**The negative equivalent mass of gravitational fields**

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**Ratios of negative gravitational mass to ordinary mass for known objects**:   
To get some idea about the amount of equivalent mass associated with the negative energy in the gravitational fields, it may be instructive to calculate the ratios of negative gravitational mass to ordinary mass for known objects. First note that 3G/(5c^2) is a constant = 4.455 X 10 ^-28. The ratio of negative gravitational mass to ordinary mass is this constant times the mass to radius ratio, M/R (using mass in kg. and radius in meters).   
  
The equivalent gravitational negative mass ratio, is calculated in [The physics of negative mass](http://ethw.org/images/9/93/PVB_the-physics-of-negative-mass.docx) for spherical masses with uniform densities. For large masses, such as Jupiter, the Sun, stars, and especially clusters and galaxies, the mass density is far from uniform. In those cases (because real objects tend to be more dense in the center) the amount of negative equivalent mass would be *greater* than that provided by the uniform density formula. Thus, the formula provides the *minimum* amount of negative equivalent mass. The maximum value, however, is not easy to determine because one would need to know the mass density profile of the object with radius.   
  
A sphere of water, one meter in radius would have a mass of about 4,188 kg., providing M/R = 4,188. In this case the negative mass ratio is -1.866 X 10^-24 , a very small number indeed. If we select a sphere of water 10 meters in radius, it would have a mass of about 4,188,000 kg. Thus, its M/R = 418,800, and its negative mass ratio is -1.866 X 10^-22, still a very small number, but a factor of 100 more than in the sphere of radius 1 meter. This is because the mass of an object increase with its volume, which increases as the cube of the radius, and M/R therefore increases with the square of the radius for masses of the same density.   
  
The following table shows the negative equivalent mass ratio for a number of well-known astronomical objects, assuming that they are of uniform density based on their average density. Thus the ratios shown are *minimum* ratios. The real ratios would be higher than those shown, especially if the density profile is extreme.

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| **Ratio of negative equivalent mass of the gravitational fields to the mass of various objects** | | | | |
| **Object** | **Mass (kg)** | **Radius (m)** | **Negative Mass Ratio** | **Notes** |
| Sphere of water 1 meter radius | 4,188 | 1 | -1.866 X 10^-24 | Density is Uniform |
| Sphere of water 10 meter radius | 4,188,000 | 10 | -1.866 X 10^-22 | Density is Uniform |
| Moon | 7.3 X 10^22 | 1.738 X 10^6 | -1.87 X 10^-12 | Density is Fairly Uniform 3,340 kg/m^3 |
| Earth | 5.97 X 10^24 | 6.37 X 10^6 | -4.17 X 10^-10 | Density is Fairly Uniform 5,220 kg/m^3 |
| Jupiter | 1.91 X 10^27 | 6.91 X 10^7 | -1.23 X 10^-8 | Density is Non-Uniform avg. = 1,330 kg/m^3 |
| Sun | 1.99 X 10^30 | 6.96 X 10^8 | -1.27 X 10^-6 | Density is Highly Non-Uniform avg. = 1,411 kg/m^3 |
| M13, Globular Cluster in Hercules | 2 X 10^36 | 7.5 X 10^15 | -1.2 X 10^-7 | Density is Extremely Non-Uniform avg. = 1.1 X 10^-18 kg/m^3 |
| M31, Andromeda, Typical Galaxy | 6 X 10^41 | 7.71 X 10^17 | -3.5 X 10^-4 | Density is Extremely Non-Uniform avg. = 3 X 10^-13 kg/m^3 |
| M87, largest known Galaxy,  Giant Elliptical | 2 X 10^43 | 2.3 X 10^20 | -3.9 X 10^-5 | Density is Extremely Non-Uniform avg. = 3 X 10^-19 kg/m^3 |
| Typical Galactic Cluster | 2.5 X 10^44 | 9 X 10^21 | -1.2 X 10^-5 | Density is Extremely Non-Uniform avg. = 8.2X 10^-23 kg/m^3 |
| Entire Universe | 2 X 10^50 | 1 X 10^26 | -9 X 10^-4 | Density is Extremely Non-Uniform avg. = 4.8 X 10^-29 kg/m^3 |
| Any Black Hole See Text Below | M = R(c^2)/2G | R = 2GM/(c^2) | -0.3 | Density profile is unknown avg. = 3(c^2)/[8(pi)(R^2)G] |

The data in this table is more accurate for the objects up to Jupiter, because of the more uniform mass densities. It can easily be seen that the negative mass ratio rises dramatically and steadily through 16 orders of magnitude from a laboratory sized object to a planetary mass such as that of Jupiter.   
  
A model of the density profile of Jupiter as a function of radius is discussed in *The Cambridge Encyclopedia of Astronomy*, Crown Publishers, page 215 in the 1977 edition. This model shows that the average density is reached at a radius of about 50,000 km from the center of the planet. This would imply that the maximum gravitation pull is somewhere near that radius. Thus the negative mass ratio may be about 15 to 20% higher than is shown in the table above. However, it would probably not be anywhere close to an order of magnitude higher under any reasonable model for Jupiter’s density profile.   
  
With respect to the Sun, the density profile has a more serious effect. On page 128 of *The Cambridge Encyclopedia of Astronomy*, there is a model of the Sun’s density profile which shows that it drops quickly from a value of 150,000 kg/m^3 at the center to 10,000 kg/m^3 at a radius of only 200,000 km. (less than 1/3rd of the full radius). This could mean that more than 3/4th of the Sun’s mass is in 1/3rd of its full radius, so that the negative mass ratio could be more than twice the value in the table above. This would mean that the Sun’s negative equivalent mass from its gravitational field is about 2.5 parts per million.   
  
For larger objects, the average density drops. The Sun is thought to be representative of an average sized star. Larger stars would have greater masses and larger radii, but their average densities decline with size. Therefore it is not likely that any star would have a negative equivalent mass ratio larger than the Sun’s by an order of magnitude.   
  
In the next grouping of objects in the table, we see that globular clusters, galaxies, and clusters of galaxies are much more massive, but have larger radii as well, and their average densities decline with size, except for the Andromeda galaxy, which represents a typical galaxy. In a galaxy, there is a central mass that significantly increases the average mass density by as much as five or six orders of magnitude over that of a globular cluster or a giant elliptical galaxy. This creates a very sharp density profile, such that the negative equivalent ratio for galaxies may be one or even two orders of magnitude higher that as indicated on the table. Most galaxies are far from spherically symmetrical, taking the shape of flattened spirals or barred spirals. This alone would raise the negative equivalent mass ratio by an order of magnitude, and the sharp density profile could raise it another, meaning that a galaxy could have as much as a 5% ratio of negative equivalent mass in its gravitational field to its total mass.   
  
Unless there is an enormous amount of mass in the form of intergalactic non-luminous dust clouds that would raise the average density of intergalactic space by three orders of magnitude, the negative equivalent mass of the entire universe is about one tenth of one percent of its total mass.   
  
Metaphysically speaking, the universe could have a net zero mass if, ironically, there was about three orders of magnitude more mass than we believe there is. This is about the same amount of additional mass density needed for so-called "closure" following the Hubble expansion. However, a zero or net negative mass universe would be self-repellent, so that closure may be impossible.   
  
Another speculative possibility is that the centers of galaxies, taken independently as massive objects that they are, may have negative equivalent mass ratios greater than unity, causing them to eject much of their own mass into their spiral arms.   
  
If black holes exist, their mass to radius ratio is governed by the equation for the Schwartzchild mass-radius relationship, 2MG = R(C^2), or M/R = (c^2)/(2G). For a black hole, the negative equivalent mass ratio is exactly 0.30 or 3/10 for a uniform density profile.   
  
However, for very large and massive black holes, such as might exist at the centers of galaxies, their average density drops inversely as the square of their radius. This could mean that the Schwartzchild radius of a very massive black hole could extend well beyond the "surface" of its massive component within. In such a case, the negative equivalent mass ratio could rise from the non-uniform density profile to unity or greater, creating a net zero or negative mass that would explode.   
  
Perhaps this is what the universe is. An ultra-massive black hole, from which nothing escapes. It has masses concentrated in the centers of galaxies in quark-gluon plasmas and smaller black holes that are themselves exploding as their radii reach the critical value where their mass goes into a net negative value.   
  
Perhaps the negative equivalent mass of a dense object prevents the ordinary formation of a black hole, but enables quark-gluon plasmas to form in the interiors of large neutron stars. Perhaps as quarks and gluons recombine in the outer atmosphere (the recombination zone) of a quark-gluon plasma, , near the surface of a large neutron star, the attractive force that bound the quarks to their previous partners is relieved, exerting a net outward thrust to the atomic particles formed in the recombination zone. This may be the source of galactic ejecta.   
  
These processes, negative equivalent gravitational mass, and recombination of quarks and gluons in the outer atmosphere of quark-gluon plasmas, may prevent black holes from forming, except under very rare conditions.   
  
Such a rare condition may possibly be the collision of two massive quark-gluon plasmas, producing a "big bang". Perhaps we live inside a black hole, the only black hole, or one of a very few. The discovery of the relics of the "big bang" is a memory of a gigantic collision of two massive quark-gluon plasmas, forming the black hole that we live in.   
  
Certainly, the universe as we know it, has all the properties of a black hole. Nothing escapes it, yet it appears to have an outer bound. Additional mass may be falling into it forming high energy cosmic ray bursts, which have yet to be explained. The microwave relict radiation may be a measure of its temperature as seen from the inside!