Quantum Magnetodynamics of Gravity

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Abstract

In assessments of the *quasi*-magnetic monopoles, experimentally discovered in tetrahedral crystal structures of spin ices, 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. Introduction

In 1931 Paul Dirac discovered, when using Maxwell's equations for electromagnetism, that removing the electrically charged particles from the calculations produced duality symmetry; the electric and magnetic fundamental fields could be interchanged without changing their forms. Reinstating the electrically charged particles in the equations destroyed the duality symmetry. Dirac theorised that the existence of magnetic monopole particles and, by their inclusion in the equations together with electrically charged particles, will reinstate the duality symmetry, which in this instance, must manifest in some topological form. The quantisation condition Dirac concluded stated that if theoretical magnetic monopole particles existed, they would justify electric charge. This charge would have to exist in certain quantised units and, due to the duality symmetry, the elementary magnetic charge of magnetic monopoles must be quantised in units inversely proportional to those of elementary electric charge [1].

[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.

2. Theoretical premise

The theoretical premise is based on the reasoning that magnetic monopoles would emanate from non-confinement in QCD (in furtherance of [2]); 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.

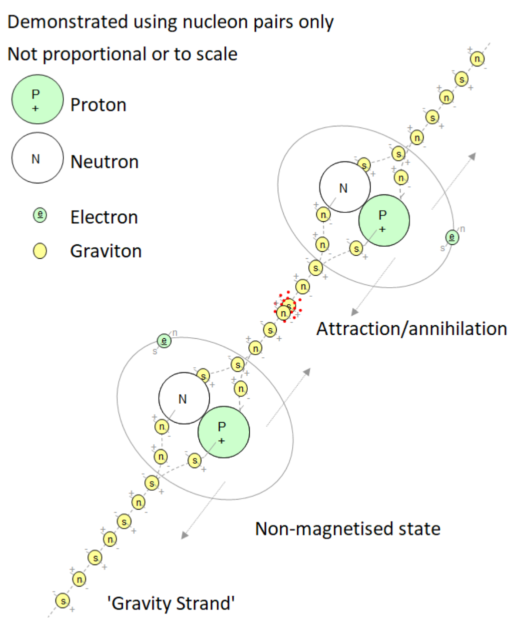

Figure 1.1: Gravitational force

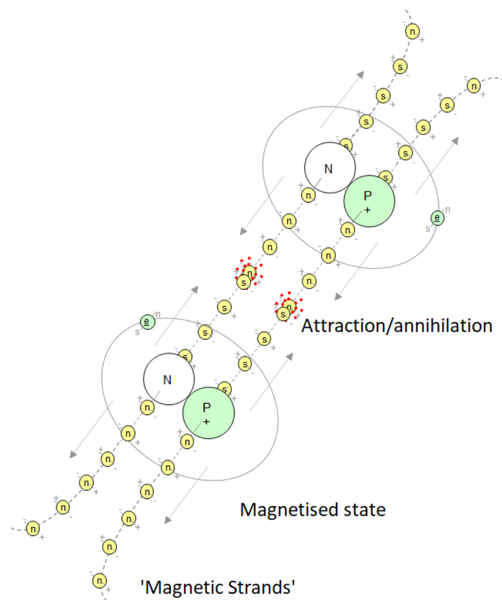

Figure 1.2: Magnetic force

[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 massless gauge bosons, comprising of monopoles and antimonopoles of opposite charges, which facilitates annihilation. 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). 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 [3].

The disclosures by Richard Feynman were that the proton's magnetic moment, rather than being close to 1, was instead 2.79, and the neutral neutron, which should not have had any magnetic interaction, had a magnetic moment of 1.93 [4]. These magnetic moments are central to Nuclear Magnetic Resonance, where, in essence, spectra are produced in atomic nuclei that have at least one unpaired proton or neutron. The significance of these anomalous magnetic moments is potentially attributable to the emission of magnetic monopoles as posited.

3. Foundation for magnetodynamics

In the past, Ptolemy's geocentric model required increasing complexity to accurately describe astronomical observations and maintain its predictive capabilities. The complexity was an indication of the incompleteness of past understanding. It was confirmed in a paradigm shift by Copernicus' heliocentric model, subsequently followed by Kepler's planetary laws and Newton's gravity [5].

Today, the complexity of condensed matter physics and the inability to accurately compute many-body interactions beyond three particles [6] in describing the heterogeneity of matter, is analogous to the above. This current complexity is potentially indicative of an incompleteness in current understanding and, as such, is prime for a paradigm shift in exposition. The origin of this, like Ptolemy's model, would predominantly centre on a false assumption.

The continuing discussion introduces magnetodynamics and the fundamental interactivity of quantum gravity is elucidated; the thermodynamic aspect of this force will become apparent. This underlying phenomenon will be consistent with the thermodynamic properties of matter.

3.1 Relative aspects of matter

External to matter, gravitational interactions correlate with the masses of *hadronic* objects. The mass of an object is the product of its volume and mass density. Internally, at the quantum level, mass becomes irrelevant, therefore, it can be demonstrated that quantum gravitational interactions correlate with mass densities – in the requisite form of a Specific Density for individual elements and substances: [1]

$$R_\rho = \frac{\rho}{uN} \quad \text{kg·m}^{-3}\text{·u}^{-1} \tag{3.10}$$

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:

$$R_v = \frac{1}{R_\rho} \quad \text{kg}^{-1}\text{·m}^{3}\text{·u} \quad \text{or} \quad \text{m}^{3}\text{·kmol}^{-1} \tag{3.11}$$

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 (this will be discussed in detail later):

$$\langle d \rangle = \sqrt{MR_v} \qquad \text{m} \tag{3.12}$$

where constant $M = e^2/2\pi\varepsilon_0 G$ kg·m^{-1}·u^{-1} (see later quantum applicable derivation of G).

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

3.2 Interatomic interactions of intermolecular forces

There is continuing uncertainty as to the strength of interactions between the electron clouds of atomic particles. This repulsion force is apparently difficult to measure experimentally as it is offset by an attraction force, where such data is presented in a measurement of *stiffness*, $N \cdot m^{-1}$, between atomic particles. In a recent experiment involving platinum atoms [7], the strength of interaction was 'estimated' to be thirty-five per cent stronger than the interaction between two single point charges. Whereas, in an alternative experiment concerning gold atoms [8] there was no indication of an increase in strength. In realising a proportional increase in the strength of interaction by the electrostatic force between atomic particles would dictate that, to retain duality symmetry, must equally apply to the gravitational force, which would be irrational. Therefore, the electrostatic repulsion (e^{-} - e^{-} or ion^{+} - ion^{+}) between atomic particles can only conform to the fundamental Coulomb interaction:

$$F_{\mathrm{e}} = \frac{e^2}{4\pi\varepsilon_0 \langle d \rangle^2} \tag{3.20}$$

As 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:

$$F_{\mathrm{g}} = -\frac{G R_{\rho}}{2} \tag{3.21}$$

The opposing Coulomb and Gravitational interactions then attain equilibrium that will maintain the position of atomic particles within the heterogeneity (topology) of matter: [1]

$$F_{\mathrm{e}} - F_{\mathrm{g}} = 0 \tag{3.22}$$

Appendix B contains the full quantum applicable derivation of the gravitational constant, derived from Planck units, $G = F_{\mathrm{p}} l_{\mathrm{p}}^3 u_{\mathrm{p}} / m_{\mathrm{p}}$ $N \cdot kg^{-1} \cdot m^3 \cdot u$, where the Planck mass unit, u_{p}, is a further derived unit. In addition, it has been substantiated that thermal pressure is an exclusive property of R_v [9]: a distinction that differentiates the Coulomb and Gravitational interactions.

Beyond the exotic state of quark-gluon plasma, nucleons are the only stable hadron particles predicted to produce gravitons and, thereby, are the only particles able to interact gravitationally. Electrons, like all remaining subatomic particles, are posited not to produce gravitons and, as such, are unbound to the gravitational force; electron retention is bound by electrostatics. Furthermore, the application of Newton's classical gravitational law in equivalence to a quantum law has inherently been a false assumption.

3.3 Thermodynamics of gravity

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.

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[1] Example: For diamond, in which all the carbon atoms forming the crystalline structure are uniformly spaced 0.154 nm apart, $\langle d \rangle$, corroborates Dirac's duality symmetry: $F_{\mathrm{e}} = 9.779\,560\,953 \times 10^{-9}$ - $F_{\mathrm{g}} = 9.779\,560\,953 \times 10^{-9}$.

The previous deduction reveals a crucial underlying dynamical phenomenon of the gravitational force, which is its dependence on temperature and, as such, will be participatory in the thermodynamic properties of matter. Equivalence in interactions between these two opposing intermolecular forces will produce an equilibrium state within a closed system, equating to symmetry between the two forces, whereby, any loss of equilibrium will correspond to the differential in force strengths arising from spontaneous symmetry-breaking. Asymmetry in these force strengths will be the cause of expansion or contraction in matter until an equilibrium state is reinstated, and any restricted asymmetry in the gaseous state will be the cause of thermal pressure.

It brings forth an important distinction between two fundamental forms of pressure: accumulative and thermal pressure. Accumulative pressure is the result of gravitational influence, and is a contractive pressure that contributes to the density of matter. It is consequential to atmospheric pressure and this influence increasingly accumulates within matter until ultimately it can overcome the electron degeneracy pressure (or neutron degeneracy pressure in the case of neutron stars). Thermal pressure however, is purely attributable to thermodynamics and is a repulsive pressure, which is non-contributory to mass density [9].

3.3.1 Mean interactive molecular distance

Atomic particles in different elements and substances, and also in their different phase states, cohere by different combinations of continuous and intermittent interactions of gravity strands, causing diverse variation in interactive strengths. The mean interactive molecular distance, thereby, resolves the complexity in establishing the coulomb interactions to remain in symmetry with the diverse interactions of gravity strands by assuming these are continuous in strength over this relative distance.

With increase in molecular kinetic energy, the effect of increase molecular kinetic motion will potentially contribute to the intermittency of gravity strand interactions between atomic nuclei, which will greatly reduce their interactional strength. Accordingly, the magnetic field strength of each magnetically charged monopole will give gravity strands of continuous interaction elastic ability, or as explained in [7] by a novel concept of "string tension", which is empirically evident in certain materials and is expositive of the tensile strengths of solids.

An established molar volume will determine the approximate Mean Molecular Separation between atomic particles:

$$\langle r \rangle = \sqrt[3]{\frac{R_v}{N_\mathrm{A}}} \tag{3.30}$$

where N_A = Avogadro constant (for kmol). Thereby, an indication as to the proportion of continuous gravity strand interactions occurring within a system can be determined as a fraction of the mean molecular separation to the mean interactive molecular distance:

$$f_c = \frac{\langle r \rangle}{\langle d \rangle} \tag{3.31}$$

where $0 < f_c \leq 1$ (associated fractions of continuous gravity strand interactions are presented in Table A of Appendix A). Mean molecular separation is, statistically, where the opposing interactions occur. For coulomb interactions to comply with mean molecular separation would simply reaffirm Eqn. 3.20:

$$F_\mathrm{e} = \frac{e^2}{4\pi\varepsilon_0 \langle r \rangle^2}\left(\frac{\langle r \rangle}{\langle d \rangle}\right)^2 \tag{3.32}$$

3.3.2 Mass densities attributed to gravity

Thermal pressure has been established as an exclusive property of volume and is not a property of mass density, which is only dependent on the properties of accumulative pressure and temperature [9]. Furthermore, it has been substantiated that in all heterogeneous states of matter, mass density remains consistent with unsuppressed volume, which is a manifestation of an equilibrium state [9]. This has produced a significant paradigm shift in our understanding of mass density in that it is not just a straightforward ratio of mass and volume, but it is a representation of a true ratio when substances are in an equilibrium state.

This paradigm can be comprehensively demonstrated in the processes within an explosive combustion. The sudden increase in temperature produced in the exothermic reaction will cause spontaneous increase in molecular kinetic motion, which proportionally decreases the strength of gravitational interactions, resulting in a corresponding drop in mass density that is equivalent to a pending equilibrium state. Thereby, allowing a spontaneous increase in volume generated by the accumulative electrostatic repulsion of atomic particles (constituting thermal pressure), till this equilibrium state is attained. This quantum gravitational effect will be explicable for the work produced in heat engines and in chemical explosions.

It can be concluded that the volume of a system manifest from the repulsion force of coulomb interactions, which remains thermodynamically consistent in strength in relation to separation of atomic or subatomic charged particles. Whereas, mass densities are attributed to the attraction force of gravity where the thermodynamics of this governing force will ultimately effect change within a system.

3.4 Interatomic Coulomb-Magnetic interactions

Not all magnetic monopoles radiating from atomic nuclei integrate by self-organising into gravity strands, i.e. nuclei that have at least one unpaired proton or neutron or where paired nucleon spins are not inversely orientated. Non-integrated magnetic monopoles form individual magnetic strands that mediate the magnetic force. Atomic hydrogen (H) is a prominent example, emitting only magnetic strands (see figure 1.2 with respect to a single proton), therefore, are only able to interact magnetically, whereas, molecular hydrogen (H_2) forms gravity strands and interacts gravitationally. The bonds formed by atomic hydrogen will arise from Coulomb-Magnetic interactions where the short covalent bonds are attraction alignments of magnetic strand interactions between the hydrogen's proton and an unpaired proton or neutron within the nucleus of the atom or between atoms it is bonded to. In addition to the relevant Coulomb interaction, such duality symmetrical covalent bond/s are maintained by electron sharing between the bonded atoms.

Beyond electron sharing, the longer hydrogen bonds form with either attraction or repulsion alignment or intermittency of magnetic strand interactions between atomic nuclei, according to the spin alignments in atomic structures. Insomuch that any magnetic strand interactions within the atomic structures of matter can be furthermore the cause of underlying complexity. As epitomised by negative thermal expansion in which certain materials expand on cooling; ice is an example. With this consideration, will posit that negative thermal expansion is where reduction in temperature and the subsequent reduction in molecular kinetic motion allows increasing sustainment between atomic nuclei (rigidity) by the continuous alignment of gravity strand interactions, evolving from intermittent interactions. As a consequence, the sustainment results in a proportional increase in repulsion alignment of magnetic strand interactions that effectuate the expansion.

3.5 Unification of fundamental forces

It has been established within the heterogeneity of matter, volume derives from the *static* consistency of the electrostatic repulsion force and in equipollence, mass density derives from the *dynamic* gravitational attraction force.

The above declaration culminates in realising importance not only relating to the construct of matter but also, in the same way interactions between *electrical* and *magnetic fundamental* forces formalise in unification, the presented unity of interactions between electrical and gravitational fundamental forces would infer a more integrated unification.

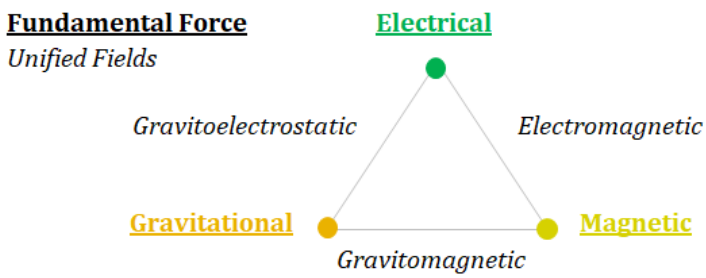

Figure 2: Integrated unification (3D)

This conceptual realisation arose naturally following development of the theoretical premise. A concept investigated, without success, by Faraday then Einstein — who endeavoured to unify general relativity with electromagnetism.

If this theoretical presentation for quantum gravity were substantiated, the import would ultimately give rise to Quantum Magnetodynamics and, in placing it between the well-established quantum field theories of QCD and QED, would advance the potential to realise further integrated unifications, and validity to Nature's optimum formation and utilisation of fundamental forces.

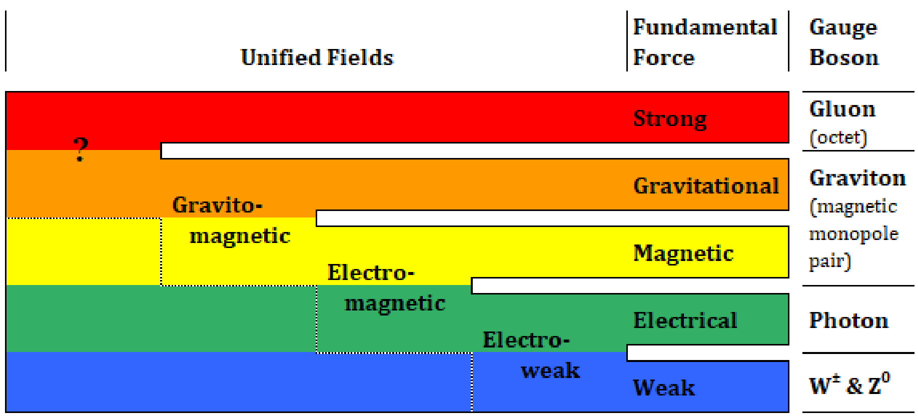

Figure 3: Fundamental model of forces (2D)

Annotation to figure 3: The unification between the strong and gravitational forces, implied from extrapolation, specifically emerges from the theoretical premise in which magnetic monopoles emanate from non-confinement in QCD — as a by-product of quark/gluon interactions, which optimises in the strong nuclear, gravitational and magnetic forces.

Appendix A

Table A: Quantum coulomb-gravitational interactions at STP

Element	Periodic Table Symbol	Protons (Element: Atomic number)	Neutrons	Nucleon Number	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})	R_ρ % of Diamond	Molar Volume $R_v = \frac{1}{R_\rho}$ (m^3 kmol^{-1})	Mean Interactive Molecular Distance $\langle d \rangle = \sqrt{MR_v}$ (nm)	Fraction of Continuous Gravity Strand Interactions f_c as a %	Coulomb Interaction $\frac{e^2}{4\pi\varepsilon_0 \langle d \rangle^2}$ (N)	Gravitational Interaction $-\frac{GR_\rho}{2}$ (N)	Stiffness (N m^{-1})
Hydrogen (H_2)	H	1	0	1	1.007941	2	0.0899	0.045	0.015%	22.424	12.451	26.8%	1.49E-12	-1.49E-12	0.0004
Helium	He	2	2	4	4.002602	1	0.1785	0.045	0.015%	22.424	12.451	26.8%	1.49E-12	-1.49E-12	0.0004
Lithium	Li	3	4	7	6.940037	1	530	76.368	26%	0.0131	0.301	92.8%	2.55E-09	-2.55E-09	9.1
Beryllium	Be	4	5	9	9.012182	1	1850	205.278	70%	0.0049	0.184	100.0%	6.85E-09	-6.85E-09	34.1
Boron	B	5	6	11	10.811028	1	2340	216.446	74%	0.0046	0.179	100.0%	7.22E-09	-7.22E-09	36.6
Carbon	C	6	6	12	12.010736	1	2260	188.165	64%	0.0053	0.192	100.0%	6.28E-09	-6.28E-09	30.4
Diamond		6	6	12	12.010736	1	3520	293.071	100%	0.0034	0.154	100.0%	9.78E-09	-9.78E-09	54.9
Graphene		6	6	12	12.010736	1	4120	343.026	117%	0.0029	0.142	100.0%	1.14E-08	-1.14E-08	67.7
Nitrogen (N_2)	N	7	7	14	14.006743	2	1.251	0.045	0.015%	22.393	12.443	26.8%	1.49E-12	-1.49E-12	0.0004
Oxygen (O_2)	O	8	8	16	15.999405	2	1.429	0.045	0.015%	22.392	12.443	26.8%	1.49E-12	-1.49E-12	0.0004
Fluorine (F_2)	F	9	10	19	18.998403	2	1.696	0.045	0.015%	22.404	12.446	26.8%	1.49E-12	-1.49E-12	0.0004
Neon	Ne	10	10	20	20.180046	1	0.900	0.045	0.015%	22.422	12.451	26.8%	1.49E-12	-1.49E-12	0.0004
Sodium	Na	11	12	23	22.989770	1	970	42.193	14%	0.0237	0.405	84.0%	1.41E-09	-1.41E-09	4.1
Magnesium	Mg	12	12	24	24.305052	1	1740	71.590	24%	0.0140	0.311	91.8%	2.39E-09	-2.39E-09	8.4
Aluminium	Al	13	14	27	26.981538	1	2700	100.068	34%	0.0100	0.263	97.0%	3.34E-09	-3.34E-09	13.1
Silicon	Si	14	14	28	28.085413	1	2330	82.961	28%	0.0121	0.289	94.1%	2.77E-09	-2.77E-09	10.2
Phosphorus (White)	P	15	16	31	30.973762	1	1820	58.759	20%	0.0170	0.343	88.8%	1.96E-09	-1.96E-09	6.4
Phosphorus (Red)	P	15	16	31	30.973762	1	2200	71.028	24%	0.0141	0.312	91.6%	2.37E-09	-2.37E-09	8.3
Phosphorus (Black)	P	15	16	31	30.973762	1	2700	87.171	30%	0.0115	0.282	94.8%	2.91E-09	-2.91E-09	10.9
Sulphur	S	16	16	32	32.066085	1	2070	64.554	22%	0.0155	0.327	90.2%	2.15E-09	-2.15E-09	7.3
Chlorine (Cl_2)	Cl	17	18	35	35.452539	2	3.214	0.045	0.015%	22.061	12.350	26.9%	1.51E-12	-1.51E-12	0.0005
Argon	Ar	18	22	40	39.947677	1	1.784	0.045	0.015%	22.392	12.442	26.8%	1.49E-12	-1.49E-12	0.0004
Potassium	K	19	20	39	39.098301	1	860	21.996	8%	0.0455	0.561	75.4%	7.34E-10	-7.34E-10	1.7
Calcium	Ca	20	20	40	40.078023	1	1550	38.675	13%	0.0259	0.423	82.8%	1.29E-09	-1.29E-09	3.7
Scandium	Sc	21	24	45	44.955910	1	2990	66.510	23%	0.0150	0.322	90.7%	2.22E-09	-2.22E-09	7.6
Titanium	Ti	22	26	48	47.866750	1	4540	94.847	32%	0.0105	0.270	96.2%	3.16E-09	-3.16E-09	12.2
Vanadium	V	23	28	51	50.941472	1	6110	119.942	41%	0.0083	0.240	100.0%	4.00E-09	-4.00E-09	16.7
Chromium	Cr	24	28	52	51.996138	1	7190	138.280	47%	0.0072	0.224	100.0%	4.61E-09	-4.61E-09	20.1
Manganese	Mn	25	30	55	54.938050	1	7440	135.425	46%	0.0074	0.226	100.0%	4.52E-09	-4.52E-09	19.6
Iron	Fe	26	30	56	55.845150	1	7874	140.997	48%	0.0071	0.221	100.0%	4.70E-09	-4.70E-09	20.7
Cobalt	Co	27	32	59	58.933200	1	8900	151.018	52%	0.0066	0.214	100.0%	5.04E-09	-5.04E-09	22.7
Nickel	Ni	28	31	59	58.693356	1	8900	151.636	52%	0.0066	0.214	100.0%	5.06E-09	-5.06E-09	22.8
Copper	Cu	29	35	64	63.545644	1	8960	141.001	48%	0.0071	0.221	100.0%	4.71E-09	-4.71E-09	20.7
Zinc	Zn	30	35	65	65.395567	1	7130	109.029	37%	0.0092	0.252	98.4%	3.64E-09	-3.64E-09	14.7
Gallium	Ga	31	39	70	69.723072	1	5910	84.764	29%	0.0118	0.286	94.4%	2.83E-09	-2.83E-09	10.5
Germanium	Ge	32	41	73	72.612759	1	5320	73.265	25%	0.0136	0.307	92.1%	2.44E-09	-2.44E-09	8.6
Arsenic	As	33	42	75	74.921596	1	5780	77.147	26%	0.0130	0.299	92.9%	2.57E-09	-2.57E-09	9.3
ά-Arsenic	As	33	42	75	74.921596	1	2000	26.695	9%	0.0375	0.509	77.9%	8.91E-10	-8.91E-10	2.2
Selenium	Se	34	45	79	78.959389	1	4790	60.664	21%	0.0165	0.338	89.3%	2.02E-09	-2.02E-09	6.7
Bromine (Br_2)	Br	35	45	80	79.903529	2	3120	19.524	7%	0.0512	0.595	73.9%	6.51E-10	-6.51E-10	1.5
Krypton	Kr	36	48	84	83.799325	1	3.75	0.045	0.015%	22.346	12.430	26.8%	1.49E-12	-1.49E-12	0.0004
Rubidium	Rb	37	48	85	85.467664	1	1532	17.925	6%	0.0558	0.621	72.9%	5.98E-10	-5.98E-10	1.3
Strontium	Sr	38	50	88	87.616646	1	2540	28.990	10%	0.0345	0.488	78.9%	9.67E-10	-9.67E-10	2.5
Yttrium	Y	39	50	89	88.905848	1	4470	50.278	17%	0.0199	0.371	86.5%	1.68E-09	-1.68E-09	5.2
Zirconium	Zr	40	51	91	91.223647	1	6510	71.363	24%	0.0140	0.311	91.7%	2.38E-09	-2.38E-09	8.3
Niobium	Nb	41	52	93	92.906378	1	8570	92.243	31%	0.0108	0.274	95.7%	3.08E-09	-3.08E-09	11.7
Molybdenum	Mo	42	54	96	95.931292	1	10220	106.535	36%	0.0094	0.255	98.1%	3.55E-09	-3.55E-09	14.2
Technetium	Tc	43	55	98	97.907216	1	11500	117.458	40%	0.0085	0.243	99.7%	3.92E-09	-3.92E-09	16.2
Ruthenium	Ru	44	57	101	101.064945	1	12370	122.397	42%	0.0082	0.238	100.0%	4.08E-09	-4.08E-09	17.1
Rhodium	Rh	45	58	103	102.905504	1	12410	120.596	41%	0.0083	0.239	100.0%	4.02E-09	-4.02E-09	16.8
Palladium	Pd	46	60	106	106.415328	1	12000	112.766	38%	0.0089	0.248	99.0%	3.76E-09	-3.76E-09	15.4
Silver	Ag	47	61	108	107.868151	1	10500	97.341	33%	0.0103	0.267	96.6%	3.25E-09	-3.25E-09	12.6
Cadmium	Cd	48	64	112	112.411553	1	8650	76.949	26%	0.0130	0.300	92.9%	2.57E-09	-2.57E-09	9.2
Indium	In	49	66	115	114.818086	1	7310	63.666	22%	0.0157	0.330	90.0%	2.12E-09	-2.12E-09	7.2
Tin (White)	Sn	50	69	119	118.710111	1	7310	61.579	21%	0.0162	0.335	89.5%	2.05E-09	-2.05E-09	6.9
Tin (Grey)	Sn	50	69	119	118.710111	1	5800	48.859	17%	0.0205	0.376	86.1%	1.63E-09	-1.63E-09	5.0
Antimony	Sb	51	71	122	121.759788	1	6690	54.944	19%	0.0182	0.355	87.8%	1.83E-09	-1.83E-09	5.9
Tellurium	Te	52	76	128	127.603125	1	6240	48.902	17%	0.0204	0.376	86.1%	1.63E-09	-1.63E-09	5.0
Iodine	I	53	74	127	126.904468	1	4930	38.848	13%	0.0257	0.422	82.9%	1.30E-09	-1.30E-09	3.7
Xenon	Xe	54	77	131	131.292481	1	5.9	0.045	0.015%	22.253	12.404	26.9%	1.50E-12	-1.50E-12	0.0005
Caesium	Cs	55	78	133	132.905447	1	1870	14.070	5%	0.0711	0.701	70.0%	4.70E-10	-4.70E-10	1.0
Barium	Ba	56	81	137	137.326886	1	3590	26.142	9%	0.0383	0.514	77.6%	8.72E-10	-8.72E-10	2.2

Element	Periodic Table Symbol	Protons (Element: Atomic number)	Neutrons	Nucleon Number	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})	R_ρ % of Diamond	Molar Volume $R_v = \frac{1}{R_\rho}$ (m^3 kmol^{-1})	Mean Interactive Molecular Distance $\langle d \rangle = \sqrt{MR_v}$ (nm)	Fraction of Continuous Gravity Strand Interactions f_c as a %	Coulomb Interaction $\frac{e^2}{4\pi\varepsilon_0 \langle d \rangle^2}$ (N)	Gravitational Interaction $-\frac{GR_\rho}{2}$ (N)	Stiffness (N m^{-1})
Lanthanum	La	57	82	139	138.905449	1	6150	44.275	*15%*	0.0226	0.395	*84.7%*	1.48E-09	-1.48E-09	4.4
Cerium	Ce	58	82	140	140.115722	1	6770	48.317	*16%*	0.0207	0.378	*85.9%*	1.61E-09	-1.61E-09	5.0
Praseodymium	Pr	59	82	141	140.907648	1	6770	48.046	*16%*	0.0208	0.379	*85.9%*	1.60E-09	-1.60E-09	4.9
Neodymium	Nd	60	84	144	144.236127	1	7010	48.601	*17%*	0.0206	0.377	*86.0%*	1.62E-09	-1.62E-09	5.0
Promethium	Pm	61	84	145	144.912744	1	7220	49.823	*17%*	0.0201	0.373	*86.4%*	1.66E-09	-1.66E-09	5.2
Samarium	Sm	62	88	150	150.366344	1	7520	50.011	*17%*	0.0200	0.372	*86.4%*	1.67E-09	-1.67E-09	5.2
Europium	Eu	63	89	152	151.964336	1	5240	34.482	*12%*	0.0290	0.448	*81.2%*	1.15E-09	-1.15E-09	3.2
Gadolinium	Gd	64	93	157	157.252119	1	7900	50.238	*17%*	0.0199	0.371	*86.5%*	1.68E-09	-1.68E-09	5.2
Terbium	Tb	65	94	159	158.925343	1	8230	51.785	*18%*	0.0193	0.365	*86.9%*	1.73E-09	-1.73E-09	5.4
Dysprosium	Dy	66	97	163	162.497030	1	8550	52.616	*18%*	0.0190	0.362	*87.2%*	1.76E-09	-1.76E-09	5.6
Holmium	Ho	67	98	165	164.930319	1	8800	53.356	*18%*	0.0187	0.360	*87.4%*	1.78E-09	-1.78E-09	5.7
Erbium	Er	68	99	167	167.256301	1	9070	54.228	*19%*	0.0184	0.357	*87.6%*	1.81E-09	-1.81E-09	5.8
Thulium	Tm	69	100	169	168.934211	1	9320	55.169	*19%*	0.0181	0.354	*87.9%*	1.84E-09	-1.84E-09	5.9
Ytterbium	Yb	70	103	173	173.037692	1	6970	40.280	*14%*	0.0248	0.414	*83.4%*	1.34E-09	-1.34E-09	3.9
Lutetium	Lu	71	104	175	174.966718	1	9840	56.239	*19%*	0.0178	0.351	*88.2%*	1.88E-09	-1.88E-09	6.1
Hafnium	Hf	72	106	178	178.484971	1	13310	74.572	*25%*	0.0134	0.304	*92.4%*	2.49E-09	-2.49E-09	8.8
Tantalum	Ta	73	108	181	180.947876	1	16650	92.015	*31%*	0.0109	0.274	*95.7%*	3.07E-09	-3.07E-09	11.7
Tungsten	W	74	110	184	183.841779	1	19300	104.982	*36%*	0.0095	0.257	*97.8%*	3.50E-09	-3.50E-09	14.0
Rhenium	Re	75	111	186	186.206706	1	21000	112.778	*38%*	0.0089	0.248	*99.0%*	3.76E-09	-3.76E-09	15.4
Osmium	Os	76	114	190	190.224861	1	22600	118.807	*41%*	0.0084	0.241	*99.9%*	3.96E-09	-3.96E-09	16.5
Iridium	Ir	77	115	192	192.216054	1	22600	117.576	*40%*	0.0085	0.242	*99.7%*	3.92E-09	-3.92E-09	16.2
Platinum	Pt	78	117	195	195.077791	1	21450	109.956	*38%*	0.0091	0.251	*98.6%*	3.67E-09	-3.67E-09	14.8
Gold	Au	79	118	197	196.966552	1	19300	97.986	*33%*	0.0102	0.266	*96.7%*	3.27E-09	-3.27E-09	12.7
Mercury	Hg	80	121	201	200.599149	1	13550	67.548	*23%*	0.0148	0.320	*90.9%*	2.25E-09	-2.25E-09	7.8
Thallium	Ti	81	123	204	204.383317	1	11850	57.979	*20%*	0.0172	0.345	*88.6%*	1.93E-09	-1.93E-09	6.3
Lead	Pb	82	125	207	207.216892	1	11350	54.774	*19%*	0.0183	0.355	*87.8%*	1.83E-09	-1.83E-09	5.9
Bismuth	Bi	83	126	209	208.980383	1	9750	46.655	*16%*	0.0214	0.385	*85.4%*	1.56E-09	-1.56E-09	4.7
Polonium	Po	84	125	209	208.982416	1	9300	44.501	*15%*	0.0225	0.394	*84.8%*	1.48E-09	-1.48E-09	4.4
Astatine	At	85	125	210	209.987131	1	7000	33.335	*11%*	0.0300	0.455	*80.8%*	1.11E-09	-1.11E-09	3.0
Radon	Rn	86	136	222	222.017570	1	9.73	0.044	*0.015%*	22.818	12.560	*26.7%*	1.46E-12	-1.46E-12	0.0004
Francium	Fr	87	136	223	223.019731	1	1870	8.385	*3%*	0.1193	0.908	*64.2%*	2.80E-10	-2.80E-10	0.5
Radium	Ra	88	138	226	226.025403	1	5000	22.121	*8%*	0.0452	0.559	*75.5%*	7.38E-10	-7.38E-10	1.7
Actinium	Ac	89	138	227	227.027747	1	10070	44.356	*15%*	0.0225	0.395	*84.7%*	1.48E-09	-1.48E-09	4.4
Thorium	Th	90	142	232	232.038050	1	11720	50.509	*17%*	0.0198	0.370	*86.6%*	1.69E-09	-1.69E-09	5.3
Protactinium	Pa	91	140	231	231.035879	1	15400	66.656	*23%*	0.0150	0.322	*90.7%*	2.22E-09	-2.22E-09	7.6
Uranium	U	92	146	238	238.028913	1	18950	79.612	*27%*	0.0126	0.295	*93.4%*	2.66E-09	-2.66E-09	9.7
Neptunium	Np	93	144	237	237.048167	1	20200	85.215	*29%*	0.0117	0.285	*94.5%*	2.84E-09	-2.84E-09	10.6
Plutonium	Pu	94	150	244	244.064198	1	19840	81.290	*28%*	0.0123	0.292	*93.7%*	2.71E-09	-2.71E-09	9.9
Americium	Am	95	148	243	243.061373	1	13700	56.364	*19%*	0.0177	0.350	*88.2%*	1.88E-09	-1.88E-09	6.1
Curium	Cm	96	151	247	247.070347	1	13500	54.640	*19%*	0.0183	0.356	*87.7%*	1.82E-09	-1.82E-09	5.8

Key:
Non-metal
Semi-metal
Metal
Lanthanide
Actinide
Gas
Liquid
Solid
Synthetic

Mass Density @ 300 K (gases @ 273.15 K) and 1 atm.

Mean Interactive Molecular Distance: Constant M = 6.913 785 004 x 10^{-18} kg·m^{-1}·u^{-1}

Criterion: Accuracy of computation entails high precision

Source of Data: Cross-checked from various sources

Substance (samples)

Ice (273 K)	H_2O	10	8	18	18.015287	1	917	50.901	*17%*	0.0196	0.369	*86.7%*	1.70E-09	-1.70E-09	5.3
Water (277 K)	H_2O	10	8	18	18.015287	1	999.973	55.507	*19%*	0.0180	0.353	*88.0%*	1.85E-09	-1.85E-09	6.0
Steam (373.15 K)	H_2O	10	8	18	18.015287	1	0.60	0.033	*0.011%*	30.025	14.408	*25.5%*	1.11E-12	-1.11E-12	0.0003
Air ($4N_2 + O_2$)	(Approx.)				14.405000	2	1.29	0.045	*0.015%*	22.333	12.426	*26.8%*	1.49E-12	-1.49E-12	0.0004
Ozone (O_3)		8	8	16	15.999405	3	2.144	0.045	*0.015%*	22.387	12.441	*26.8%*	1.49E-12	-1.49E-12	0.0004
Methane	CH_4	10	6	16	16.042500	1	0.716	0.045	*0.015%*	22.406	12.446	*26.8%*	1.49E-12	-1.49E-12	0.0004
Ammonia	NH_3	10	7	17	17.030566	1	0.77	0.045	*0.015%*	22.118	12.366	*26.9%*	1.51E-12	-1.51E-12	0.0005
Carbon dioxide	CO_2	22	22	44	44.009546	1	1.98	0.045	*0.015%*	22.227	12.396	*26.9%*	1.50E-12	-1.50E-12	0.0005
Dimethyl ether (298 K)	CH_3OCH_3	26	20	46	46.068518	1	72.72	1.579	*0.539%*	0.6335	2.093	*48.6%*	5.27E-11	-5.27E-11	0.0518

Liquid Gas (samples)

Oxygen (90 K) (O_2)	O	8	8	16	15.999405	2	1140	35.626	*12%*	0.0281	0.441	*81.7%*	1.19E-09	-1.19E-09	3.3
Methane (109 K)	CH_4	10	6	16	16.042500	1	464.54	28.957	*10%*	0.0345	0.489	*78.9%*	9.66E-10	-9.66E-10	2.5

Appendix B: Gravitational constant (derivation)

Planck length	l_{p}	1.61619997 x 10^{-35}	m
Planck mass	m_{p}	2.17651130 x 10^{-8}	kg
Planck time	t_{p}	5.39106320 x 10^{-44}	s
Planck force	F_{p}	1.21034164 x 10^{44}	N
Planck density	ρ_{p}	5.15555760 x 10^{96}	$\mathrm{kg \cdot m^{-3}}$

Table B1: *ad rem* Planck units

The current Newtonian derivations of the gravitational constant are:

$$G = \frac{F_{\mathrm{p}} l_{\mathrm{p}}^2}{m_{\mathrm{p}}^2} = 6.6738(48) \times 10^{-11} \quad \mathrm{N \cdot kg^{-2} \cdot m^2} \qquad \text{(B.1a)}$$

$$G = \frac{l_{\mathrm{p}}^3}{m_{\mathrm{p}} t_{\mathrm{p}}^2} = 6.6738(57) \times 10^{-11} \quad \mathrm{kg^{-1} \cdot m^3 \cdot s^{-2}} \qquad \text{(B.1b)}$$

In a quantum applicable derivation of the gravitational constant, the force element from Eqn. B.1a is to be utilised in combination with the inverse mass density element from Eqn. B.1b. A dimensionless unit, u, was assigned to atomic mass units in order to notate a distinction between mass density and specific density. Correspondingly, to represent mass density as specific density, the derivation will need to include a 'mass units' element in the form of Planck Mass Units, which at present does not exist and must be derived from first principles. The value for this required Planck mass units is to be derived from existing Planck units independent of G:

$$f_1 = \frac{m_{\mathrm{p}}^2}{l_{\mathrm{p}}^2} = 1.8135589 \times 10^{54} \quad \mathrm{kg^2 \cdot m^{-2}} \qquad \text{(B.2a)}$$

$$f_2 = \frac{m_{\mathrm{p}}}{l_{\mathrm{p}}^3 u_{\mathrm{p}}} \quad \mathrm{kg \cdot m^{-3} \cdot u^{-1}} \qquad \text{(B.2b)}$$

The quantifying stipulation for Eqns. B.2a and B.2b is they are equivalent, i.e. f_2 must equal f_1. Therefore, u_{p}, Planck mass units, can be derived from using the value of f_1, inversely with Planck density, with the units of f_2:

$$u_{\mathrm{p}} = \frac{\rho_{\mathrm{p}}}{f_1} = 2.84278477 \times 10^{42} \quad \frac{\cancel{\mathrm{kg}}}{\cancel{\mathrm{m^3}}} \, \frac{\cancel{\mathrm{m^3}}\,\mathrm{u}}{\cancel{\mathrm{kg}}} \qquad \text{(B.3)}$$

From the now known value for Planck mass units, further new Planck components in the form of Planck specific density, $P_\rho = \rho_{\mathrm{p}}/u_{\mathrm{p}}$, and Planck molar volume, $P_v = 1/P_\rho$, can be derived.

Planck mass units	u_{p}	2.84278477 x 10^{42}	u
Planck specific density	P_ρ	1.81355890 x 10^{54}	$\mathrm{kg \cdot m^{-3} \cdot u^{-1}}$
Planck molar volume	P_v	5.51401999 x 10^{-55}	$\mathrm{m^3 \cdot kmol^{-1}}$

Table B2: New Planck components

A quantum derivation of the gravitational constant is then derived from Planck units:

$$G = \frac{F_{\mathrm{p}} l_{\mathrm{p}}^3 u_{\mathrm{p}}}{m_{\mathrm{p}}} = \frac{F_{\mathrm{p}}}{P_\rho} = 6.673848 \times 10^{-11} \quad \mathrm{N \cdot kg^{-1} \cdot m^3 \cdot u} \qquad \text{(B.4)}$$

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