star after it has collapsed within its Schwarzschild radius, orthodox theory is unable to furnish satisfactory answers. It is said that the rate of radiation of energy from the star surface when near the Schwarzschild surface, even at temperatures of the order of 10^{12} K, is so low that the energy of collapse cannot be radiated away in the time t_0 during which collapse is occuring. Thus the radius R of the star reaches the value R_S with a velocity close to c, and keeps on going. Once inside R_S, STR forbids any material or radiation to escape, so it remains locked up in a black hole and cannot be investigated further because no information can leave the black hole. Theoretical speculation either regards black holes as magical objects around which all sorts of weird fantasies are built, or suggests that at $R = 0$ is a singularity and, because R cannot be less than 0, the material of the star reaches $R = 0$ and then disappears into the singularity—even, one writer has suggested, reappearing in another universe!

A different view is possible if STR is abandoned together with the restriction that nothing can escape from within the Schwarzschild radius, and Newtonian principles are adhered to. Firstly, the orthodox conclusion that a collapsing star cannot radiate energy fast enough to dissipate the kinetic energy of collapse depends on the assumption that the radiation is electromagnetic, according to Stefan's law. No allowance is made for turbulence in the star, with the possibility of ejection of ordinary matter.

Such turbulence may arise in various ways. We have assumed in section III that the density r is a function of time only, and that it is the same, at any instant, everywhere in the star. But if r is a function of r_2, it is to be expected that the star will not collapse uniformly, so that turbulence will be generated. When R approaches R_S, the material will be tightly packed and collisions between particles will be much more frequent than when the star is fully expanded. Also, if reasonable values are assumed for the initial angular momentum of an expanded star, simple calculation based on the principle of conservation of angular momentum shows that when collapsed to $R = R_S$ the rate of rotation is such that the velocity of a point in the "equator"at $R = R_S$ will lie in the range from $c/\sqrt{10}$ to $c\sqrt{10}$. When this velocity is composed with the velocity of collapse, bearing in mind that the latter will be modified by the variation of r with r_2, and some random motion (arising from the initial state of the star) is added, it is not to be expected that at $R = R_S$ the star will have the uniform motion of collapse that is commonly supposed.

It may be imagined that as the star collapses, more and more turbulence is generated, until a point is reached when as much matter is moving outwards as inwards. At this point expansion will start, and continue till R becomes approximately equal to the initial value R_0. Also, in the turbulence there will be a distribution of velocities and some material will have a velocity greater than escape velocity. This material will escape, carrying energy with it. The material may be ordinary matter or photons. The remaining matter will expand to nearly R_0, then collapse again, and the cycle will repeat itself.

Table I: Collapse Times for Stars of Mass *m* Times Sun's Mass (Eqn 6)

m	***n***	t_0 (seconds)	
50	10^7	$2.45\times10_7$	
	10^5	2.45×10^4	
	10^3	24.5	
15	1.7×10^6	5.15×10^5	(a)
	10^4	232	
	10^3	7.34	
5	10^5	2.45×10^3	
	10^3	2.45	
	10	0 0024	
1	2.36×10^5	1.774×10^3	(b)
	10^3	0 489	
	10	0 00048	
0.14	2.9×10^4	10.7	(c)
	10^3	0 069	

Values of *m* and *n* as for (a) Betelgeuse, (b) the Sun, (c) Van Maanen's star.

The picture emerges of a spherically symmetrically pulsating object, which on every contraction radiates a burst of material and electromagnetic energy. At large distances from the object, this will produce signals like those attributed to pulsars. The periodic time between pulses will be something less than $2t_0$ since contraction will cease before R reaches R_S. It is clear from eqn (7) or Table I that the periodic time may be anywhere in the range from a few years to a millisecond or less, in keeping with observations. Moreover, on each contraction the star loses matter, and it can be deduced from eqn (7) that the periodic time will increase as the mass falls; this feature too is in keeping with observation.

The orthodox view of a pulsar is that after a star collapses it sheds some matter and energy, and the remainder then becomes a rapidly rotating sphere. The pulses that are observed are accounted for by assuming some kind of irregularity in the sphere, which gives a continuous radiation. As this continuous radiation sweeps round with the irregularity, it is perceived as a pulse by a distant observer, just as a steady beam from a lighthouse is perceived as a flash as it sweeps past the observer. What the irregularity might be is problematical. Such a problem does not arise on the neo-Newtonian ballistic theory.

V. Conclusion

According to the ballistic theory black holes do not exist. When a star exhausts all its store of thermonuclear fuel, it collapses to a very dense state, then expands, and alternately collapses and expands. On each contraction to maximum density it ejects matter and electromagnetic radiation. It is a pulsar. Depending on its mass and maximum radius, the period may be anything from a millisecond or less to a year or more. As it loses mass, the period decreases. Eventually the pulsar will "evaporate"away completely.

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