On Gravity and the Motion of Dark Matter.

It has proved problematic, within General Relativity, to form a general definition of mass. The results of singularity theorems also seem to indicate an incompleteness of General Relativity. A simple model of the effect of the gravitational self binding energy of masses, on both gravitational and inertial mass, is considered. The result is a reduction in gravitational mass for compact objects, consequently it is proposed that General Relativity, or its successor, will ultimately show that singularities cannot form. As another consequence it is found that dark matter can best account for the flat shape of galactic rotation curves, if it is moving continuously towards the galactic centre. It is proposed that dark matter is ejected periodically from galactic centres. These proposals may best be tested by computer simulation, and if found to give a realistic match to observations, they may act as a guide to those attempting a fully formulated theory.

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Introduction

General Relativity predicts singularities in some circumstances. It seems probable that this is due to the theories incompleteness, or of our lack of understanding of it. In either case it is important that efforts are made to remedy this situation. The effect of the self gravitational binding energy on an object’s inertial and gravitational mass is discussed in section 1. Dark matter has been postulated to provide the greater gravitational attraction deemed necessary to account for the flat shape of galactic rotation curves (Zwicky,1933). The presence of dark matter alone, however, does not give a full understanding of the shape of the graphs. It is also necessary to understand the required distribution of the dark matter. In section 2, it is proposed that dark matter is moving continuously towards the galactic centre. It is suggested in section 3 that dark matter is periodically ejected from the galactic centre, a possible connection to cosmic rays is considered.

1. Gravitational and inertial mass

Taking the self gravitational potential energy into account, the total internal energy, of any stationary mass m of radius r, is

$$mc^2 - \frac{Gm^2}{r} \qquad (1)$$

Where m is a simplistic definition of mass, which includes all contributions, from internal kinetic energy, pressure etc.., but not the self binding energy.

Experiments to find any deviation between gravitational and inertial mass have shown no evidence. The most sensitive tests are by searching for the Nordtvedt effect, by lunar laser ranging (Nordtvedt, 2002) and (Williams, 2009). The Strong Equivalence Principle (SEP) of General Relativity has thus been confirmed to a high degree of accuracy. Deviations from unity, of the ratio of gravitational to inertial masses have been limited to 0.0005. The SEP is assumed valid, consequently the effective gravitational (active and passive) and inertial masses stay equal and both reduce to

$$m(1-\frac{Gm}{rc^2}) \qquad (2)$$

Let us consider what would happen for a mass collapsing under its own gravity. If a small amount of mass is added, within a specific radius (to increase the mass by factor $1+\delta$), what effect would this have on the total gravitational attraction towards the centre of the mass, at that radius? It depends only on the total gravitational mass within the radius which changes to

$$(1+\delta)m(1-\frac{G(1+\delta)m}{rc^2}) \qquad (3)$$

Dividing (3) by (2), it can be shown that the ratio is less than one, i.e. a decrease in total gravitational attraction, if

$$\frac{1}{2+\delta} \leq \frac{Gm}{rc^2} \leq 1 \qquad (4)$$

Since δ is small, this means that any additional mass arriving for an object at the Schwarzschild radius, leads to reduction in resultant gravitational mass. Since pressure adds to the mass of an object, according to general relativity, then we find that the gravitational mass of such a collapsing object decreases. Singularity theorems (Senovilla, 2006) show that a singularity must form for an object which collapses to within its Schwarzschild radius - instead (with this proposal) both the inertial and gravitational mass reduce and approach zero as

$$\frac{m}{r} \to \frac{c^2}{G} \qquad \text{the 'critical ratio'.} \qquad (5)$$

When a more complete understanding of General Relativity is achieved, it is expected that singularities will not form, as shown in the simplified argument above.

Equation (2) predicts that the gravitational and inertial mass of the sun would be decreased by about 2 parts in a million. For the earth and moon the factor is lower. It seems unlikely that any solar system experiment would be able to detect this effect (in comparison to inertial and gravitational masses both being unaffected by self binding energy), as both gravitational and inertial masses are changed by the same factor. The reduction due to the self binding energy of heavenly bodies will already have been included in their measured masses.
For a galaxy the reduction in gravitational mass is still small, of the order 1 part in a million. However evidence of the effect comes from the flat shape of galactic rotation curves, as shown below. It is recommended that these proposals be tested by computer simulation.

2. The motion of dark matter

If and when the nature of dark matter is understood, there may remain the outstanding question of why it is distributed in such a way as to give the flat rotation graphs. Some of the curves are exceedingly flat over large radii. The dynamics of galaxies are complicated. The fact that even some galaxies show this behaviour can be regarded as support for formula (2) and for the motion of dark matter, as described below.
It is supposed that dark matter is strongly attracted, at all radii, to the galactic nucleus, but is prevented from reaching arbitrary speed of approach due to a spiralling motion, or a pressure build up.

For dark matter approaching the galactic centre, it could only spiral in at such a rate, so as to give a constant m/r ratio for every value of r. If matter within a given radius approached too fast, the value of m/r ratio would be increased – and the gravitational mass within that radius would be reduced, from (2). Matter would then be attracted less strongly, allowing the m/r ratio to reduce (section 3). If matter within a given radius approached the nucleus too slowly, the m/r ratio is lower, giving a higher value for the gravitational mass, attracting more matter to within that radius.
In this way the m/r ratio at each radius is self-regulating and variations in the ratio (for different radii) would tend to disappear over time. A steady 'flow' of dark matter towards the nucleus is maintained. A constant m/r ratio, then leads to the constant velocity of rotation, for stars at each radius, from

$$\frac{v^2}{r} = \frac{Gm}{r^2} \qquad (6)$$

The situation is reminiscent of water flowing in a whirlpool down a plughole. The water surface assumes a steady shape.

3. Ejection of dark matter from galactic centres

From the arguments above, that dark matter may be continuously approaching galactic centres, it is evident that it must leave again in some way. It seems likely that it is ejected periodically from the centre, with visible matter too, in AGNs.
It is proposed that singularities do not form but instead that the gravitational mass of the galactic centre periodically reduces. Incoming matter increases the mass/radius ratio. An ejection of matter (dark and visible) then occurs due to a sudden decrease in gravitational mass at the galactic centre. The ejected matter would take the path of least resistance, along the axis perpendicular to the galactic plane. The amount of mass in the galactic nucleus is then reduced - and the mass to radius ratio. The gravitational mass of the remaining mass at the centre is then increased - matter continues to be attracted towards the galactic centre until such a time as the mass/radius ratio again approaches the critical value.

Such a sudden decrease in gravitational mass may allow a large collapsing mass to 'bounce' giving rise to explosive, or ejection phenomenon. Such a feature may also be able to account for the spherical void phenomenon of the large scale structure, and even Big Bang cosmology. As there is a good correlation between the direction of cosmic rays and AGNs (The Pierre Auger Collaboration, 2008), it seems likely that dark matter is connected with cosmic rays. The above supports proposals (Blasi, 2002) and others that cosmic rays and dark matter are connected.

Conclusion

It is suggested that the gravitational binding energy can decrease the gravitational mass of a body, to such an extent that singularities cannot form. The flat shape of galactic rotation curves indicate that dark matter is in continuous motion towards the centres of galaxies. It is ejected from galactic centres, due to periodic reductions of the gravitational mass of the nucleus. It is recommended that these proposals be tested by computer simulation, to see if realistic models emerge. If so, the above may act as a guide, to those attempting to amend or reinterpret General Relativity.

References

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