

THE CRITICAL SIZE OF A
GRAVITATIONAL SOURCE
AND
THE LAW OF THE GRAVITATIONAL
ACCUMULATION OF MATTER

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Abstract.

This paper investigates the possibility of a gravitational source possessing a physical radius of the same order of magnitude as its gravitational radius, and accordingly, its resulting characteristics. Also an empirical law for the gravitational accumulation of matter is determined.

1 Introduction.

The vast majority of gravitational sources are such that their physical radius is very much larger than their gravitational radius. In addition, these two parameters remain largely constant over many aeons, and so the gravitational radius is never approached by either the physical radius of the source itself, or by some other object. Even in a gravitationally collapsing star at the end of its main stream life, the collapse normally stops when the white dwarf stage is reached, and the physical radius remains much larger than the gravitational radius. The only instance where the above is not purported to be the case, is that of the entire Universe where it was shown in [2] that, at the end of its first phase of evolution, the physical radius was gravitationally reduced to less than three times the gravitational radius. The outcome was shown to be the second phase of evolution wherein the gravitational field of the Universe, its Acceleration Potential, had become repulsive and was responsible for the eventual recession of the distant galaxies. This paper investigates the possibility of other celestial bodies possessing characteristics such that a similar scenario could be enacted.

The results enable discussions concerning the characteristics of such diverse subjects as the maximum mass of gravitationally stable accumulated matter, black holes, neutron stars, and the nucleon particle. The investigation also leads to an apparent new relationship between the mass and the physical size of gravitationally accumulated matter. The consequences of this relationship are subsequently reviewed in some detail.

For a complete understanding of the subject matter presented in this paper, it is necessary that reference [2] be read thoroughly first.

In the interests of brevity, unless necessary for complete clarity, a parameter will only be defined in this paper if it has not previously been so in either [1] or [2] with which familiarity is assumed.

2 The Critical Size of a Gravitational Source.

2.1 Mathematical Derivation.

The critical size of a gravitational source is herewith defined as the size at which the internal characteristics change, such that it starts to generate a repulsive type internal gravitational field, (Acceleration Potential), instead of an attractive type field. For the entire Universe this was shown in [2] to be when

$$\sigma_u = 3\alpha_u \quad (2.1)$$

where

σ_u = The physical radius of the Universe.

α_u = The gravitational radius of the Universe.

To determine whether this condition can apply to any other naturally occurring accumulation of matter, [1], Eq.(4.6) is inserted into (2.1), the nomenclature changed to reflect that of a normally sized gravitational source, and the resulting equation re-arranged for the mass, thus

$$m_g = \frac{\sigma_g c^2}{3\gamma} \quad (2.2)$$

Eq.(??) shows the relationship between the mass and the radius of any gravitational source for which an identical criteria to (2.1) is met. Using a value of $2.99E10$ cm/sec for c , [3], and $6.67E-8$ $cm^3/gm.sec^2$ for γ , [4], a table of values of m_g versus σ_g for this criteria can be constructed from (??), as in Table 1 below.

σ_g	m_g
10^{-14}	4.5×10^{13}
10^{-10}	4.5×10^{17}
10^{-5}	4.5×10^{22}
10^0	4.5×10^{27}
10^5	4.5×10^{32}
10^{10}	4.5×10^{37}
10^{15}	4.5×10^{42}
10^{20}	4.5×10^{47}
10^{25}	4.5×10^{52}
10^{30}	4.5×10^{57}

Table 1 - Mass Versus Radius for the 3α Criterion.

For reasons that will be discussed later, Table 1 has been constructed to cover the smallest composite matter particle for which a dimension is known, the Nucleon, up to the largest known accumulation of matter, the entire Universe. Also note that the above value used for c is the velocity of light at the surface of the Earth. This represents an approximation because the correct value that should be used is the Terminal Velocity in Pseudo-Euclidean Space, which will be slightly larger than the above value because of the absence of a gravitational field, See [1] Appendix D for a further explanation.

Table 1 is now graphed, to LOG-LOG axes, (base 10), in Fig.1, as the straight line relationship denoted A.

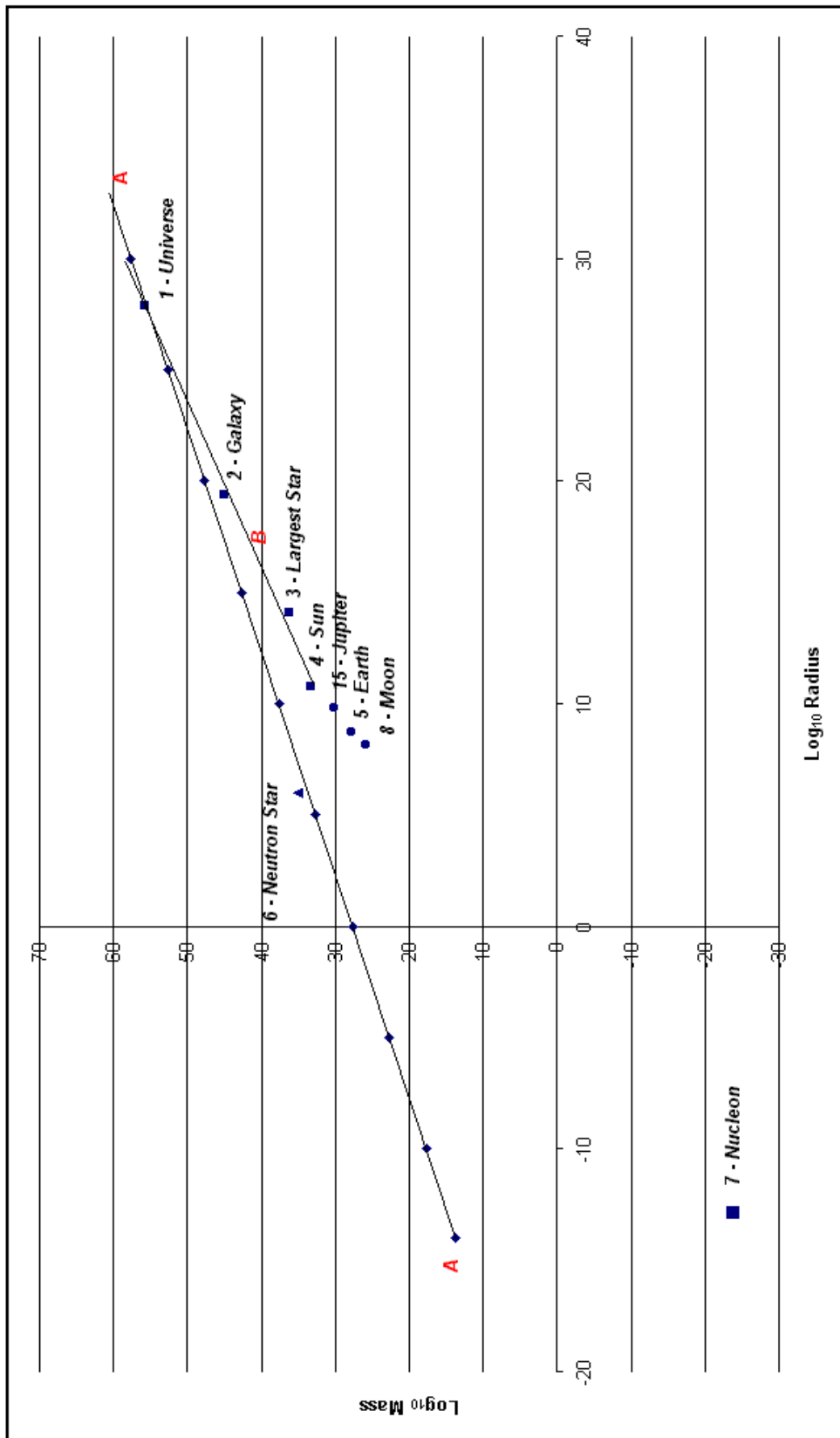


Figure 1: - The 3 x Gravitational Radius Criteria

To the right of Line A, a gravitational source would be stable and produce internally a normal attractive type gravitational field in which the Acceleration Potential was negative. To the left of Line A the opposite would be true. To determine whether any celestial bodies other than the entire Universe can produce an internal field of repulsive gravity, Fig.1 needs to be augmented with points representing the full range of celestial bodies for which the appropriate parameters are known.

Table 2 has therefore been constructed relating the radius and mass of various objects within and up to the entire Universe. Scientific notation is used.

Item	Object	Mass (<i>gm</i>)	Radius (<i>cm</i>)	Reference	Notes
1	Universe	1.6E55	5.7E27	5	1
2	Galaxy	1.0E45	3.0E19	5	2
3	Largest Star	2.0E36	1.4E14	5, 7	3
4	Sun	2.0E33	7.0E10	5, 6	
5	Earth	5.4E27	6.3E8	5, 6	
6	Neutron Star	1.0E35	1.0E6	5	
7	Nucleon	1.7E-24	1.4E-13	3	
8	Moon	6.7E25	1.7E8	6	
9	Mercury	3.3E26	2.4E8	9	
10	Mars	6.0E26	3.4E8	9	
11	Venus	4.4E27	6.1E8	9	
12	Uranus	7.9E28	2.5E9	9	
13	Neptune	9.2E28	2.4E9	9	
14	Saturn	5.2E29	6.0E9	9	
15	Jupiter	1.7E30	7.1E9	9	
16	Pluto	1.1E25	1.1E8	10	

Table 2 - Size and Mass of Celestial Objects

Notes to Table 2.

1. Mass. Calculated from the radius in Table 2 and an average density of $2.1E-29 \text{ gm/cm}^3$. The latter is the average density obtained from [2] Eq. (3.24) with a Hubble Constant, (H_0), of $22.6 \text{ Km/sec}/10^6 \text{ L.Y.}$ See Appendix A for details.

Radius. Estimated as $5.7E27 \text{ cm} \equiv 6.03E9 \text{ L.Y.}$, the radius of the Universe at the cosmological time when $H_0 = 22.6 \text{ Km/sec}/10^6 \text{ L.Y.}$. This has been estimated via the process shown in Appendix A.

2. Mass. Taken as the multiple of the estimated number of stars in the Galaxy, (10^{11}), [5], and the mass of the Sun as an average star in the Galaxy, plus an allowance for non-luminous matter, (x 5).

Radius. Taken as equivalent to a sphere of radius equal to the distance of the Sun from the centre of the Galaxy, ($\sim 32 \text{ L.Y.}$),. This incorporates the majority of the surrounding globular clusters.

3. Mass. Taken as typical of the "earliest stars", [7].

Radius. Taken as that of Aurigae B although this star may still be in the (latter) stages of forming and its size may not yet be stable. Further reduction of its diameter may be possible.

Insertion of the mass and radius for items 1 - 8 and 15 from Table 2 into Fig.1 then produces the individual points so labelled. The other entries in Table 2 are discussed later. Interpretation of the graph then results in the comments in the following five Sections.

2.2 The "Law" of the Gravitational Accumulation of Matter.

The first observation concerning Fig.1 is that the points designated 1 to 4, appear to lie on a straight line. That line has been designated B. This suggests that the gravitational accumulation of matter where nuclear fusion is present in the core, may conform to a "law" represented by the equation of this line. Note that point 1 for the entire Universe has been included in this trend despite the fact that its radius is a variable. However, the radius of the Universe used in Fig.1 is that estimated via the process described in Note 1 to Table 2, and in Appendix A. This value is sufficiently close to line B in Fig.1 for its inclusion in the trend line not to produce a significant error. This is so in view of the magnitude of the numbers concerned and the relative "slowness" with which the radius of the Universe is changing. This "coincidence" is explained in Section 2.3. Also it is noted that the use of a straight line makes allowance for the possibility that the radius of the largest star, point 3, may still be reducing as the star continues to evolve.

The equation of line B is,

$$m_g = 5.36 \times 10^{17} \sigma_g^{1.3812} \quad (2.3)$$

From (??), for any such celestial body it is only necessary to determine an estimate of its size in order to obtain an estimate of its mass and/or its average density. However, the axes scales of Fig.1 are extremely coarse and so any prediction using (??) is only accurate to about a factor of 4, (except for point 3 which is accurate to a factor of 9). Nevertheless, because the masses of such celestial bodies is so large, the above degree of inaccuracy is acceptable as an initial estimate.

From Fig.1 it is clear that the planetary data points, 5, 8 and 15 do not lie on line B, and therefore (??) does not apply to planetary sized bodies. To determine whether an alternative empirical relationship to (??) exists for such bodies, Fig.2 has been constructed from all the planetary data of Table 2. Again, although some spread is evident, a clear trend is apparent as shown by the trend line drawn. The equation of this line is

$$\text{LOG}_{10}(m_g) = -0.5684[\text{LOG}_{10}(\sigma_g)]^2 + 12.842\text{LOG}_{10}(\sigma_g) - 41.375 \quad (2.4)$$

Predictions using (??) are accurate to about a factor of 2. A quadratic law has been chosen here for two reasons. Firstly, it clearly fits all the points reasonably well, and secondly it would be expected that its slope should decrease as it converged with line B in Fig.1. This is so because at the exact point of convergence, the planetary mass would then have become sufficiently large for fusion to ignite in the core, and the

mass begin the process of turning into a star. To illustrate this, when (??) and (??) are equated, i.e. the masses produced by both equations are the same, they reduce to

$$-0.5684 [LOG_{10}(\sigma_g)]^2 + 11.461 LOG_{10}(\sigma_g) - 59.104 = 0 \quad (2.5)$$

Eq. (??) has roots of

$$LOG_{10}(\sigma_g) = \frac{-11.461 \pm (131.35 - 134.38)^{1/2}}{-1.1338} \quad (2.6)$$

$LOG_{10}(\sigma_g)$ cannot be complex and so it is assumed that the appearance of the small imaginary term in (??) is due to the inaccuracies in the data used in the plots. Therefore, assume that this small imaginary term can be ignored. Then (??) gives

$$LOG_{10}(\sigma_g) = 10.08 \quad (2.7)$$

which therefore yields

$$\sigma_g = 1.2E10 \text{ cm} \quad (2.8)$$

Inserting (??) into either (??) or (??) then gives for the corresponding mass

$$m_g = 2.1E30 \text{ gm} \quad (2.9)$$

Eqs.(??) and (??) are then the radius and mass at which a planetary body starts to

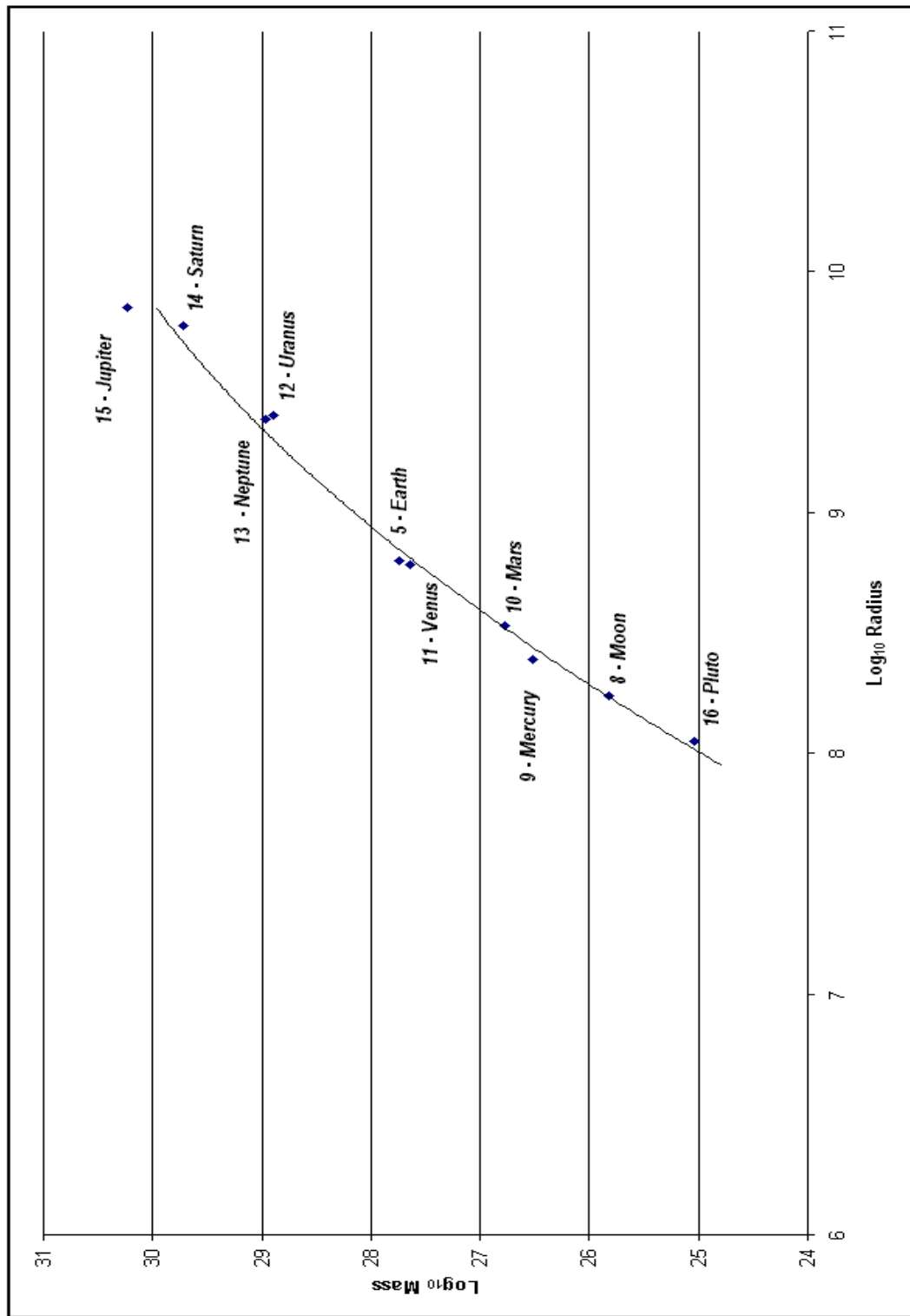


Figure 2: - Planetary Mass to Radius Relationship.

transform into a star. To provide further support for this hypothesis consider the slopes of (??) and (??). First for (??)

$$\frac{d[LOG_{10}(m_g)]}{d[LOG_{10}(\sigma_g)]} = 1.3812 \quad (2.10)$$

and then for (??)

$$\frac{d[LOG_{10}(m_g)]}{d[LOG_{10}(\sigma_g)]} = -1.1368LOG_{10}(\sigma_g) + 12.842 \quad (2.11)$$

When these slopes are equal, equating (??) and (??) produces

$$-1.1368LOG_{10}(\sigma_g) + 12.842 = 1.3812 \quad (2.12)$$

from which

$$LOG_{10}(\sigma_g) = 10.04 \quad (2.13)$$

i.e. virtually the same value as in (??). Therefore, the trend line in Fig.2 is tangential to line B in Fig.1 at the point of convergence.

These laws exist because as matter gravitationally accumulates, the external and internal processes governing its formation, result in its mass/radius relationship, i.e. its average density, moving towards conformance with these curves. The external process is the increasing gravitational compression as the mass grows and, the internal process is the pressure and temperature generated throughout the internal structure in response to this compression. Stability is reached when the external and internal processes balance, and there is no further external material from which the mass can grow. When that occurs the accumulated mass remains on the point of the curve, B in Fig.1 or the trend line in Fig.2, it has reached. Thus, as a planetary mass starts to gravitationally accumulate, its mass/radius ratio will move towards and then up the trend line in Fig.2 until its mass reaches the value given in (??). At that point the internal temperature and pressure have become sufficiently high for nuclear fusion to ignite in the core, and the accumulated mass begins transformation into a star. Further gravitational accumulation of matter causes the mass/radius ratio to move up line B in Fig.1. It is of course not necessary for stars to always form from planetary bodies in this manner. Provided there is a sufficiently vast amount of closely distributed matter available, gravitational accumulation can lead straight into line B of Fig.1 at any point. It is believed that in this manner the accumulation can proceed all the way up to the size of an entire universe where, in phase I of its evolution, complete star systems and galaxies are being gravitationally attracted to the original core.

Note that the mass of the Sun is approximately 1000 times that of (??) and its radius about 5.8 times that of (??). The interesting point is however, if the radius of Jupiter, the largest planet in the Solar System, were only 1.68 times larger and its mass 1.21 times greater, it would be at the point of transforming into a star.

2.3 The Maximum Mass of Gravitationally Stable Accumulated Matter.

During the dissertation in Section 2.2 above, it was stated that the gravitational accumulation of matter could proceed all the way up to the size of a universe, following the law represented by line B in Fig.1. A limit is however reached at the coincidence of lines A and B in Fig.1. At this point the radius of the accumulated matter

equates to three times its gravitational radius. Temporal flow in the core centre stops, and gravitational reversal takes place. Further gravitational accumulation of matter is progressively halted and all material previously gathered is then gravitationally repelled. This was the detailed subject of [2].

From Fig.1 it can be seen that this co-incidence occurs at a mass of approximately $6.0E+53$ gm., and a radius of some $1.3E+26$ cm, ($\sim 4.6E+9$ L.Y.). Both of these values are quite close to those estimated for the Universe. Amounts of gravitationally accumulated matter in excess of the above figures, eventually, due to intrinsic gravitational attraction, develop a physical radius that crosses to the LHS of line A in Fig.1 i.e. contracts to a value less than three times the gravitational radius. It thereby, via the process detailed in [2], starts to generate internal repulsive gravity which eventually results in its complete dispersal. The location of the point representing the Universe in Fig.1 is therefore quite in keeping with the above interpretation, being just 100 times greater in mass. This now explains the conformance of the mass/radius characteristic of the Universe to Line B in Fig. 1 as discussed in Section 2.2

2.4 Black Holes.

In classical Cosmology theory, a black hole is defined as a gravitational source so strong that no material body, nor even electro-magnetic radiation, can escape its gravitational field. In the literature the critical distance from the source below which this occurs is termed the Event Horizon, and from [1], Eq.(4.7) is seen to be when

$$\sigma = 2\alpha \quad (2.14)$$

Thus if the physical radius of a gravitational source is less than, or equal to, twice its gravitational radius, the object is classified as a black hole. However, in the Relativistic Domain Theory of gravitation, it is seen from [2], and this paper, that before a large gravitational source contracts to the "Event Horizon", an earlier critical radius occurs at three times the gravitational radius. At this point it was shown in [2] that internal gravity reverses and becomes repulsive. Also at this point, the temporal rates both inside and outside the source change such that a new critical radius is established at $\sigma = \alpha$, i.e. a radius equal to the gravitational radius, and the apparent critical radius of (??) no longer exists. In a future paper it will be shown that subsequent to the 3α criterion being reached, the source continues to contract to a minimum radius, the point of inflexion, equal to this new criterion, but then immediately starts to expand again under the influence of the repulsive gravity field generated internally. This was partially demonstrated in [2], for the entire Universe. Consequently, subsequent to the gravitational reversal, and the dispersal of the outer layers, the inner core that would be left would probably be degenerate matter in the form of compacted neutrons, i.e. a neutron star as discussed below. Thus, it is clear that within the Relativistic Gravitational Space-Time Domain D_1 , black holes do not exist. Consequently, the most compact astronomical objects within a Relativistic Domain Universe, would be neutron stars.

2.5 The Neutron Star.

The position of the point for this object in Fig.1 is to the left of the line designated A. Consequently, it would be expected that such an object would exhibit an internal repulsive gravitational field. In accordance with [2] Eq.(3.12) the Acceleration Potential

internal to the star would then be

$$A_{i\sigma} = \frac{\gamma m_g}{\sigma_g^3} \sigma_i \quad (2.15)$$

Its external gravitational field would still be attractive with an Acceleration Potential in accordance with [2] Eq(3.16), thus

$$A_\sigma = -\frac{\gamma m_g}{2\sigma^2} \quad (2.16)$$

which is seen to be half the strength of a normal gravitational field.

Neutron stars are purported to be the remnant of a supernova which is said to occur when a large star starts to run out of fusion fuel in the core. Following an initial expansion to a red giant, the ensuing gravitational collapse becomes more and more rapid, as it leads to more and more complex fusion processes, involving the higher elements up to iron. Finally, it is then said to end with the process becoming unstable, thereby culminating in a vast nuclear explosion. The precise reason for the onset of this instability is not clear.

An alternative to the above explanation could be as follows. If the gravitational collapse is sufficiently rapid, and the radius reduces fast enough, as it falls below the 3α limit, the reversal of the gravitational Acceleration Potential could be sufficiently violent that, in addition to the nuclear release of energy in the form of particulate and electromagnetic radiation, the ensuing gravitational expulsion of the outer layers of the star would appear, on an astronomical time scale, similar to a vast nuclear explosion. The final result would be a rapidly expanding shell of high temperature gas, radiation and other debris. In the middle of this would remain the small nucleus of the neutron star now steadily generating the Acceleration Potentials exemplified by (??) and (??) above. Some or all of the expanding shell of gas etc would then either drift out into inter-stellar space or, under the influence of the reduced gravitational field of the neutron star, slowly return to its surface.

The internal repulsive gravitational field of the star would also act to disperse its remaining matter content into inter-stellar space. However, because such objects are purported to be constructed from "neutrons in contact" the strong nuclear force would oppose this and thereby maintain its structural integrity.

2.6 The Nucleon Particle.

Very little need be said about this end of the scale from the gravitational point of view. Clearly the point on Fig.1 representing this particle is very far from any of the lines on Fig's 1 or 2. This is of course an expected result because gravity plays little if any part in the existence of the individual nucleon. The only significant thing that can be said, and the only reason it has been included, is that from Fig.1 it is clearly impossible for particles of this size to exist with internal gravitational fields of a repulsive nature.

3 Concluding Remarks.

The three times gravitational radius criterion that has been investigated in this paper, has been shown to be possibly applicable to more than just the single case of the entire Universe; as was demonstrated in [2]. The characteristics of neutron stars are such that they could also be producing an internal repulsive gravitational field. This must

suggest the additional possibility that much larger celestial bodies other than large stars, i.e. complete galaxies, could also collapse to this state. However, despite the observational sophistication available in the modern era, such events have not been reported. There are several reasons why this may be so.

(i) Many galaxies are rotating and just as in planetary systems, stars making up the outer part of these galaxies may be in stable orbits. Such galaxies would remain in this state for many aeons, despite the possible demise of many stars at the core. In fact many such galaxies may live out their entire lifetime in such a stable state.

(ii) In (i) even if the outer galactic stars were in degenerative orbits, given the time required for such a galaxy to form, the time required for the degenerate star orbits to completely decay, and the time required for the resultant giant core to exhaust its nuclear fuel, may simply mean that potential candidates have not yet reached the said state.

(iii) Where a galaxy had undergone this process, in the latter stages of expansion, (phase II), such an "exploding" galaxy could, depending upon its characteristics before the collapse, exhibit a near spherical shape as the stars making up the outer layers receded from the centre. There are many such galaxies extant within the Universe and because of the relatively short time that they have been observed in sufficient detail, it may be that, if they are in a state of expansion, this has not been recognised.

(iv) In a galaxy that had undergone this event, and was still rotating due to having exhibited this feature before the collapse, under the reduced gravitational field of the core, the outer stars would not rotate as quickly, as in a similar galaxy that had not undergone this process. Slowly rotating outer stars are characteristic of some galaxies and have been explained as possibly due to the gravitational effect of so called dark matter on the periphery of such galaxies. The possibility of a neutron core exhibiting reduced external gravitation should also be considered as an alternative to this explanation.

A further very important consequence of the 3α criteria concerns the possible existence of black holes. In the classical theory, the existence of such objects is predicated upon the physical radius of a large stellar object collapsing below the Event Horizon, a distance of 2α from its centre. As stated in this paper, and as effectively demonstrated in [2], subsequent to the 3α criteria being passed by a collapsing gravitational source, the apparent 2α criteria disappears and a new criterion, exactly equal to the gravitational radius, α , is established. This means that black holes, as defined in the classical theory do not exist in Relativistic Domain Theory. This removes the awkward situation where in classical theory, at the centre of a black hole a singularity can exist, where, according to much of the literature all matter and energy, despite the law of conservation of energy, is crushed out of existence. Therefore the most compact composite matter within the cosmos, apart from the nucleon and similar particles, is the degenerate matter of the neutron stars.

Finally, as part of the above investigation, the mass/radius characteristics of a number of representative celestial bodies was compared with the 3α radius criterion discussed above. It was thus that the possibility of neutron stars generating an internal repulsive gravity field was identified. However, this exercise also identified the two empirical relationships detailed in Section 2.2 governing the gravitational accumulation of matter. It is unlikely that these relationships have not been identified before, however, no reference to them has been found in the literature, although, as is very clear, the literature available to the author is very limited and largely somewhat

antiquated.

It is believed that the gravitational accumulation of matter will always follow these "laws" due to the eventual balance of internal and external forces in action during its formation, i.e. the thermal/fusion process versus gravitational compression. The only exception to this, and then only in the latter stages of formation, is when the accumulated mass exceeds the maximum value determined in Section 2.3 for a gravitationally stable source. Then gravity reversal occurs in the core, resulting in the total mass subsequently gravitationally dispersing.

Using these laws, as exemplified by (??) and (??), Appendix B contains tables of calculated versus actual masses for all the entries in Table 2 together with their ratio errors, i.e. (calculated mass)/(actual mass).

Appendix A

Determination of the Size and Mass of the Universe.

To start this derivation, consider the rate of expansion of the Universe in Phase II of its evolution, exemplified by the recession velocity of a random galaxy, a distance of σ_i from the centre, as given by [2], Eq.(2.22)

$$\dot{\sigma}_i = u_i \left(\frac{\gamma m_u}{\sigma_u^3} \right)^{1/2} \sigma_i \quad (\text{A.1})$$

In [2] this was simplified to

$$\dot{\sigma}_i = H_0 \sigma_i \quad (\text{A.2})$$

where H_0 is the value of Hubble's "constant" at σ_i , and in which u_i had been approximated by unity. In (A.2) the latter approximation can be avoided by using the current empirical value for H_0 , which automatically includes the correct effect for u_i . However, this value applies only at the cosmologically applicable time of τ_C as fully explained in [2], Section 3.5.

Now if (A.2) is to apply to the boundary of the Universe then it becomes

$$\dot{\sigma}_u = H_0 \sigma_u \quad (\text{A.3})$$

and in using the above value of H_0 in (A.3), the spatial gradient effect between σ_i and σ_u , both at τ_C , has been ignored. This is effectively once again assuming $u_i = 1$ over this distance. Thus (A.3) includes the same degree of approximation as was used in [2] to determine the theoretical value of H_0 . Therefore, treating H_0 in (A.3) as a constant, (A.3) can be integrated to give

$$\text{Ln}(\sigma_u) = H_0 \tau_C + k \quad (\text{A.4})$$

where Ln represents Napierian logarithms.

In (A.4) the cosmologically applicable time τ_C is the time the Universe has been expanding from the point of inflexion, and the constant of integration is therefore the Napierian logarithm of the radius of the point of inflexion from the centre. In a next paper it will be shown that this radius is equal to twice the gravitational radius. Thus in (A.4) when $\tau_C = 0$

$$\text{Ln}(2\alpha_u) = k \quad (\text{A.5})$$

which when substituted into (A.4) gives

$$\sigma_u = 2\alpha_u \exp(H_0 \tau_C) \quad (\text{A.6})$$

Eq.(A.6) is a simplified relationship between the radius of the Universe and the time at τ_C in Phase II of its evolution from the point of inflexion. To eliminate α_u in (A.6) substitute

$$\alpha_u = \frac{\gamma m_u}{c^2} = \frac{4\pi\gamma\rho_u\sigma_u^3}{3c^2} \quad (\text{A.7})$$

Eq.(A.6) then becomes

$$\sigma_u = \left(\frac{3c^2}{8\pi\gamma\rho_u \exp(H_0\tau_C)} \right)^{1/2} \quad (\text{A.8})$$

At the time τ_C in (A.8), H_0 is known to be $22.6 \text{ Km/sec}/10^6 \text{ L.Y.}$ for which the corresponding value of ρ_u from [2] Eq.(3.24) is $2.1E-29 \text{ gm/cm}^3$ and all other terms are constants. Thus if τ_C were known, a value of σ_u at τ_C could be calculated. An estimate of τ_C is constructed as follows.

In surveying the recession velocities of the distant galaxies and the density of the Universe, if the range of observations was between say 4 and 8 billion L.Y., and assuming a uniform distribution of observations between that range, then the value of τ_C would be at the median point of the range and can accordingly be estimated to be approximately 6 billion years ago. In [2] it was stated that the evolution of the Universe was probably some 15 billion years into Phase II from the point of inflexion. The cosmologically applicable time in (A.8), τ_C , is then estimated as the difference between the above two numbers, i.e. 9 billion years.

Inserting this value, and those for H_0 and ρ_u above, together with the known values for c and γ as previously stated, into (A.8) then yields

$$\sigma_u = 5.7E27 \text{ cm} \cong 6.03E9 \text{ L.Y.} \quad (\text{A.9})$$

as the radius of the Universe at τ_C . The mass of the Universe can now be calculated using the standard formula to be

$$m_u = \frac{4}{3}\pi\rho_u\sigma_u^3 = 1.65E55 \text{ gm}. \quad (\text{A.10})$$

The values in (A.9) and (A.10) can now be inserted into Table 2.

Finally, as a matter of interest, α_u the gravitational radius of the Universe can now be established as

$$\alpha_u = \frac{\gamma m_u}{c^2} = 1.22E27 \text{ cm} = 1.29E9 \text{ L.Y.} \quad (\text{A.11})$$

It should be noted that all the numbers generated here, are very approximate estimates resulting from approximations in the expressions used and the uncertainties in such parameters as ρ_u , H_0 and τ_C . However, these numbers are so large that errors of even one or two magnitudes are insignificant when used in Table 2 and Fig.1 for the purpose intended.

Appendix B

Ratio Error Tables for Laws Governing the Gravitational

Accumulation of Matter.

These tables have been constructed from (??) and (??) for comparison with the actual values used in Table 2. As such it assumes that the values in Table 2 are correct even though some of these values have been estimated in this paper for other reasons.

(i) Planetary.

Planetary Body	Radius (cm)	Calculated Mass (gm) (Eq.(2.3))	Actual Mass (gm) (Table 2)	Ratio Error (Cal / Act)
Pluto	1.10E+8	1.37E+25	1.10E+25	1.25
Moon	1.70E+8	6.56E+25	6.70E+25	0.98
Mercury	2.40E+8	2.12E+26	3.30E+26	0.64
Mars	3.40E+8	6.53E+26	6.00E+26	1.09
Venus	6.10E+8	3.77E+27	4.40E+27	0.86
Earth	6.30E+8	4.13E+27	5.40E+27	0.76
Neptune	2.40E+9	1.18E+29	9.20E+28	1.29
Uranus	2.50E+9	1.29E+29	7.90E+28	1.64
Saturn	6.00E+9	7.08E+29	5.20E+29	1.36
Jupiter	7.10E+9	9.40E+29	1.70E+30	0.55

(ii) Celestial

Celestial Body	Radius (<i>cm</i>)	Calculated Mass, (<i>gm</i>) (<i>Eq.(2.3)</i>)	Actual Mass, (<i>gm</i>) (<i>Table 2</i>)	Ratio Error (Cal/Act)	Notes
Sum	7.00E+10	4.96E+32	2.00E+33	0.25	
Largest Star	1.40E+14	1.78E+37	2.00E+36	8.91	Radius may still be reducing
Galaxy	3.00E+19	4.05E+44	1.00E+45	0.41	Estimated in this paper
Universe	5.70E+27	1.08E+56	1.65E+55	6.5	Radius at τ_C - Estimated in this paper

Appendix C

Computer Data for FIG's 1 and 2 in Section 2.

The link below provides access to the MS EXCEL spreadsheet used to produce Fig's 1 and 2 in Section 2. Both Figs 1 and 2 are included with the spreadsheet. The spreadsheet itself is essentially a repeat of table 2 with added columns to generate the figures.

3 α gravitational Criterion

The spreadsheet can be downloaded, (at www.relativitydomains.com), for experiment.
Requirements:- MS WINDOWS 95 and MS EXCEL 97, or later.

APPENDIX D - SEDNA

The recently discovered planetoid Sedna, is reported to have a diameter of 1609 km. If this body is a natural gravitational accumulation of matter, (and not the remains of a larger body that has disintegrated), then its mass will conform to (2.4). Accordingly, the mass of Sedna is estimated as **4.21E24 grms**. Comparison with the data presented in Appendix B(ii), shows Sedna to be the smallest body in the Solar System apart from the Asteroids and Comets.

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