Quantum Magnetodynamics' Governance of the Cosmos

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Updated[1]: 30 November 2022

Abstract

Quantum Magnetodynamics is presented as the foundation for Quantum Gravity where the solution realised a perfect unity with the *magnetic* and *electrical fundamental* forces. It also advances a plausible explanation for the existence of dark matter. This conceptual foundation is used to explore the influence of magnetodynamical processes throughout the cosmos, from the evolving conditions in the early universe which ensued from the Big Bang to current compact cosmic objects that are associated with powerful magnetic fields. Magnetodynamical processes would fundamentally reconcile the extreme classical hierarchical scales of the universe, with its structural formations and in their cohesion, to a governing process that originates at the quantum scale.

PACS numbers: 98.80.Qc, 95.35.+d, 97.60.-s, 98.80.Bp

1. Introduction

In the original theoretical presentation [1], assessments of *quasi*-magnetic monopoles, experimentally discovered in tetrahedral crystal structures of spin ices [2–3], show them to exhibit conformity with the theoretical particles that Paul Dirac theorised to retain duality symmetry between the electromagnetic unified fields. During deliberation into the magnetic force led to the serendipitous insight that the existence of gravitons would consist of magnetic monopole dual particles, which self-organise into theoretical 'Gravity Strands' – the *modus operandi* as to the *vera causa* of the gravitational force. A theoretical premise readily developed, from which evolved a solution for quantum gravity in perfect unity with *magnetic* and *electrical fundamental* forces, thereby forming a foundation for Quantum Magnetodynamics.

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[1] This work, originally conceived in May 2009, has been updated based on ongoing development and enhancements to openly and transparently communicate its evolving progress.

1.1 Theoretical premise

The theoretical premise is based on the reasoning that magnetic monopoles would emanate from non-confinement in QCD (in furtherance of [4]); as cause, the by-product of quark/gluon interactions. The effect would be continuous streams of oppositely charged magnetic monopole *graviton* particles expelled from nucleons in opposite directions along the axes of spin. [1] The natural pairing of nucleons in up/down spin orientations enable their streams of gravitons to self-organise into *gravity strands* of alternating charged particles, thereby initiating a gravitational force (see figure 1.1). The force of attraction manifests due to continuous head-on attractions and annihilations of alternating pairs of oppositely charged gravitons. [2] Single/unpaired nucleons (or paired nucleons where protons' spin orientations readily invert in response to an electrical or magnetic field or magnetised state) produce gravitons with the same charge flowing in the same direction, thereby instigating a magnetic force [3] (see figure 1.2). The gravitational and magnetic forces are normally distinct in that they retain non-interaction, [4] whereas their interchangeability would formalise in unification: in Gravitomagnetic unified fields.

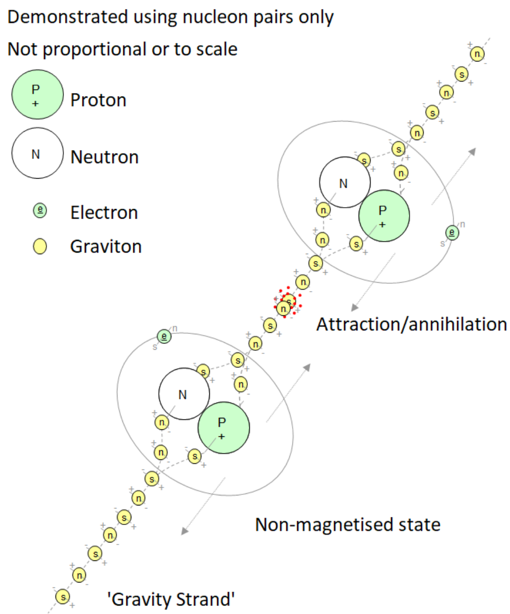

Figure 1.1: Gravitational force

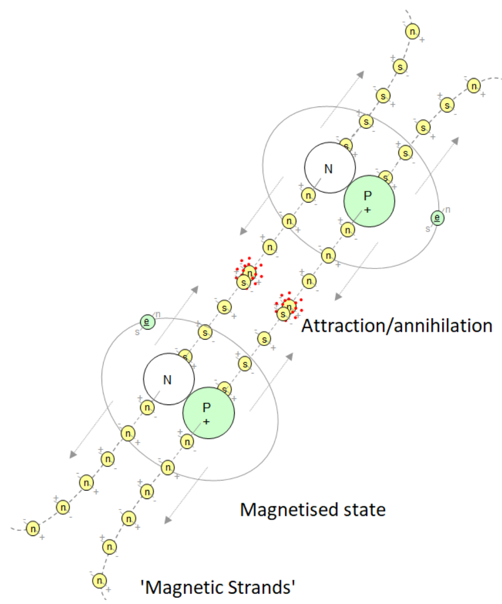

Figure 1.2: Magnetic force

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[1] It defines all forms of hadronic matter as the only sources of gravitons. This would attribute the mass of black holes to extremely dense quark-matter interiors. Correspondingly, neutron stars' sources of gravitons would originate from the neutron constituents of these stars. Gravitons' duality utilisation would thus explain both the very strong gravitational and magnetic fields of these compact cosmic objects. Regarding particles, only nucleons (as the only stable hadron particles) can have gravitational interactions to the exclusion of all other subatomic particles.

[2] It infers that gravitons are paired gauge bosons, comprising of a monopole and an antimonopole of opposite charges, which facilitates annihilation – releasing, if not initially, Dark Photons [5]. Head-on attraction/annihilation of leading particles, in converging gravity strands, exposes the next pair of oppositely charged particles in continuation of the process. The pulling force generated by the leading particles is transferred via each opposing strand formation to the source objects.

[3] It produces plausibility that lines of magnetic flux, when made visible, are displaying monopoles with the same charge in traceable streams that curve progressively apart by their mutual repulsion (and where oppositely charged streams meet in head-on attraction/annihilation [6]). It can be deduced that the magnetic monopole will have an electric moment, enabling interaction by the interconnection of fields between magnetic monopoles in magnetic strands and electrically charged subatomic particles. In gravity strands, the overall effects of electric moments and magnetic charges are neutralised throughout the length of each strand with only the leading particle retaining a net surplus magnetic charge.

[4] Exception arises within very powerful magnetic fields resulting in localise interference of gravity strand activity [7].

1.2 Intermolecular forces

In summary, quantum gravitational interactions correlate with the mass densities of individual elements and substances, in the requisite form of their relative equivalent Specific Density: [1]

$$R_{\rho} = \frac{\rho}{un} \quad \text{kg·m}^{-3}\text{·u}^{-1} \tag{1.20}$$

where ρ = mass density, u = atomic mass units and n = molecular element number (the number of atoms that form a molecular element, else 1). Precise molar volume (in kmol units) is established from the reciprocal of specific density:

$$R_{v} = \frac{1}{R_{\rho}} \quad \text{kg}^{-1}\text{·m}^{3}\text{·u} \quad \text{or} \quad \text{m}^{3}\text{·kmol}^{-1} \tag{1.21}$$

Statistically, there is a direct correlation between molar volume and the interactive strengths of electrical and gravitational forces. It is referred to as the Mean Interactive Molecular Distance:

$$\langle d \rangle = \sqrt{MR_{v}} \quad \text{m} \tag{1.22}$$

where constant $M = e^2/2\pi\varepsilon_0 G$ kg·m^{-1}·u^{-1}. The electrostatic repulsion (e^- - e^- or ion$^+$ - ion$^+$) between atomic particles is the fundamental Coulomb interaction:

$$F_{\text{e}} = \frac{e^2}{4\pi\varepsilon_0 \langle d \rangle^2} \tag{1.23}$$

Disclosed in the theoretical premise, the gravitational force is instigated by gravitons self-organising into gravity strands and culminate in their distinct multi-vectorial outward radiation from atomic nuclei. The attraction/annihilation of gravitons in the mediation of the gravitational force, of individual opposing gravity strands between two atomic nuclei, produces the resultant Gravitational interaction:

$$F_{\text{g}} = -\frac{GR_{\rho}}{2} \tag{1.24}$$

The opposing Coulomb and Gravitational interactions then attain equilibrium that will maintain the position of atomic particles within the heterogeneity (topology) of matter:

$$F_{\text{e}} - F_{\text{g}} = 0 \tag{1.25}$$

It is deduced that, atomically, solids are consolidated by a high proportion of continuous alignment of gravity strand interactions between atomic nuclei. Whereas, in the liquid state, and to a greater extent in the gaseous state, such proportion is respectively lower being replaced with continual intermittent interaction of gravity strands; as consequential of molecular kinetic motion. The strengths of all gravity strand interactions are concluded to be inversely proportional to molecular kinetic energy, which is dependent upon temperature [1].

[1] A dimensionless unit, u, was assigned to atomic mass units in order to notate a distinction between mass density and specific density.

2. Connecting the hierarchical scales

2.1 A fundamental principle of mass

Taking Einstein's famous equation in relation to the rest mass-energy of particles and in breaking it down into its components:

$$E_0 = m_0 c^2 = \frac{3V_0 \hbar^{-1/2}}{\mu_0 \varepsilon_0} \tag{2.10}$$

where the mass-energy correlative element, c^2, arises from the reciprocal of the product of vacuum permeability, μ_0, and vacuum permittivity, ε_0:

$$c^2 = \frac{1}{\mu_0 \varepsilon_0} \tag{2.11a}$$

It remains that the rest-mass element is:

$$m_0 = 3V_0 \hbar^{-1/2} \tag{2.11b}$$

and accordingly, particle density is: [1]

$$\rho_0 = 3\hbar^{-1/2} \tag{2.11c}$$

It will establish that particle density is relativistically constant. Particles' volumetric size – distinct or relativistic variant – is then determined by the quanta of energy carried as verified by Planck-Einstein formula $E = hf$:

$$V_0 f \rho_0 c^2 = hf \tag{2.12}$$

where $\hbar$ and h are Planck constants and f = wave frequency. (This would question the notion of massless particles [8], but is not the purpose of this topic.) What is important is that the densities of particles are identical and invariant, thereby inferring density has reached a finite universal limit: an absolute density or, to be more specific, the limit to which energy can be concentrated, where, as a consequence, energy has condensed into the manifestation of mass.

Particle	Measured Rest-Mass (MeV)	Rest-Mass m_0 (kg)	Absolute Density ρ_0 (kg·m^{-3})	Volume V_0 (m^3)	Calculated Radius $\sqrt[3]{3V_0/4\pi}$ (m)	Measured ~ Radius (m)	Rest Mass-Energy $E_0 = V_0\rho_0 c^2$ (J)	Rest Mass-Energy $E_0 = m_0 c^2$ (J)	Particle Energy Density (J·m^{-3})
Photon, Neutrino, Gluon and Magnetic Monopole (Graviton):	4.14E-21	7.3725E-51	2.9213E+17	2.5237E-68	1.8196E-23		6.6261E-34	6.6261E-34*	2.6256E+34
Ditto, associated Dark Photon [5]:	~ 8.40E-20	1.4974E-49	2.9213E+17	5.1258E-67	4.9647E-23		1.3458E-32	1.3458E-32	2.6256E+34
Electron:	0.5109989	9.1094E-31	2.9213E+17	3.1182E-48	9.0630E-17	9.0647E-17	8.1871E-14	8.1871E-14	2.6256E+34
Proton:	938.27205	1.6726E-27	2.9213E+17	5.7255E-45	1.1098E-15	1.1100E-15	1.5033E-10	1.5033E-10	2.6256E+34
Neutron:	939.56538	1.6749E-27	2.9213E+17	5.7334E-45	1.1103E-15		1.5053E-10	1.5053E-10	2.6256E+34
Up Quark:	2.3	4.1001E-30	2.9213E+17	1.4035E-47	1.4964E-16		3.6850E-13	3.6850E-13	2.6256E+34
Down Quark:	4.8	8.5568E-30	2.9213E+17	2.9291E-47	1.9123E-16		7.6904E-13	7.6904E-13	2.6256E+34
Top Quark:	1.71E+05	3.0521E-25	2.9213E+17	1.0448E-42	6.2947E-15		2.7431E-08	2.7431E-08	2.6256E+34

Key: [*Variant m*, *Theoretical*] - *travel at c*, Elementary, Composite

[**Demonstrated at the Planck discrete unit (quantum) of energy, h, thereby, determines minimum particle rest-mass and size.*]

Figure 2: Sample of the particle zoo
(Numerical values: acquired data, calculated results.)

As energy can neither be created nor destroyed, Eqn. 2.11a in conjunction with Eqn. 2.11c vindicates that the origin of the energy in Einstein's equation is in the vacuum wherein vacuum energy density is equivalent to $1/c$ J·m^{-3}. It will deduce that the quantum arises at the Planck scale from the discrete granularity of energy where nothing is more fundamental. The perpetual existence of vacuum energy is to be regarded as eternal and infinite and, profoundly, the genesis to everything that exists.

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[1] $3\hbar^{-1/2}$ = 2.9213 x 10^{17} kg·m^{-3}, which equates to a staggering 292 trillion t·m^{-3}.

2.2 Black holes

When a dying star collapses in a supernova, and the mass density of the remnant core exceeds the Tolman-Oppenheimer-Volkoff limit for neutron degeneracy pressure, the object left is a stellar black hole. It is defined in relation to the premise that hadronic matter is the only source of gravitons. It can be reasoned that, for black holes to emit gravitons, the consistency of their interiors must allow quark/gluon interactions; therefore, the most plausible explanation for their interiors would be the existence of an extremely dense quark-gluon plasma or, in this context, as superfluid quark matter [9]. Accepting the assumption of absolute density as the density of this quark matter, then together with the established mass of a black hole can be used to determine its volume and surface radius; whereas, its event horizon is determined by the Schwarzschild radius:

$$r_s = (2Gm)/c^2 \tag{2.20}$$

If the mass of a black hole is less than eight solar masses, its event horizon will be below the surface; it will then be contingent on the ability of quark-matter to absorb, emit or scatter photons as to whether the black hole and its surface is visible. It is postulated that all black holes are ultimate composite particles (i.e., quark matter at absolute density). Technically, they are then deemed as quark stars.

Regarding the assumption that a black hole forms a singularity, an infinitesimal dense volume presents an implausible entity, whereby the fundamental physical laws break down, and all known forces in their current form would be negated, which includes gravity (as, without quarks and gluons, there can be no gravity).

2.3 In modelling electron, neutron and quark degeneracy pressures

Below, are three refined equations of state [10], which produce related mean values in respect to cosmic objects. The radius, in metres, for a white dwarf or neutron star:

$$R = \left(\frac{81\pi^2}{512}\right)^{1/3} \frac{r\, s\, \hbar^2}{Gm_x M_u^2} N^{-1/3} \tag{2.30}$$

Where:
r, a constant applicable to neutron stars, is 3.12049069.
s, the spin scale applied to neutron stars only. It accounts for the centrifugal force, generated by rapid spinning, which counters to a degree the gravitational force and assist the neutron degeneracy pressure in supporting more mass, with corresponding increase in radii. This is clarified later.
m_x is substituted with either m_e, election mass, for objects up to and including white dwarf stars or m_u, neutron mass, for neutron stars (also applicable for the quark matter in black holes).
M_u, the atomic mass constant.
$N = m/M_u$ the total number of nucleons comprising in the object – derived from the object's mass being inversely proportional to the atomic mass constant.

The electron (or neutron or quark) degeneracy pressure – *resulting from molecular repulsion* – is in pascals:

$$p_e = s\frac{\pi^3\hbar^2}{15m_x}\left(\frac{3NN_e}{\pi}\right)^{5/3} V^{-5/3} \tag{2.31}$$

Where:
N_e, the electron fraction (protons to neutrons), if unknown, then assume 0.5. For neutron stars and black holes, the fraction is inverted and equals 1.
V, the volume of the object.

The gravitational pressure – *resulting from molecular attraction* – within white dwarf or neutron stars:

$$p_g = -\frac{1}{5}Gm^2\left(\frac{4\pi}{3}\right)^{1/3} V^{-4/3} \tag{2.32}$$

where m, the mass of the star. In ordinary condensed-matter objects where, as a consideration, there is atomic structuring, p_g cannot be calculated in such a direct way but, as demonstrated later, be determined from the mean quantum construct of the objects. The stability of all cosmic objects is due to their opposing pressures being in equilibrium, and therefore are equivalent: $p_e - p_g = 0$.

A close on correlation between a cosmic object's physical volume and its mean interactive volume can be attributed to either pressure. With respect to the above equivalence:

$$v = \left(\frac{1}{5}\frac{GQ}{p_e}\right)^{3/4}\left(\frac{4\pi}{3}\right)^{1/4} \tag{2.33}$$

where Q is the correlation constant.

Amongst astrophysicists, there remains uncertainty regarding the maximum mass and minimum diameter for a neutron star. Furthermore, their calculations on all observed neutron stars with different masses produce diameters that result in these stars' mean mass densities exceeding absolute density, which is only tenable if the black hole singularity is also deemed a tenable reality.

To continue, a crucial constraint will therefore be imposed: the postulation that absolute density – the limit to which energy can be concentrated – as derived in Eqn. 2.11c, cannot be exceeded.

The spin scale for neutron stars is dependent on the rate of spin which is different for each star. For a non-spinning neutron star $s = 1$. A rapidly rotating millisecond pulsar called PSR J0740+6620 has been detected and astrophysicists believe this star approaches the limit to how massive a neutron star can become before ultimately collapsing into a black hole: with a mass of $2.072^{+0.067}_{-0.066}\ M_\odot$ and a ascertain diameter of $24.78^{+2.60}_{-1.96}$ km [11]. Again, this ascertainment results in a mean density that exceeds absolute density by 1.77 orders of magnitude. This millisecond pulsar has a spin frequency of 346 Hz, which when converted to the spin scale sets $s = 1.7791$ (see Model 3) and this is a contributory factor to the final diameter. In modelling this pulsar using the given mass and within the density constraint, the equations of state produced a diameter of 34.43 km and a consequential mean density at sixty-six per cent of absolute density. As presented in model 1, in complying with this density constraint will naturally dispute the diameter astrophysicists ascertained for this pulsar.

G	6.673848000E-11
$M_\odot$	1.988500000E+30
M_u	1.660539040E-27
m_u	1.674927351E-27
m_e	9.109382910E-31
$\hbar$	1.054571726E-34
e	1.602176621E-19
ε_0	8.854187817E-12
M	6.913785010E-18
M_A	6.022140760E+23
Q	2.896039500E-16

Figure 3: Constants

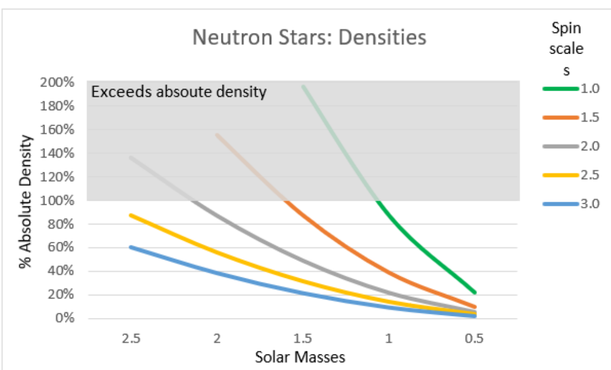
	White dwarf	Neutron star	Black Hole (Min.)	Black Hole (Largest)
ʘ Masses	1.44	2.072	1.06	6.60E+10
Mass	2.8634E+30	4.1202E+30	2.1078E+30	1.3124E+41
M.Radius	6.4182E+06	1.7215E+04	1.1987E+04	4.7512E+07
Volume	1.1075E+21	2.1370E+13	7.2152E+12	4.4925E+23
M.Density	2.5856E+09	1.9280E+17	2.9213E+17	2.9213E+17
N	1.7244E+57	2.4599E+57	1.2584E+57	7.8356E+67
Ne	50.0000%	100.0000%	100.0000%	100.0000%
Pe	1.5397E+22	6.1593E+32	6.9201E+32	6.9201E+32
Pg	-1.5397E+22	-6.1593E+32		

Model 1: White dwarf, neutron star and black holes

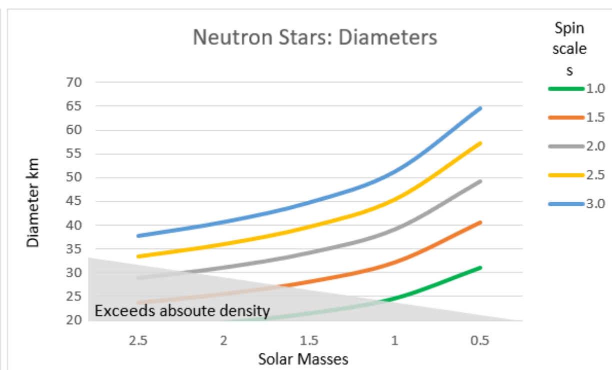
With a projected upper limit with respect to the mass of neutron stars, it has presented astrophysicists with a so-called *mass gap*; as to what types of objects exist between the maximum size for a neutron star and the minimum size for a stellar black hole. Model 1 show, for any mass and size of a black hole, the quark degeneracy pressure is consistent and, therefore, will deduce two implications: firstly, such pressure is trivial, and secondly, gravitational pressure cannot overcome the energy density of quark matter; in that this matter cannot be condensed any further. At a neutron star's core where density reaches equivalence to absolute density, the constituent neutron particles will become so compressed they will progressively collapse into their component quarks that behave independently and which forms quark matter [9]. Any progressive transition of neutron-rich matter into quark matter will not involve a nova or a sudden collapse.

Quark matter composing of only up and down quarks has a high Fermi energy and is unstable. The Bodmer-Witten conjecture is that quark matter will gravitate towards its lowest-energy state by conversion of some of the down quarks into the next generation heavier strange quarks, which will then dramatically stabilise the quark matter [12].

It is presumed that the majority of neutron stars will contain a quark-matter core to some degree. The size of their quark-matter core, as a percentage to the star's size, will be dependent on the percentage of the star's mean density to absolute density. Model 2.a, demonstrates these percentages and model 2.b, the resulting diameters.



Model 2.a



Model 2.b

In a situation where a neutron star acerates matter from a stellar binary companion, the continuing increase in the star's mass will correspondingly increase its internal gravitational pressure, which proportionally increases the mean density. If the neutron star ultimately achieves a mean density equivalent to absolute density, then the star will have completely transformed into a stellar black hole. In further assessment, if the mean density of a neutron star was to approach $\langle\rho\rangle/\rho_0 = {M_\odot}^{-1/2}$ in relation to the $M_\odot$ of the star, then its internal gravitational pressure would correspondingly be approaching equivalents to the internal gravitational pressure of black holes. Therefore, it is logical to assume, that with such high internal gravitational pressure and an extensive quark-matter core, the neutron star's degeneracy pressure, produced by the remaining neutron-rich matter, is barely sustaining integrity and if this integrity is surpassed, as a result of continuing increase in mean density, would be consequential in the neutron star's rapid transformation into a black hole.

Theoretically, it is modelled that a non-spinning neutron star – whose existence has low probability – can undergo transformation into the minimum mass for a stellar black hole at 1.06 $M_\odot$. Model 3 illustrates an array of the maximum solar masses' neutron stars can achieve at incremental points on the basic spin scale, S_0, where on achieving this maximum mass will transcend the stability of the neutron star, i.e., $\langle\rho\rangle/\rho_0 > M_{\odot}{}^{-1/2}$, and, therefore, has transformed into a black hole.

Spin Table			Transformation		
Basic Spin Scale S_0	Min. Spin f_L (Hz)	Max. Spin f_H (Hz)	Max. Solar Masses	Black Hole Diameter (km)	% Absolute Density @ Transition
1.0	<0	0	1.06	23.95	97.43%
1.1	1	22	1.14	24.57	93.92%
1.2	23	44	1.22	25.15	90.83%
1.3	45	67	1.31	25.70	88.07%
1.4	68	91	1.39	26.22	85.60%
1.5	92	115	1.47	26.71	83.36%
1.6	116	140	1.54	27.18	81.31%
1.7	141	166	1.62	27.62	79.44%
1.8	167	193	1.70	28.05	77.71%
1.9	194	222	1.77	28.46	76.11%
2.0	223	252	1.85	28.86	74.63%
2.1	253	284	1.92	29.24	73.24%
2.2	285	318	2.00	29.61	71.94%
2.3	319	355	2.07	29.97	70.72%
2.4	356	394	2.14	30.31	69.57%
2.5	395	436	2.21	30.65	68.49%
2.6	437	482	2.29	30.97	67.46%
2.7	483	531	2.36	31.29	66.49%
2.8	532	584	2.43	31.60	65.57%
2.9	585	642	2.50	31.90	64.69%
3.0	643	705	2.57	32.19	63.85%
3.1	706	773	2.63	32.47	63.05%
3.2	774	846	2.70	32.75	62.28%
3.3	847	926	2.77	33.03	61.55%
3.4	927	1,012	2.84	33.29	60.85%
3.5	1,013	1,105	2.91	33.55	60.18%
3.6	1,106	1,206	2.97	33.81	59.53%
3.7	1,207	1,316	3.04	34.06	58.90%
3.8	1,317	1,434	3.11	34.30	58.30%

Model 3: The transformation of neutron stars into black holes

Conversion of the neutron star's spin frequency, f, to a spin scale, s, required by the equations of state, is calculated from the data expressed in the Spin Table of Model 3:

$$s = \left(S_0 + \frac{f - f_{\mathrm{L}}}{1 + f_{\mathrm{H}} - f_{\mathrm{L}}} 0.1\right)^{2/3} \tag{2.34}$$

An interesting pulsar, PSR J1748−2446ad with a spin frequency of 716 Hz is the fastest-spinning pulsar so far discovered. It has an estimated mass of less than two solar masses and with an intriguing submitted conclusion that 'its radius is constrained by the spin rate to be < 16 km' [13]. This has raised an important question: if neutron stars are constrained by a maximum spin frequency?

$$f_{max} = \left(\frac{Gm}{4\pi^2 R^3}\right)^{1/2} \tag{2.35}$$

The conclusion to this question is that a neutron star's spin frequency is initially established as it forms from the supernova. If this spin frequency slightly exceeds a maximum spin frequency, the neutron star may potentially stabilise if it developed an equatorial bulge. Otherwise, the alternative is that the excessive centrifugal forces will overcome the gravitational force causing the newly forming neutron star to totally disintegrate. For the above pulsar, were its mass to be below 1.66 $M_{\odot}$, then its spin frequency would have been greater than its maximum spin frequency and, therefore, the concluding constraint would have applied. The circumstances are reversed with greater mass where the $M_{\odot}{}^{-1/2}$ aspect becomes the constraining factor. In applying the equations of state to PSR J1748−2446ad, with its established spin scale, $s = 2.1328$, is modelled at different solar masses:

Solar Masses	Diameter (km)	% Absolute Density	% Absolute Density Max.	Max. Spin Frequency f_{max} (Hz)
1.65	44.40	24.5%	77.8%	712
1.75	43.54	27.6%	75.6%	755
1.85	42.74	30.8%	73.5%	798
1.95	42.00	34.2%	71.6%	841
2.65	37.91	63.2%	61.4%	11,444
(2.65	32.54	100.0%	- Transformed into a black hole)	

Model 4: PSR J1748−2446ad at 716 Hz

In an overall conclusion, taking into account all constraints, it is then feasible for extremely rare ultra-rotating neutron stars to approach three solar masses – the maximum modelled was 2.935 $M_{\odot}$ at 1,098 Hz. Whereas, a theoretical minimum mass for a stellar black hole is 1.06 $M_{\odot}$. Thereby, the objects that will coexist in a so-called mass gap will include rare maximal mass neutron stars together with evolving mergers of minimal mass black holes; where those of less than eight solar masses, their event horizons will be below the surface and, as stated in section 2.2, is in question as to whether they are visible.

As an exercise, the equations of state are applied to the principal cosmic objects of the solar system, as presented in model 5.

	Pluto	Neptune	Uranus	Saturn	Jupiter	Mars	Earth	Moon	Venus	Mercury	Sun
Mass	1.3030E+22	1.0241E+26	8.6810E+25	5.6834E+26	1.8982E+27	6.4171E+23	5.9724E+24	7.3420E+22	4.8675E+24	3.3011E+23	1.9885E+30
M.Radius	1.1883E+06	2.4622E+07	2.5362E+07	5.8232E+07	6.9911E+07	3.3895E+06	6.3710E+06	1.7374E+06	6.0518E+06	2.4397E+06	6.9570E+08
Volume	7.0286E+18	6.2526E+22	6.8334E+22	8.2713E+23	1.4313E+24	1.6312E+20	1.0832E+21	2.1968E+19	9.2842E+20	6.0827E+19	1.4104E+27
M.Density	1.8539E+03	1.6379E+03	1.2704E+03	6.8712E+02	1.3262E+03	3.9341E+03	5.5135E+03	3.3422E+03	5.2428E+03	5.4270E+03	1.4098E+03
N	7.8468E+48	6.1675E+52	5.2278E+52	3.4226E+53	1.1431E+54	3.8645E+50	3.5966E+51	4.4215E+49	2.9313E+51	1.9880E+50	1.1975E+57
Ne	50.0000%	88.5000%	91.7375%	98.1936%	94.2028%	50.0000%	50.0000%	50.0000%	50.0000%	50.0000%	86.6743%
Pe	8.8438E+11	1.8633E+12	1.2953E+12	5.2090E+11	1.4544E+12	3.0992E+12	5.4395E+12	2.3617E+12	5.0017E+12	5.2980E+12	1.4017E+12

Model 5: Principal cosmic objects of the solar system

The electron fraction (protons to neutrons), N_e, as a percentage, is either assumed to be fifty per cent for cosmic objects where their composition is unknown or else obtained as illustrated in figure 4, where the composition of the Sun is used as an example.

Sun	*u*	*n*	*Ne*	% by mass	*u*	*n*	*Ne*
Hydrogen (H_2)	1.007941	2	100.0000%	73.46%	1.48086692	1.4692	73.4600%
Helium	4.002602	1	50.0000%	24.85%	0.9946466	0.2485	12.4250%
Oxygen (O_2)	15.999405	2	50.0000%	0.77%	0.24639084	0.0154	0.3850%
Carbon	12.010736	1	50.0000%	0.29%	0.03483113	0.0029	0.1450%
Iron	55.845150	1	46.4286%	0.16%	0.08935224	0.0016	0.0743%
Neon	20.180046	1	50.0000%	0.12%	0.02421606	0.0012	0.0600%
Nitrogen (N_2)	14.006743	2	50.0000%	0.09%	0.02521214	0.0018	0.0450%
Silicon	28.085413	1	50.0000%	0.07%	0.01965979	0.0007	0.0350%
Magnesium	24.305052	1	50.0000%	0.05%	0.01215253	0.0005	0.0250%
Sulphur	32.066085	1	50.0000%	0.04%	0.01282643	0.0004	0.0200%
			Sum Totals:	99.90%	2.94015467	1.7422	86.6743%

Figure 4: Composition of the Sun

Developing on from the theoretical premise for quantum gravity, the coulomb and gravitational interactions between atoms and molecules of different elements and substances, together with other quantum aspects, were derived from their molecular properties, as demonstrated in figure 5.

Element/ Substance	Ne	Atomic Mass Units u	Molecular Element Number n	Mass Density ρ (kg m^{-3})	Specific Density $R_\rho = \frac{\rho}{un}$ (kg m^{-3} u^{-1})	Molar Volume $R_v = \frac{1}{R_\rho}$ (m^3 kmol^{-1})	Mean Interactive Molecular Distance $\langle d \rangle = \sqrt{MR_v}$ (m)	Coulomb Interaction $F_e = \frac{e^2}{4\pi\varepsilon_0 \langle d \rangle^2}$ (N)	Gravitational Interaction $F_g = -\frac{GR_\rho}{2}$ (N)	Gravitational Pressure $p_g = \frac{4F_g}{\langle d \rangle^2}$ (Pa)	Mean Interactive Volume $v = \frac{4}{3}\pi\langle d \rangle^3$ (m^3)
Hydrogen H_2 (273 K)	100.0000%	1.007941	2	0.0899	0.044596	22.423604	1.245E-08	1.488E-12	-1.488E-12	-3.840E+04	8.086E-24
Helium (273 K)	50.0000%	4.002602	1	0.1785	0.044596	22.423541	1.245E-08	1.488E-12	-1.488E-12	-3.840E+04	8.086E-24
Oxygen O_2 (273 K)	50.0000%	15.999405	2	1.429	0.044658	22.392449	1.244E-08	1.490E-12	-1.490E-12	-3.850E+04	8.069E-24
Oxygen O_2 (90 K)	50.0000%	15.999405	2	1140	35.62632	0.028069	4.405E-10	1.189E-09	-1.189E-09	-2.450E+10	3.581E-28
Carbon (300 K)	50.0000%	12.010736	1	2260	188.1650	0.005314	1.917E-10	6.279E-09	-6.279E-09	-6.835E+11	2.950E-29
Diamond (300 K)	50.0000%	12.010736	1	3520	293.0711	0.003412	1.536E-10	9.780E-09	-9.780E-09	-1.658E+12	1.518E-29
Aluminium (300 K)	48.1481%	26.981538	1	2700	100.0684	0.009993	2.629E-10	3.339E-09	-3.339E-09	-1.933E+11	7.607E-29
Iron (300 K)	46.4286%	55.845150	1	7874	140.9970	0.007092	2.214E-10	4.705E-09	-4.705E-09	-3.838E+11	4.548E-29
Mercury (300 K)	39.8010%	200.59915	1	13550	67.54764	0.014804	3.199E-10	2.254E-09	-2.254E-09	-8.809E+10	1.372E-28
Water (277 K)	55.5556%	18.015287	1	999.973	55.50691	0.018016	3.529E-10	1.852E-09	-1.852E-09	-5.948E+10	1.841E-28

Figure 5: Examples of the quantum aspects instrumental in elements and substances

The process of deriving the quantum aspects for the elements and substances can be applied to cosmic objects by calculating in an initial reverse procedure from the mean interactive volume, as determined by Eqn. 2.33. The quantum aspects, disclosed by this process for such objects, are shown to be in perfect harmony with both the equations of state and with the theoretical facets of quantum gravity.

Cosmic Object	Ne	Atomic Mass Units $u = \frac{\rho}{nR_\rho}$	Molecular Element Number n	Mass Density ρ (kg m^{-3})	Specific Density $R_\rho = \frac{M}{\langle d \rangle^2}$ (kg m^{-3} u^{-1})	Molar Volume $R_v = \frac{1}{R_\rho}$ (m^3 kmol^{-1})	Mean Interactive Molecular Distance $\langle d \rangle = \sqrt[3]{3v/4\pi}$ (m)	Coulomb/ Pauli Exclusion Interaction $F_e = \frac{e^2}{4\pi\varepsilon_0 \langle d \rangle^2}$ (N)	Gravitational Interaction $F_g = -\frac{GR_\rho}{2}$ (N)	Gravitational Pressure $p_g = \frac{4F_g}{\langle d \rangle^2}$ (Pa)	Mean Interactive Volume v (m^3)	Degeneracy pressure p_e (Pa)
Pluto	50.0000%	8.661712	1	1853.8625	214.0296	0.004672	1.797E-10	7.142E-09	-7.142E-09	-8.844E+11	2.432E-29	8.844E+11
Neptune	88.5000%	3.030028	1.74	1637.9344	310.6710	0.003219	1.492E-10	1.037E-08	-1.037E-08	-1.863E+12	1.391E-29	1.863E+12
Uranus	91.7375%	2.681543	1.829	1270.3712	259.0193	0.003861	1.634E-10	8.643E-09	-8.643E-09	-1.295E+12	1.827E-29	1.295E+12
Saturn	98.1936%	2.131291	1.96273	687.1230	164.2602	0.006088	2.052E-10	5.481E-09	-5.481E-09	-5.209E+11	3.617E-29	5.209E+11
Jupiter	94.2028%	2.565696	1.88326	1326.2238	274.4741	0.003643	1.587E-10	9.159E-09	-9.159E-09	-1.454E+12	1.675E-29	1.454E+12
Mars	50.0000%	9.818942	1	3934.0809	400.6624	0.002496	1.314E-10	1.337E-08	-1.337E-08	-3.099E+12	9.495E-30	3.099E+12
Earth	50.0000%	10.387133	1	5513.5224	530.8031	0.001884	1.141E-10	1.771E-08	-1.771E-08	-5.439E+12	6.227E-30	5.439E+12
Moon	50.0000%	9.555686	1	3342.1529	349.7554	0.002859	1.406E-10	1.167E-08	-1.167E-08	-2.362E+12	1.164E-29	2.362E+12
Venus	50.0000%	10.300337	1	5242.8043	508.9935	0.001965	1.165E-10	1.698E-08	-1.698E-08	-5.002E+12	6.631E-30	5.002E+12
Mercury	50.0000%	10.359790	1	5427.0121	523.8535	0.001909	1.149E-10	1.748E-08	-1.748E-08	-5.298E+12	6.351E-30	5.298E+12
Sun	86.6743%	3.003224	1.7422	1409.8437	269.4544	0.003711	1.602E-10	8.991E-09	-8.991E-09	-1.402E+12	1.722E-29	1.402E+12
White dwarf	50.0000%	91.555343	1	2.586E+09	2.824E+07	3.541E-08	4.948E-13	9.424E-04	-9.424E-04	-1.540E+22	5.074E-37	1.540E+22
Neutron star	100.0000%	34134.556	1	1.928E+17	5.648E+12	1.770E-13	1.106E-15	1.885E+02	-1.885E+02	-6.159E+32	5.673E-45	6.159E+32
Black Hole (Min.)	100.0000%	48794.656	1	2.921E+17	5.987E+12	1.670E-13	1.075E-15	1.998E+02	-1.998E+02	-6.920E+32	5.198E-45	6.920E+32
Black Hole (Largest)	100.0000%	48794.656	1	2.921E+17	5.987E+12	1.670E-13	1.075E-15	1.998E+02	-1.998E+02	-6.920E+32	5.198E-45	6.920E+32

Model 6: Quantum construct of cosmic objects
(Note: Values for each object are related mean values.)

2.4 Compact cosmic objects associated with powerful magnetic fields

The duality utilisation of gravitons that culminate in gravitomagnetic unified fields will realise a correlation between gravitational field strengths and the powerful magnetic fields of compact cosmic objects. This can be understood based on the fact that, when these objects are in a highly energised state (e.g., during formation), the ability for gravitons to self-organise into gravity strands is reduced, which inversely increases the formation of magnetic strands responsible for the magnetic force. Thereby, this process can be used to elucidate the origin of such strong magnetic fields.

Magnetars with extremely powerful magnetic fields of between 10^8–10^{11} tesla are up to 1000 times more powerful than the magnetic fields of neutron stars. The magnetic field of a magnetar rapidly decays over approximately 10,000 years [14–15] to the equivalence of a regular neutron star. A hydrodynamic dynamo process from the rapid rotation of a magnetar, which is postulated as the source of the magnetic field, cannot explain the decay in the strength of the magnetic field, because the rotation increases in rate over the decay period from 5–12 seconds for most magnetars [15] to less than one second for regular neutron stars [16].

It is further reasoned that, as the energised state of the magnetar decreases, the gravitational field increases in strength as gravitons, manifested in magnetic strands, progressively self-organise into gravity strands, which explains the cause of the magnetic field's decay. Increasing gravitational pressure proportionally increases the mass density of the magnetar, which is evidenced in starquakes brought about by the internal structure of the star contracting. Therefore, it also explains magnetars' increasing rate of rotation, which is due to the conservation of angular momentum.

The above is also considered for super-Chandrasekhar mass supernovae, where the mass of white dwarf stars can achieve up towards ~2.3 $M_\odot$ before exploding into a supernova, thereby breaking the Chandrasekhar limit of 1.44 $M_\odot$ maximum for a white dwarf star. It has been identified in a paper by Upasana Das and Banibrata Mukhopadhyay, *Violation of Chandrasekhar Mass Limit: The Exciting Potential of Strongly Magnetized White Dwarfs* [17], as a plausible connection to this phenomenon. As presented in their paper, would again associate compact cosmic objects with initially powerful magnetic fields. A highly energised white dwarf star can form a surface magnetic field of up to 10^5 tesla [17] and, based on a previously realised correlation between gravitational and magnetic field strengths, will have an inversely weaker gravitational field. The electron degeneracy pressure will be in equilibrium with the reduced gravitational pressure, causing an increase in volume and corresponding lower mass density for the star. This allows a white dwarf star, during this highly energised period, to grow through mass transfer from a binary companion before its mass density, as extracted from model 1 in section 2.3, exceeds a critical mean density of ~2.59×10^9 kg m^{-3}, which will trigger a type Ia supernova, thereby, providing an explanation as to how the mass of the white dwarf star can grow beyond the Chandrasekhar limit.

The above are epitomise quantum magnetodynamical processes and, thereby, the given explanations will form predictions to test for quantum gravity.

2.5 Gravitational radiation

The external gravitational field of a hadronic object will consist of high concentrations of unconfined free radiating gravity strands in outward gravitational radiation. [1] Including the gravitational radiation from all hadronic matter within the universe, would make gravitons among the most numerous of any particle. Their substantial non-annihilated accumulative surplus would advance an explanation as to the unexplained existence and amount of Dark Matter; the explanation becomes resolved by the continuing existence of a Cumulative Gravitational force (clarification is given in section 2.6). The explanation would further advance a deduction that magnetic monopole *graviton* massless gauge-bosons do not couple with photon massless gauge-bosons, thereby, it remains that only subatomic particles possessing, presumably integer units of, electrical charge can couple with the quanta of light. [2]

It is plausible that, when light traverses a gravitational field of radiating gravity strands, the light is refracted in proportion to the density of the gravity strands and the angle to perpendicular of the radiation. Furthermore, the recognised frame-dragging effect can, potentially, be attributed to a rotating field of gravity strands.

[1] The density of gravity strands in gravitational radiation, which decreases inversely proportional to the square of the distance from a hadronic object, arises proportional to the mass of that object and will fluctuate in degree from any variability in mass densities within the mass. This last facet is in agreement with data collected by the ESA GOCE geoid project [18]. A consequence of gravitational radiation (relativistic) has been observed with binary pulsar PSR 1913+16 [19]. (General relativity predicts that accelerating masses should emit gravitational radiation in the same way that accelerating charged particles emit electromagnetic radiation.) Radiation is conveyed by particles.

[2] Similar to neutrinos, it would explain why magnetic monopoles remain undetected due to their apparent 'invisibility', whereas, unlike neutrinos, magnetic monopoles are not free radical particles but have precise functionality.

2.6 Dark matter

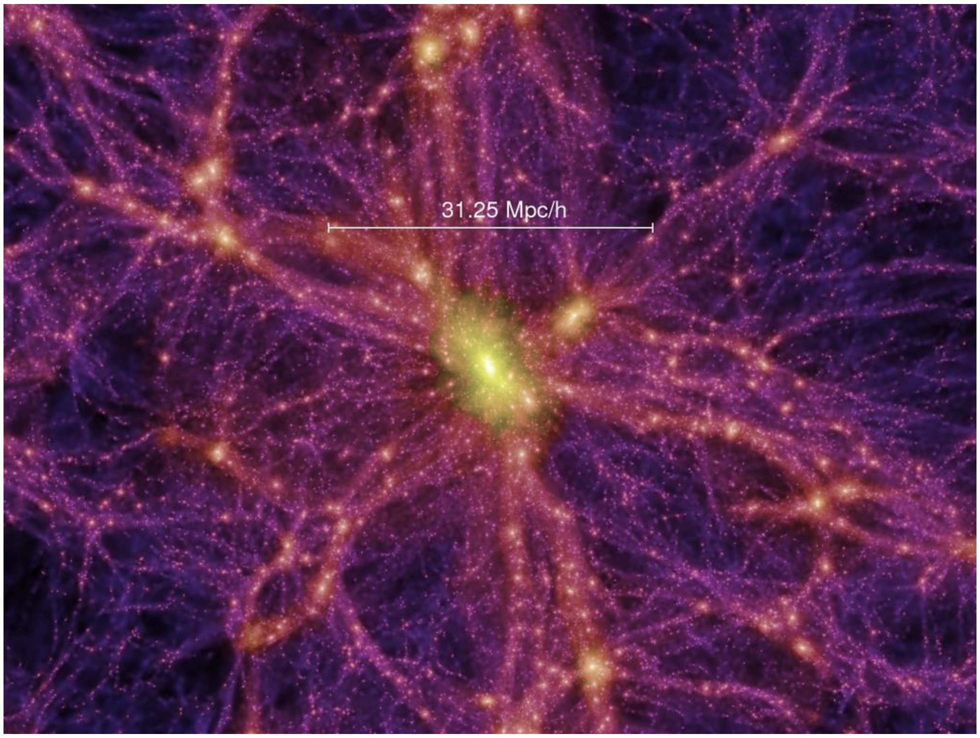


Image 1: Galaxies, galactic clusters and superclusters

The cumulative mass of the galactic supercluster at the centre of image 1 should cause curvature in space-time, which would cause the surrounding structural material to manifest to some degree in a spiral or orbital motion around the supercluster; however, this curvature is non-evident. The conglomeration of the overall megastructure is fibrous and emphasises its heterogeneous nature, as illustrated in the way filaments form between galactic structures and in which their formation is explained by a cumulative gravitational force.[1] Formerly known as dark matter, is the substantial non-annihilated accumulative surplus of gravity strands radiating from all cosmic hadronic matter. Where, existence of so-called dark matter within the filaments of the cosmic web [20] and that engulf galactic structures, are among examples of these accumulative surpluses that emanate from within galaxies. Each of these accumulations would constitute to and act as a *massless graviton boson gas* where the consistency of this boson gas is explanatory to its observed displacement or distortion when two galaxies or galactic clusters collide, and also to its gravitational lensing effect; in which intensifying density of gravity strand accumulations proportionally causes light that passes through to be refracted.

The image produces an analogy that reflects, as a manifestation at the macroscopic scale, the multi-vectorial interactions of gravity strands occurring at the microscopic scale.

[1] The effect of the cumulative gravitational force over a large scale is heterogeneous in that propagation is non-uniform, while the gravitational force in a local region is homogeneous and propagates uniformly. Both are coactive at the same time over different scales. The transition from a gravitational force to a cumulative gravitational force will be realised, over a large scale, when there is a change from homogeneous to heterogeneous in interactivity; this is a consequence of the differentiation in scale that gives rise to two different aspects of the same force. (Magnetic monopole gravitons, intrinsic to all discrete scales of the gravitational force, would eliminate the need for any other non-evidential hypothetical exotic particles proposed as constituting dark matter, which, to enable interaction with gravity, would need to be hadronic (i.e. matter/particles comprising of quarks).

2.7 The early quantum universe

The conceptual foundation for quantum gravity is applied to the early universe to ascertain the conditions arising from magnetodynamical processes ensued from the Big Bang event. The period to be considered is from after the universe was one second old – the juncture at which quark-gluon plasma condensed into protons and neutrons – to the universe at 400 million years old when the first stars formed, leading to the formation of the first galaxies at approximately one billion years.

Within the first few minutes after the Big Bang, there was a limited period when helium and traces of lithium were formed in a nucleosynthetic process. In analysing the helium nuclei, the opposite spin orientations of the two pairs of nucleons outwardly emit four monopole strands that combined by self-organising into two directionally opposite radiating gravity strands. On the other hand, in the close confinement of the inwardly emitted monopole strands, as four individual magnetic strands, interacted as attracting magnetic pairs and assisted, to some degree, nuclear binding (which is produced by the strong nuclear force by exchanging pions between nucleons). The assistance from the magnetic binding forms an explanation for the pronounced stability of helium nuclei. [1] This primordial element accounted for 25% of all baryonic matter and would have been the only source effectuating a gravitational force, and this remained the case until the recombination epoch.

The prevailing 75% of baryonic matter consisted of ionized atomic hydrogen each producing same charged magnetic monopoles in corresponding opposite radiating magnetic strands (see figure 1.2 with respect to a single proton). The accumulative effect of the predominant atomic hydrogen magnetic strand radiation resulted in the magnetic force being the dominant force during the first 379,000-year period (between the nucleosynthesis and recombination epochs), which was a period when the early universe was still in a highly energised state. The dominance of magnetism would have produced very strong turbulent magnetic forces, which would have changed the homogeneous and isotropic distribution of matter, resulting in localised perturbation in densities. It is predicted that this period of magnetic turbulence will eventually become evident in the cosmic microwave background (CMB) when higher resolution in detail is achieved – in resembling the surface of the Sun but at a vastly greater scale.

At the recombination epoch, when the energised state of the early universe decreased substantially, matter decoupled from energy (photon radiation), which allowed electrons to combine with atomic nuclei to form atoms. From this moment on, vicinal atomic hydrogen will naturally bond by covalence to form molecular hydrogen H_2. Magnetic field moments within H_2 molecules will align the two protons' spins in opposite up/down orientations (in accordance with the Pauli exclusion principle whereby two identical adjoining fermions cannot simultaneously be in the same quantum state). Although the two protons remain repelled apart, their continuous streams of magnetic monopole gravitons will still self-organise into two directionally opposite radiating gravity strands. Once bonded, stability as H_2 molecules is dependent on energy levels. The formation of molecular hydrogen would have increasingly contributed to the overall gravitational potential. Over the next 400 million years, the dominant magnetic force has significantly diminished to its present level (still evident in the cosmic web; in the filaments between galactic structures [21], as radiation of magnetic strands emanating from energetic ionise hydrogen). During this period, gravitational strength conversely increased to become the predominant governing force.

[1] Furthermore, viscosity can be explained by the degree of magnetic strand interactions between neighbouring atoms. The non-existence of external radiation of magnetic strands from helium nuclei will forward an explanation to the superfluidity of liquid helium at near zero in absolute temperature.

At this early stage in the universe's development, where there were no significant structures for the gravitational force to interact with, the substantial non-annihilated surplus of gravity strands rapidly accumulated into effectuating a cumulative gravitational force (formerly referred to as dark matter).

(Conceptualism of Modified Newtonian Dynamics – MOND – or in some other modified form is considered as, potentially, a necessary approach when dealing with the presence of dark matter, or referred to as the cumulative gravitational force, which must also take into account the complexity of such a force, as over large scales, its propagation is heterogeneous.)

The manifestation of a cumulative gravitational force within large scale regions would have initiated the process of drawing matter together, causing localised perturbation in densities to grow. At first, the process will be slow but will proceed to accelerate, eventually leading to an abrupt eruption of star formation at an unprecedented rate. (This is supported by an analysis of Hubble Space Telescope deep-sky images; that is, the first stars in the universe appeared abruptly, rather than at a gradual pace. It is also evident that localised regions were in the midst of rapidly accelerating gravitational contraction.) It is expected that those regions experiencing accelerating gravitational contraction would have continued to contract and develop into a localised runaway process, where all available regional matter would finalise in a supermassive black hole. Therefore, for this not to have happened, indicates the existence of a counterbalancing mechanism that prevented total collapse.

In my subsequent paper, *Formulation of a Principle Model of Forces* [22], I methodologically use extrapolations, from a recursive pattern relating to unified fields and previously unrealised recurring structures, to deduce that an additional fundamental *inflationary* force existed in unity with the weak nuclear force. The major sources of this inflationary force emanate from a by-product of nucleosynthetic processes within active stars. The repulsive aspect of this force only interacts with other nucleosynthetic active stars, which explains why these stars within galaxies naturally stay or move apart and do not collide or merge. (Only non-nucleosynthetic remnants, i.e., white dwarf stars, neutron stars or black holes, readily cause mergers.) The current accelerating expansion of the universe is also attributed to this inflationary force (formerly known as Dark Energy).

It would take the presence of this inflationary force to stop the potential for regional gravitational collapse. As regional stars form, their activation contributes to the repulsive aspect of a localised inflationary force. This activation is counterbalanced in a self-regulatory process with the regional cumulative gravitational force and thus initiates the preconditions to allow the formation of galaxies. Within galaxies, this self-regulatory counterbalancing process is dependent upon the ratio of matter densities to star densities. At the onset of star formation, the formation of black holes was still at the infancy stage. As a consequence, the first galaxies to form were dwarf galaxies and, in many cases, their matter to star density ratio was insufficient to overcome the dominance of the local cumulative gravitational force. In such cases, they finalised in total collapse, which accounts for the large deficit in dwarf galaxies expected to currently exist. This also explains the mechanism that, over a relatively short timescale, caused a significant leap from the infancy stage in the formation of black holes to the existence of supermassive black holes, which are the seeds in the same early abrupt evolution of large galaxies.

The conclusion is that the gravitational force gradually developed over the first 400 million years of the universe's existence. Within approximately the first 400,000 years, the total gravitation potential was just 25% of its present potential. During this same period, the magnetic force prevailed as the dominant force that effectuated disturbances in the distribution of matter. The introduction of the inflationary force, while speculative, is conceptually an essential precondition for the formation of galaxies.

Appendix A: Loop quantum gravity

Carlo Rovelli's informative account of the development and meaning of loop quantum gravity, also referred to as loop theory, is presented in his book *Reality Is Not What It Seems: The Journey to Quantum Gravity*. At the quantum level, the gravitational field is described by Faraday's field lines. These imaginary lines represent the field emanating from a source where the separation between the lines reflects the magnitude of the field. They are usually presented two-dimensionally but should be envisaged in three-dimensions. Illustrated below are the negatively charged electrical field of an electron and the magnetic field surrounding a magnet:

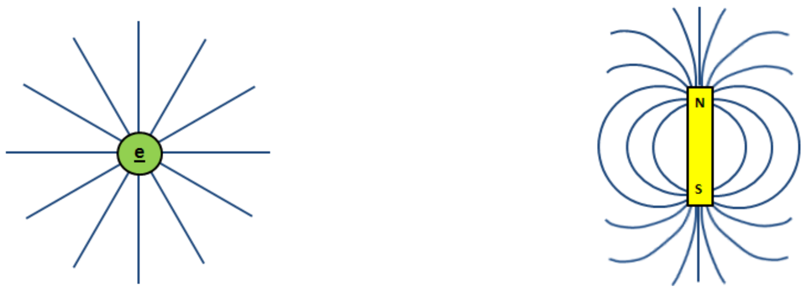


Figure A1: (a) Electron's field lines (b) Magnetic field lines

The following quote by Carlo Rovelli on an early stage in the development of loop quantum gravity is extracted from his aforementioned book:

> *...I remember a period of intense discussions and burning intellectual fervour.* [Abhay] *Ashtekar had rewritten the Wheeler–De Witt equation in a simpler form; and* [Lee] *Smolin, together with Ted Jacobson of the University of Maryland in Washington, had been the first to find some of the strange solutions of the equation. The solutions had a curious peculiarity: they depended on closed lines in space. A closed line is a 'loop'...*
>
> *...Remember Faraday's* [field] *lines – the lines which carry the electric force and which, in Faraday's vision, fill space? Well, the closed lines that appear in the solutions of the Wheeler–De Witt equation are Faraday lines of the gravitational field.* [23]

Interpretation of the loops, as presented in loop theory, concluded in quantum foam of space-time. An alternative interpretation is that for Faraday's field lines to loop on themselves is illustrated by the example of the magnetic field in (b) of figure A1. The field lines of an individual magnetic monopole will be identical to the field lines of an electron as illustrated by (a) in figure A1, but, with consideration, the size of a magnetic monopole is anticipated to be extremely small in comparison to the size of an electron. In the case of gravity strands, the field lines that are produced in an individual strand by alternating charged magnetic monopoles will be loops and where the centres of each loop are at discrete distances apart:

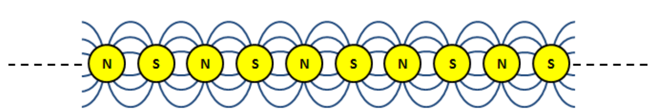


Figure A2: Gravity strand (section of) field lines

Acknowledgement

Image 1 is used with the permission and courtesy of Prof. Volker Springel *et al.* and Virgo Consortium in association with the Millennium Simulation Project at the Max Planck Institute for Astrophysics: https://wwwmpa.mpa-garching.mpg.de/galform/virgo/millennium/

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