Black Hole vs. Variable Rest Mass Neutron Star

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ABSTRACT

In a previous paper we have discussed the conjecture of a variable particle rest mass as a function of gravitational potential [1]. This paper discuses the implications, in regard to a large neutron star, and contrast the difference between the predicted phenomena, and Black Hole theory as put fourth by standard GR. As most know, Einstein was not convinced of the existence of Black Holes, but modern solutions of the GR field equations appear to agree with the experimental evidence. There are some problems however, as are well known, the explanations for the diffuse, and the persistent source gamma ray emissions from the galactic center, do not have an adequate explanation, and the energy engines driving Quasars and AGNs are not sufficiently explained. This paper will explore the differences between VRM neutron stars, and Black Holes, for the purpose of identifying detectable, and measurable phenomena. The validity of this theory will be established on the finding of massive neutron stars or massive pulsars. >3 suns.

From the paper "Scalar Gravitational Theory with Variable Rest Mass" [1] the rest mass of a particle as a function of gravitational potential is given by:

$$M = M_F\left(1-\frac{\mu}{r}\right), \tag{1.1}$$

Where M and M_F are the rest mass and the gravitationally free rest mass.
or:

$$M = M_F\left(1-\frac{GM}{c^2 r}\right) = M_F\left(1-\Phi\right) \tag{1.2}$$

As a particle falls onto the gravitating mass, the total energy is constant, but the rest mass declines until arriving at the surface, at which point the particle, liberates its kinetic energy. It then has a reduced rest mass, and assumes the same mass ratio of free to bound, as all the other particles in the star. The gravitational radius cannot become as great as the surface radius, because at that point the mass of the entire body would becomes zero. As more mass is added to a neutron star the radius, the mass increase, but because the infalling mass gives up so much of its energy, the total accumulation and size of the star is much lower than that for the Black hole. Since there is no photon entrapment, the kinetic energy is radiated away as electromagnetic radiation.

Gravitational Binding Energy, Mass Defect

General Relativity treats the Gravitational energy as non-localizable [2], there is no well-defined gravitational field energy in General Relativity[3]. This is asserted on the basis of the principle of equivalence, that the gravitational energy cannot be localized. The primary reason for this is that the gravitational field energy density mass equivalence relation $E = mc^2$ is negative, and has a negative mass density.

This non-localization results in the concept, that when a particle infalls a gravitational field, stops at the surface, and radiates the kinetic energy away, the rest mass of the particle has not changed. The binding energy, or “mass defect” lost by the system is from the gravitational field as a whole. The VRM view is that the energy is is localized, and lost from the rest mass of the infalling particle. Though, not necessarily true of time varying gravitational fields, the VRM view is that the static gravitational field has no energy.

The reduced rest mass, calculated from the Variable Rest Mass theory is exactly equivalent to the mass defect resulting from of the gravitational binding energy, but the energy lost, is localized directly in the rest mass of the infalling particle, rather than from the gravitational system as a whole.

In nucleon, and electric binding systems, the mass defect is related to the electric charge or nuclear binding energy, and the fields are relatively independent of the lost mass. In the case of gravitational binding, however the mass defect not only reduces the mass, but also reduces the binding energy because the interacting forces are dependent on the mass. From out theory, as a particle approaches the gravitational radius, its rest energy approaches zero. Thus if the surface of a gravitating body is near the gravitational radius, after the particle is stopped, and the kinetic energy is radiated away, there is less mass contribution to the gravitation body. Actually we find that the gravitational attraction of the body is equivalent to the attraction provided by the quantity of mass lying beyond the gravitational radius.

Conventional GR requires that photons leaving a surface close to the gravitational radius loose energy back to the field and thus after escape very little is radiated away. As has been pointed out in [1], if we presume the rest mass for systems at different elevations in a gravitational field are not the same, the results of the Pound-Rebka-Snider experiment, requires that the energy of the photon rising in a gravitational field is conserved. Although photons are slowed by the Shapiro effect, they must escape with the energy intact.

VRM Neutron Star

For a neutron star in a GR Black Hole scenario, the gravitational radius expands proportional to the mass, and the surface radius expands, proportional to the cube root of the mass, at some point (usually asserted to be 1.4 to 2.7 solar masses), the gravitational radius exceeds the surface radius, and a black hole is formed. In the case of a Variable Rest Mass (VRM) star, as mass is added, the gravitational potential increases, thus decreasing the per nucleon rest mass of the interior. Since the rest mass of the star is dependent on the ratio of the surface radius to the gravitational radius, there is an equilibrium established between the surface radius, and the gravitational radius. (i.e. if the gravitational radius increases the mass decreases, which causes the gravitational radius to decrease) . This means the star can never collapse into a black hole. For the purpose of simplifying the discussion, we will mostly consider cold neutron stars, however the addition of thermal energy would increase the radius for a given mass star, and would have the effect of reducing the energy of the photons emitted when a particle infalls from space to the surface.

Experimental Evidence For Black Holes

From Shaposhnikov [4]

The dynamical measurement of the mass of a compact object of more than the theoretical limit for a stable NS configuration is currently considered a sufficient evidence that the object is a BH. We note, however, that by itself such a mass measurement is not a direct proof of the nature of an object as a BH

For the most part the experimental evidence for a Black hole is that the astronomically observed mass for a compact object is greater than that of a neutron star which is gauged to be from about 1.4 to 2.7 suns. One of the most recent techniques developed for determining the existence of Black Holes is from Shaposhnikov, et..al [4], which uses a correlation between spectral index, and the quasi-periodic oscillation (QPO) frequency. Although they have shown the technique to correlate with mass, the assertion that it requires the absence of a solid surface, or is a Black Hole, results from a degree of speculation. Several assumptions are necessary among which are mass accretion rate exceeding the Eddigton limit only for Black Holes. This assertion has yet to be proven, and is known to have exceptions. The characteristics exhibited by the VRM neutron star, as shown below, seems to mimic nearly all the observational evidence so far, put forth for the existence of Black Holes.

Mechanics

Although, not altogether necessary for the purpose of the theory, for simplicity we will assert, or presume two facts regarding neutrons. 1) A very stiff equation of state, that is, cold neutrons in a star are uncompressible. This assumption makes the calculations simple, but other assumptions regarding compressibility won't change the primary results. 2) the volume of a neutron is proportional to the Compton radius, and as such, is inversely proportional to the rest mass. This later assumption is the mechanism that expands the star, always beyond the gravitational radius, and is thus a mechanism preventing the formation of a Black hole. This assumption is also not essential, since gravitationally lowering the mass, also decreases the internal pressure and would allow the required expansion of the star beyond the gravitational radius. There would be a difference in the radius of course, but since we can't know the proper equation of state for a neutron star, using an expanding Compton radius illustrates the effect quite well.

Assumed radius of a neutron:

$$r_N \approx .66\,\text{Fm} \approx 3\,\mathbf{r}_C \tag{1.3}$$

Volume of a neutron:

$$v_n = \frac{4}{3}\pi\left(3r_c\right)^3 \tag{1.4}$$

Particle Compton radius

$$\mathbf{r}_C = \hbar / Mc \tag{1.5}$$

The radius of a neutron star with this condition is then:

$$R_s \;=\; 3n^{1/3}\mathbf{r}_C \;=\; 3n^{1/3}\hbar / M_N c \tag{1.6}$$

From Eq.(1.2) we can replace the mass in Eq. (1.6)(1.4) and Eq. (1.5) with:

$$M = M_F \Big/ \left(1 + \frac{GM_F n}{c^2 R_s}\right) \tag{1.7}$$

Giving for the surface radius:

$$R_s = n^{1/3}\left(3\frac{\hbar}{M_F c}\right)\left(1 + \frac{GM_F n}{c^2 R_s}\right) \tag{1.8}$$

Where R_s is the surface radius, and n is the number of neutrons in the star.

This can now be solved for R_s :

$$R_s^2 - \left(\frac{3n^{1/3}\hbar}{M_F c}\right) R_s - \frac{3n^{1/3} nG\hbar}{c^3} = 0 \tag{1.9}$$

Giving:

$$R_s^2 - \left(\frac{3n^{1/3}\hbar}{M_F c}\right) R_s - \frac{3n^{1/3} nG\hbar}{c^3} = 0 \tag{1.10}$$

$$R_s^2 - \left(3n^{1/3}\mathbf{r}_{CF}\right) R_s - 3n^{1/3} n\mathbf{r}_{CF}\mu_F = 0 \tag{1.11}$$

$$R_s = \frac{1}{2}\left(3n^{1/3}\mathbf{r}_{CF}\right) + \sqrt{\left(3n^{1/3}\mathbf{r}_{CF}\right)^2 + \frac{3n^{1/3} n\mathbf{r}_{CF}\mu_F}{4}} \tag{1.12}$$

$$R_s = \frac{1}{2}\left(3n^{1/3}\mathbf{r}_{CF}\right)\left[1 + \sqrt{1 + \frac{4}{3} n^{2/3}\left(\frac{\mu_F}{\mathbf{r}_{CF}}\right)}\right] \xrightarrow{n >> 1} \left(n^{2/3}\sqrt{3\mathbf{r}_{CF}\mu_F}\right) \tag{1.13}$$

Since we are assuming the equation of state for a cold VRM star is stiff.

$$R_s = \left(3n^{1/3}\mathbf{r}_C\right) = \left(3n^{1/3}\frac{\hbar}{Mc}\right) \tag{1.14}$$

Thus the mass ratio of bound mass, to gravitationally free mass, for particles, as a function of the number of neutrons is:

$$\frac{M}{M_F} = 2 / \left[1 + \sqrt{1 + \frac{4}{3} n^{2/3}\left(\frac{\mu_F}{\mathbf{r}_{CF}}\right)}\right] \tag{1.15}$$

And the conversion efficiency is:

$$E = 1 - \frac{M}{M_F} = 1 - 2 / \left(1 + \sqrt{1 + \frac{4}{3} n^{2/3}\left(\frac{\mu_F}{\mathbf{r}_{CF}}\right)}\right) \tag{1.16}$$

Note that the conversion efficiency is about 60 % for a star with an accumulation of 100 solar masses. and 80% for a star with an accumulation of 1000 solar stars. Of course the actual mass of a VRM star after accumulation is 40 and 200 stars respectively.(see Table 1)

We can solve for the actual gravitational radius:

$$R_{SW} = \frac{GnM}{c^2} = \frac{GnM_F}{c^2} 2 / \left[1 + \sqrt{1 + \frac{4}{3} n^{2/3} \left(\frac{\mu_F}{r_{CF}} \right)} \right] \tag{1.17}$$

Which is always smaller than the surface radius R_S

The ratio of the actual gravitational radius to the VRM radius is:

$$\frac{R_{SW}}{R_s} = \frac{\left(n^{2/3} \frac{4\mu_F}{3 r_{CF}} \right)}{\left(1 + \sqrt{1 + \left(n^{2/3} \frac{4\mu_F}{3 r_{CF}} \right)} \right)^2} \tag{1.18}$$

Note that it is always less than 1 but approaches 1 as the number of neutrons increases. Making the radius of large BHs and VRM stars, about the same for the same externally observed mass. The major difference being that the large BH accumulates the rest mass, whereas the VRM star burns a very high percentage.

Note that $r_{CF} = \hbar / M_F c$ is the Compton and $\mu_F = GM_F / c^2$ the gravitational radius, of a gravitationally free neutron.

We can now proceed with some calculations to compare the difference between Black Hole and VRM neutron star.

For the free Neutron:

Neutron Mass		1.674927e−24 gm
Neutron gravitational radius	$\mu_F = GM_F / c^2$	1.254715e-52 cm
Neutron Compton radius	$r_{CF} = \hbar / M_F c$	2.100234e-14 cm
$\frac{\mu_p}{r_{CF}} =$		5.9824014496e-39

Number of neutrons in a solar mass neutron star:

Solar mass	1.989e33	gm
N	1.189e57	

For a star with an initial N solar masses, some tabulated calculations for the VRM neutron star can be done from the above calculations.

Table 1

Mass Input (Suns)	Conversion Factor	VRM Mass Actual (Suns)	Surface Radius (Km)	Ratio Surface to Grav. Radius
0.001	0.0022	0.001	6.70E- 01	450.0
0.01	0.0102	0.010	1.45E+00	98.51
0.1	0.0440	0.096	3.25E+00	22.7
1	0.1582	0.842	7.94E+00	6.32
2	0.2171	1.566	1.08E+01	4.61
3	0.2566	2.230	1.30E+01	3.90
4	0.2864	2.854	1.49E+01	3.49
5	0.3104	3.448	1.66E+01	3.22
6	0.3304	4.020	1.81E+01	3.026
7	0.3476	4.567	1.96E+01	2.88
8	0.3627	5.099	2.10E+01	2.76
10	0.3880	6.120	2.35E+01	2.57
100	0.6363	36.37	8.53E+01	1.57
1.E+03	0.8096	1.90E+02	3.51E+02	1.23
1.E+04	0.9065	9.35E+02	1.54E+03	1.10
1.E+05	0.9554	4.46E+03	6.96E+03	1.046
1.E+06	0.9791	2.09E+04	3.19E+04	1.021
1.E+07	0.9902	9.78E+04	1.47E+05	1.010
1.E+08	0.9955	4.55E+05	6.82E+05	1.004
1.E+09	0.9979	2.11E+06	3.16E+06	1.0023
1.E+10	0.9990	9.82E+06	1.47E+07	1.0012
1.E+11	0.9995	4.56E+07	6.81E+07	1.0007
1.E+12	0.9998	2.12E+08	3.16E+08	1.0004
1.E+13	0.9999	9.82E+08	1.47E+09	1.0003
1.E+14	1.0000	4.56E+09	6.72E+09	1.0003

Note that after a few Km the gravitational radius approaches the VRM surface radius, but is always slightly less, which means the Black Hole never forms. If the temperature of the star is hot, the surface radius is greater than for a cold star, and the conversion efficiency is reduced by the actual surface radius. Eq. (1.7)

Also note that a VRM star with a mass of about 10,000 suns has conversion efficiency above 99% and a radius of only 150,000 Km (½ light sec).

Explainable Phenomena

There are several astronomical phenomena that can likely be explained better by the VRM theory than the conventional Black Hole representation. The most significant is the energy engines of Quasars and AGNs. The VRM is able to supply more energy over a more significant period of time than the standard BH accretion disc and still maintain a small size. Since the Radius of a Black Hole and a VRM neutron star, of the same externally observed mass, are virtually the same, the Black Hole size to mass ratio is not a point of difference that would be significant. This removes from consideration a notable feature of Black Hole theory, that distinguishes it from conventional Newtonian dynamics.

Items that can better be explained by the VRM, than Black Hole theory, are Quasars, and AGNs. Items that would have explanations for which there is currently no viable explanation, are the galactic Persistent Gamma Ray Emitters, the Diffuse Galactic Gamma Radiation, and the excessive Galactic positron-electron annihilation radiation.

Quasars AGNs

The current conventional theory regarding the energy engines driving Quasars and AGNs is the super massive Black Hole accretion disk. The heating of the infalling material is by turbulent friction between gas layers at successively lower orbits. The energy extracted from material falling into a Black hole is by way of heating in the accretion disc and is asserted to be about 10% of the rest energy of the infalling material [5]. Although this mechanism can produce prodigious quantities of radiation, there is a significant flaw in the mechanism, for powering Quasars and to a lesser extent AGNs.

The energy released from the accretion disc from mass falling into a non-rotating black hole is relatively modest, nominally less than 10% of the rest energy, of the infalling material. If the Black hole is a spinning Kerr Black hole, with a magnetic field, the energy generated can be somewhat more significant [6].This cannot continue indefinitely, however since the energy is actually being extracted from the spin of the black hole, and is not being replenished. The energy released form the accretion disk is energy extracted from the difference between the initial angular kinetic energy of the Black Hole, and the ambient angular kinetic energy of the infalling material. All of the infalling material, subsequent to the initial forming the Black Hole, must reduce the BH spin rate, since the total angular momentum is conserved, and there is no mechanism for restoring that which is lost. A simple doubling of the mass, by infalling material, would have the effect of doubling the Black Hole radius, and reducing the spin kinetic energy by the loss. The change as the result of doubling the mass would have the effect of reducing the spin rate by more than half, and in turn, reducing the accretion heating mechanism proportionally.

A few mass doublings, would soon reduce the spin rate, and energy output to near zero. Although this mechanism could produce large amounts of energy for newly formed Black Holes, for Quasars that consume billions of stars, for billions of years, the spinning accretion disc, does not seem like a viable option. In addition, the black hole, which has to consume trillions of stars to produce the prodigious energy output, grows linearly in diameter by about 3 Km per solar size sun consumed. After a few trillion stars are consumed, the diameter would become very large, but due to the rapid change in radiation energy flux, we know that they are actually relatively small, [7] A black hole that consumed 10 trillion stars would be over 3 light years in diameter, but from Table 1 above, we see that a VRM neutron star having consumed 10 trillion stars would be only 2.7 light hours in radius, much more in line with the observed radiation flux changes. AGNs seem to differ from Quasar in size, but not necessarily in longevity, and so the same argument would apply to their central engine.

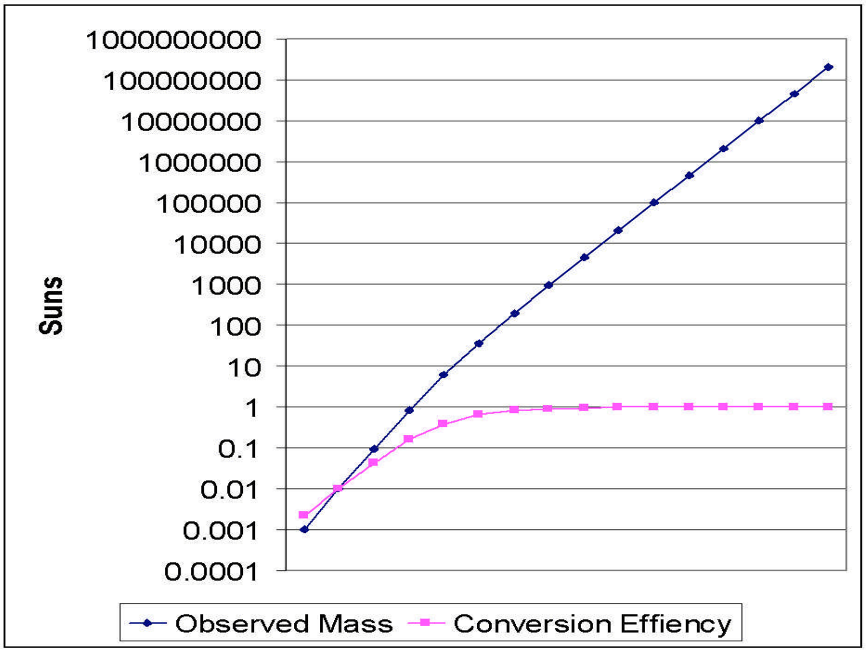
A large VRM neutron star, has all the attributes for energy production, of an accreting Black Hole, with the addition of a near 100% energy extraction rate, and a hard hot surface, the size of a black hole, to radiate the energy away. It would be a lot more suitable as a driving engine for a massive, persistent energy source.

The X-ray and Gamma Persistent Sources

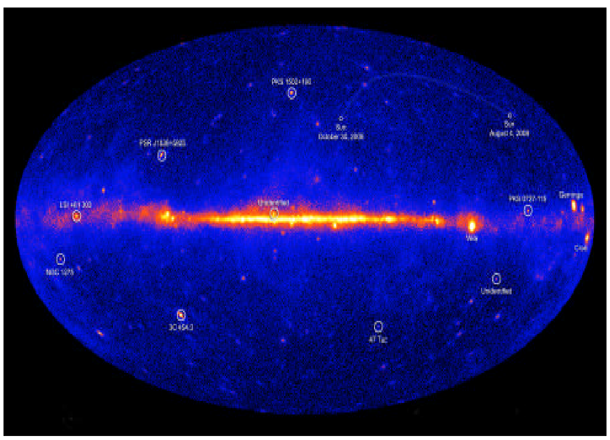
From the Integral and other space observatories there has been observed an unexplainable persistent background X-ray and Gamma Spectra emission from the Galactic center.

The conversion efficiency of electrons or protons falling onto a burned out VRM neutron star, after a few hundred solar masses, is very high.

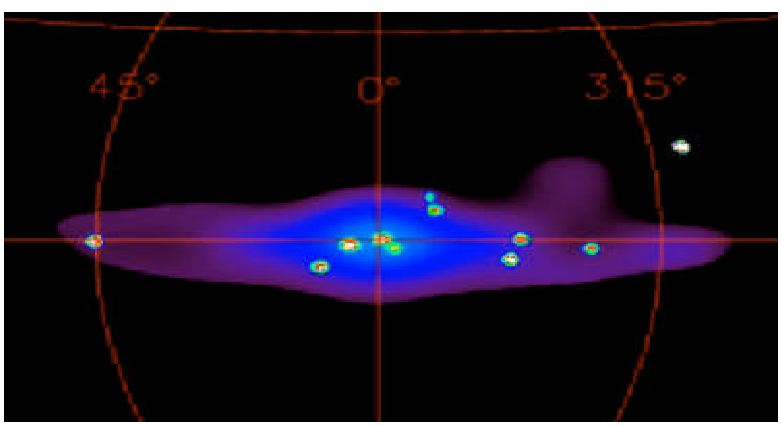
Graph I



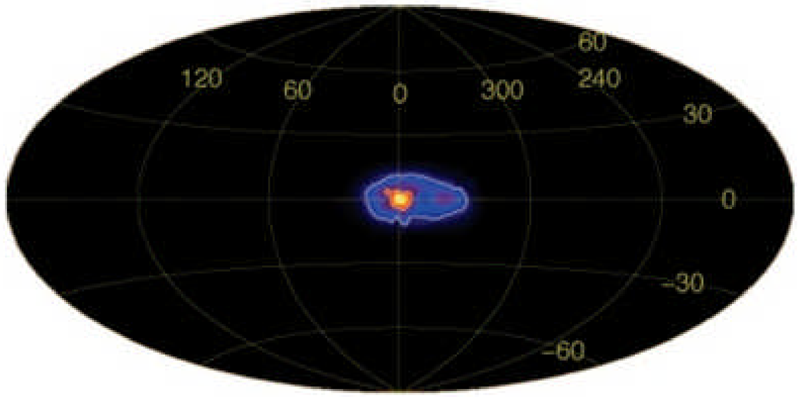
The high Mev.>100 Image[8] is:



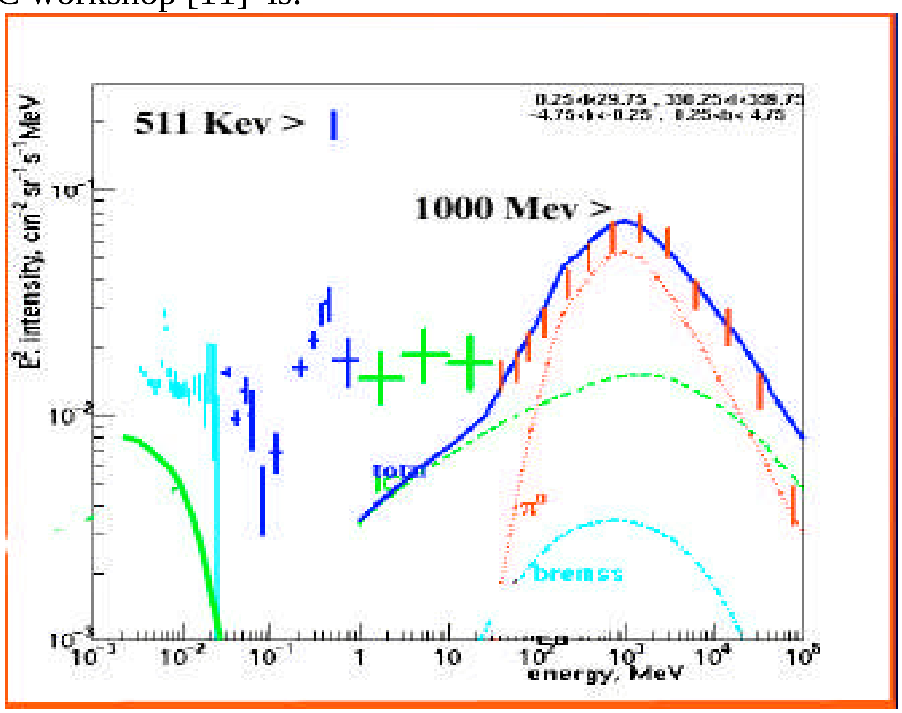
The 20 to 600 Kev image [9] is:



The Galactic 512 Kev electron-positron emission image[10] is:



And the central galactic spectra from a compendium of measurements composed for the Integral/ESTEC workshop [11] is:



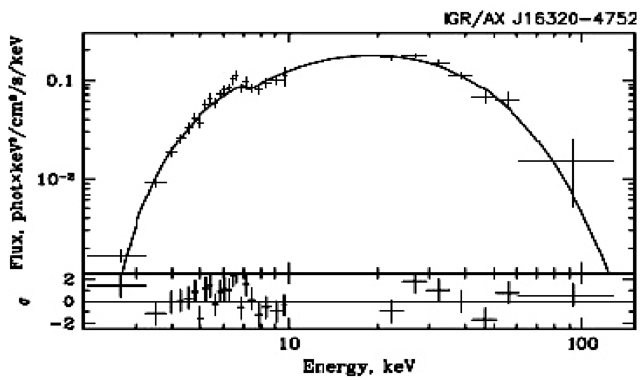
Notable peaks in this spectral presentation are at the 511 Kev Electron-Positron annihilation energy, or electron rest energy, and at the 1000 Mev proton rest energy. There is no good explanation for either of these peaks[12]. There is no source sufficient to supply the number of positrons required, and no explanation is forthcoming for the 1000 Mev peak. If we presume that the center of the galaxy is populated with a large number of cold, high mass, VRM neutron stars (>1E4 Suns), as discussed above, and if we also presume a low density hydrogen gas, or plasma, is persistent a throughout this region, which it is, then the spectra for both the positron line and the 1 Mev peak is explicable as the radiation produced by the infalling of the gas on the surface of these big cold neutron stars.

The peak at electron-positron spectra point, 511 Kev is just the energy released as the result of the electron falling on the surfaces, and the large Gamma peak, which is at just less than 1 Mev, corresponds to the rest energy, and the radiation that would be released by the proton.

Central Galaxy Gamma Persistent Sources

The spectra of the Soft Gamma ray persistent sources in the Galaxy center can be typified by[13]:

Fig. 4



"20–100 keV range resulted in a soft gamma-ray sky populated with more than 200 sources, most of them being galactic binaries, either Black Hole Candidates (BHC) or Neutron Stars (NS)"

These objects have an explanation in the VRM view, as simple hot neutron stars. From thermal measurements we know many to be hot, (1.6e6) From Table 1. If a 1.5 solar mass, VRM neutron star, which would have a cold radius of about 10.8 Km were thermally enlarged to about 21.6 km, the nominal size of neutron stars, the energy release of the electron falling into the surface would be about 50 Kev and would have an offset Gaussian thermal distribution typical of that shown in Fig. 4

Conclusion

Whether this view of mass, gravitation, and Black Holes, is correct, cannot yet proven, but based on available data, is a promising avenue of investigation, and cannot be rejected out of hand. As of the current date, there does not seem to be another viable, testable, alternative to the Black Hole, and thus this conjecture could as a minimum serve that purpose. As better understanding, and more precise measurements of Black Hole phenomena is developed, distinguishing characteristics should make clear, whether The Variable Rest Mass view has merit.

1 DT Froedge, Scalar Gravitational Theory with Variable Rest Mass: http://www.arxdtf.org/

2 C. W. Misner, K. S. Thorne and J. A. Wheeler, Gravitation (pp466)

3 Relativity (L. D. Landau and E. M. Lifshitz, The Classical Theory of Fields, Sec. 96

4 Determination of Black Hole Masses in Galactic Black Hole
Binaries using Scaling of Spectral and Variability Characteristics
Nickolai Shaposhnikov1,2 and Lev Titarchuk2,3,4 Accepted and scheduled for publication in The Astrophysical
Journal arXiv:0902.2852v1 [astro-ph.HE] 17 Feb 2009

6 Accretion Disk Torqued by a Black Hole, Li-Xin Li, Princeton University Observatory, Princeton, NJ 08544–1001, USA, arXiv:astro-ph/0012469v2 9 Mar 2001

7 Rapid fluctuations of radio flux and polarization in quasar 3C273, V. A. EFANOV, I. G. MOISEEV, N. S. NESTEROV & N. M. SHAKHOVSKOY, Crimean Astrophysical Observatory, P/O Nauchny, Crimea, 334413, USSR,
Nature 269, 493 - 494 (06 October 1977); doi:10.1038/269493a0

8 All-sky view from Fermi GLAST reveals bright emission in the plane of the Milky Way
All-sky map at energies above 100 MeV Credit: NASA/DOE/International LAT Team.

9 INTEGRAL SPI all-sky view in soft X-rays: Study of point source and Galactic diffuse emissions L., Bouchet et al., 2008, accepted for publication in ApJ; astro-ph:0801.2086).

10 The sky distribution of 511 Kev positron annihilation line emission
as measured with Integral/SPI G.Weidenspointner1, et al http://arxiv.org/abs/astro-ph/0702621

11 Galactic g -ray Continuum with INTEGRAL/SPI A. Strong, MPE INTEGRAL/ESTEC Workshop

"20–100 keV range resulted in a soft gamma-ray sky populated with more than 200 sources, most of them being galactic binaries, either Black Hole Candidates (BHC) or Neutron Stars (NS). Very recently, the INTEGRAL new source IGR J18135-1751 has been identified as the soft gamma-ray counterpart of HESS J1813-178 and AXJ1838.0-0655 as the X/gamma-ray counterpart of HESS J1837-069"

12 Observing with a space-borne gamma-ray telescope: selected results from INTEGRAL

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http://www.iop.org/EJ/article/1742-6596/41/1/004/jpconf6_41_004.pdf?request-id=6bae4f2f-e29c-4346-8ae0-1ec06d35b438

13 INTEGRAL insight into the inner parts of the Galaxy. High mass
X-ray binaries. A.Lutovinov1 arXiv:astro-ph/0411550v2 29 Aug 2005