Quantum Magnetodynamics of Gravity

David W Gold

Torquay, Devon, England UK

Email: david.gold@scienceau.uk

Updated[1]: 28 April 2025

Abstract

A deliberation into whether hypothetical magnetic monopole particles mediated the magnetic force led to the serendipitous insight that the existence of gravitons would constitute magnetic monopole dual particles, which self-organize into gravity strands, and that these formations mediate the gravitational force. This initial premise readily evolved into realizing a solution for quantum gravity in perfect unity with *magnetic* and *electrical fundamental* forces, thereby forming a foundation for Quantum Magnetodynamics.

PACS numbers: 04.60.-m, 14.80.Hv, 34.20.Cf, 05.70.Ce

1. Introduction

In 1931, when using Maxwell's equations for electromagnetism, Paul Dirac discovered 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 theorized 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 quantization condition Dirac concluded stated that if theoretical magnetic monopole particles existed, they would justify the electric charge. This charge would have to exist in certain quantized units, and due to the duality symmetry, the elementary magnetic charge of magnetic monopoles must be quantized in units inversely proportional to those of elementary electric charge [1].

The current situation regarding magnetic monopole particles is that the absence of proof is not proof of absence. The experimental discovery of the elementary magnetic charge of magnetic monopole particles will add a new dimension to scientific knowledge in the realization that the dynamic existence of magnetic charge is prolific (in contrast to the static existence of electric charge). Such a prospect is revealed in this theoretical presentation.

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

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]): the cause, the by-product of quark/gluon interactions. The effect will be continuous streams of oppositely charged magnetic monopole particles expelled from nucleons in opposite directions along the axes of spin. The natural pairing of nucleons in up/down spin orientations enables streams of magnetic monopoles to self-organize into Dirac strings or *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*.[1] Single/unpaired nucleons (or paired nucleons where protons' spin orientations readily invert in response to electromagnetic activity) will expel in opposite directions magnetic monopoles with identical charges, thereby instigating a magnetic force [2] (see Figure 1.2). The gravitational and magnetic forces are distinct in that they retain non-interaction, whereas their transpositional duality will formalize their unification as Gravitomagnetism.[3]

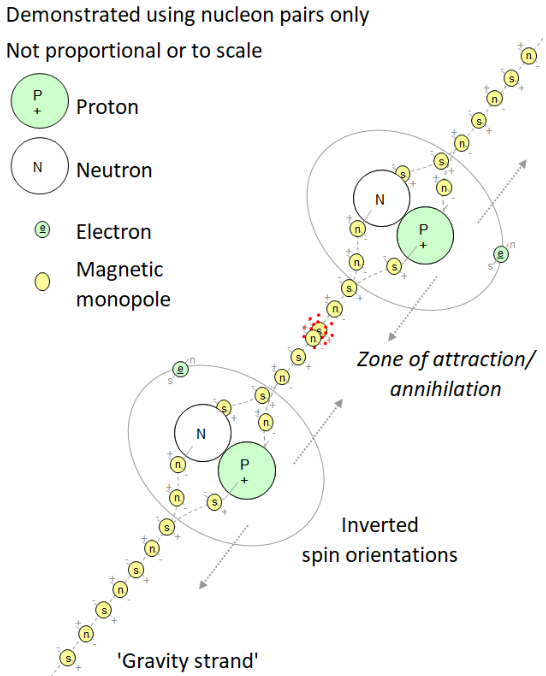

Figure 1.1: Gravitational force

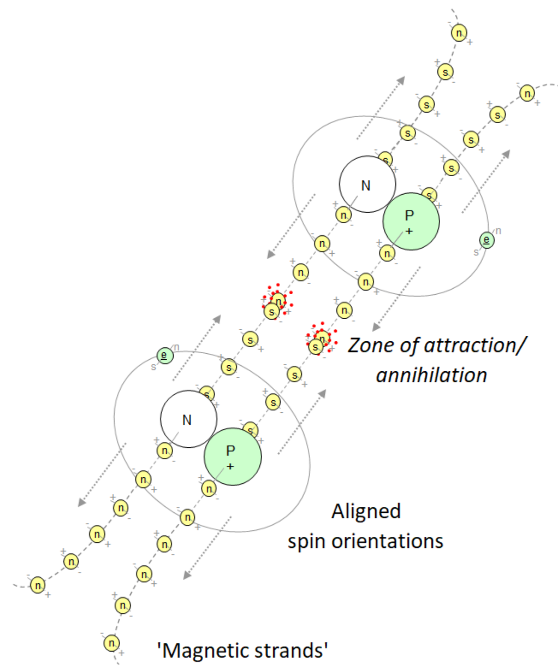

Figure 1.2: Magnetic force

[1] This infers that gravitons are paired massless gauge bosons each comprising a monopole and an antimonopole of opposite magnetic 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.
[2] This produces plausibility that lines of magnetic flux constitute magnetic monopoles with identical charges 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 each strand with only the leading particle retaining a net surplus magnetic charge.
[3] The QCD origin restricts the source of gravitons to hadronic matter. This will 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. The duality of the subject forces is then explanatory to 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.

The anomalies of the proton's magnetic moment of 2.79 and of the neutral neutron's magnetic moment of 1.93, which should not have any magnetic interaction [3], are significant and potentially attributable to the emission of magnetic monopoles, as posited.

3. Laying the Foundation

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. This was confirmed in a paradigm shift by Copernicus' heliocentric model, subsequently followed by Kepler's planetary laws and Newton's gravity [4].

Today, the complexity of condensed matter physics and the inability to accurately compute many-body interactions beyond three particles [5] is analogous to the above. This complexity is potentially indicative of incompleteness in current understanding and, as such, is prime for a paradigm shift in exposition. Like Ptolemy's model, the origin predominantly centres on a false assumption.

The introduction to the foundation of magnetodynamics continues by elucidating the fundamental transpositional interactivity of the quantum gravitational and magnetic forces.

3.1 Relative Aspects of Matter

In the classical realm, gravity correlates with objects' masses, where mass is the product of volume and mean mass density. Within the quantum realm, gravitationally, mass becomes irrelevant as it can be demonstrated that quantum-gravitational interactions correlate with mass densities – in the requisite form of a Specific Density for individual elements and compounds:

$$R_\rho = \frac{\rho}{un} \quad \mathrm{kg{\cdot}m^{-3}{\cdot}u^{-1}} \tag{3.10}$$

where ρ, the mass density, u, the atomic mass units[1] and n, the element atomicity. Precise molar volume is established from the reciprocal of specific density:

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

Statistically, there is a direct correlation between molar volume and the interactive strengths of electrostatic and gravitational forces. It is referred to as the Mean Interactive Distance (this will be discussed later):

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

where constant $M = e^2/2\pi\varepsilon_0 G$ $\mathrm{kg{\cdot}m^{-1}{\cdot}u^{-1}}$ (see quantum derivation of G in Appendix B).

[1] A dimensionless unit, u, is assigned to atomic mass units 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 atoms. This repulsive force is difficult to measure experimentally as it is offset by an attraction force. The theoretical premise attributes this attraction force to the gravitational force and accordingly, by attaining symmetry, will infer the Coulomb accumulative repulsion interaction (e^{-}- e^{-} or ion^{+} - ion^{+}) between atoms:

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

As disclosed in the theoretical premise, the gravitational force is initiated by gravitons self-organizing into gravity strands, culminating in their distinct multi-vectorial outward radiation from atomic nuclei. In the mediation of the gravitational force, the attraction/annihilation of gravitons in converging individual gravity strands between two atomic nuclei produces the resultant gravitational interaction:

$$F_{\mathrm{g}} = -2GR_{\rho} \tag{3.21}$$

Atoms cohere into the heterogeneity (topology) of matter by reason of equilibrium attained by the opposing Coulomb and gravitational interactions: [1]

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

A quantum-applicable derivation of the gravitational constant is derived from Planck units: $G = F_{\mathrm{p}} l_{\mathrm{p}}^3 u_{\mathrm{p}} / m_{\mathrm{p}}$ N·kg^{-1}·m^{3}·u, where the Planck mass unit, u_{p}, is a further derived unit. In addition, induced pressure is an exclusive property of volume [6], a distinction that effectuates asymmetry between the Coulomb and gravitational interactions.

The existence of magnetic monopoles will possess an elementary magnetic charge and, in accordance with the Dirac quantization condition, are quantized in units inversely proportional to those of elementary electric charge [1]. These elementary charges have been definitively quantized in SI base units:

$$e = N\sqrt{2\varepsilon_0 hc\alpha} \quad \mathrm{A{\cdot}s} \tag{3.23a}$$

$$\mathcal{M} = N\sqrt{\frac{2hc\alpha}{\mu_0}} \quad \mathrm{A{\cdot}m} \tag{3.23b}$$

where N is a non-zero integer, h, is Planck's constant, c, the speed of light, and α, the fine-structure constant. A consequence of the Dirac quantization is a development upon Maxwell's conclusion:

$$\frac{\mathcal{M}}{e} = \frac{1}{\sqrt{\varepsilon_0 \mu_0}} = c \tag{3.24}$$

The net force resulting from the constituent magnetic charges in opposing gravity strands would stem from accumulative charges in attraction that have comparability with electric charges whose field strength conforms to the inverse-square law. This conformity applies to the gravitational

[1] Example: For diamond, in which all the carbon atoms forming the crystalline structure are uniformly spaced 0.154 nm apart, $\langle d \rangle$, exemplifies symmetry: F_{e} = 3.9120901966 x 10^{-8} - F_{g} = 3.9120901966 x 10^{-8}.

interaction of Eqn. 3.21 and is apparent when specifically expressed as a magnetic interaction that maintains symmetry with Eqn. 3.20:

$$\frac{e^2}{\pi\varepsilon_0\langle d\rangle^2} - \left|\frac{\mu_0\mathcal{M}^+\mathcal{M}^-}{\pi\langle d\rangle^2}\right| = 0 \tag{3.25}$$

Gravitational interactions are by emission and not the absorption of gravitons. Beyond the exotic state of quark-gluon plasma, nucleons are the only stable hadron particles predicted to emit gravitons and, thereby, are the only particles able to interact gravitationally. Electrons, like all remaining subatomic particles, are posited not to emit gravitons and, therefore, are unbound to the gravitational force; electron retention is bound by electrostatics. Moreover, the application of Newton's classical gravitational law in equivalence to a quantum law has inherently been a false assumption insomuch that rectification will result in a paradigm shift concerning the coupling constant for the gravitational force:

$$\frac{e^2}{\pi\varepsilon_0\hbar c} = \left|\frac{\mu_0\mathcal{M}^+\mathcal{M}^-}{\pi\hbar c}\right| = 4\alpha \tag{3.26}$$

This gravitational coupling constant is only realized and explained by the elementary magnetic charges of magnetic monopole particles. In addition, substantiation of the coupling constant will manifest from the fact that the degeneracy pressure within states of matter is countered by gravitational pressure: $p_{\mathrm{g}} = F_{\mathrm{g}} /\langle d\rangle^2$ – a fundamental causation of mass density:

$$\rho = un\frac{p_{\mathrm{g}}\langle d\rangle^2}{-2G} \tag{3.27}$$

3.3 Mean Interactive Distance

It can be 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 lower and is replaced with continual intermittent interaction of gravity strands due to 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, thus revealing within the quantum realm a crucial underlying dynamical phenomenon of the gravitational force – its temperature dependence. Consequently, this will establish that quantum gravity's interactivity is central to the thermodynamic properties of matter.

The magnetic field strength of each magnetically charged monopole would give gravity strands of continuous interactions elastic ability, which is evidential in certain materials and is an exposition to the tensile strengths of solids. The mean molecular distance is ascertained from the molar volume:

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

where N_{A} is the Avogadro constant (for kmol) and is statistically where opposing interactions approximately occur. The constituent atoms of elements and compounds in heterogeneous states will cohere by different proportionalities, $\langle r\rangle^2/\langle d\rangle^2$, of continuous and intermittent gravity-strand interactions [1] causing diverse interactive strengths aggravated by the divergent distances between atoms.

[1] In the gaseous state, variances in the interactive distances are directly proportional to temperature: $\langle r\rangle^2/\langle d\rangle^2 \propto \sqrt[3]{T/T'}$

The mean interactive distance resolves the complexity by enabling the gravitational interaction to be expressed as continuous in strength over this relative distance coupled with the mean Coulomb interaction between atoms:

$$F_{\mathrm{e}} = \frac{e^2}{\pi\varepsilon_0\langle r\rangle^2}\left(\frac{\langle r\rangle}{\langle d\rangle}\right)^2 \tag{3.31}$$

3.4 Interatomic Coulomb-Magnetic Interactions

Not all magnetic monopoles radiating from atomic nuclei integrate by self-organizing into gravity strands, i.e., nuclei with 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, can only interact magnetically. In contrast, molecular hydrogen (H_2) forms gravity strands and interacts gravitationally. The bonds formed by atomic hydrogen would arise from Coulomb-magnetic interactions whose 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 nuclear structures. Insomuch that any magnetic-strand interactions within the atomic structures of matter can furthermore be the cause of underlying complexity. As epitomized 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 a reduction in temperature and the subsequent decrease 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 of the sustainment where there remains a higher proportion of repulsion alignment of magnetic-strand interactions will cause material expansion [7]. (Also, diverse angular repulsion alignments of magnetic strands manifest patterns in snowflakes.)

There will be a distinction in the interactive strengths of magnetic and gravity strands arising from the configuration of magnetic monopoles in the respective strands, whereby magnetic-strand interactions at micro-distances would have direct comparability with Coulomb's law:

$$F_m = \pm\frac{\mu_0}{4\pi}\cdot\frac{\mathcal{M}^{\pm}\mathcal{M}^{\pm}}{r^2} \tag{3.40}$$

It should be noted that adding to the complexity, the magnetic moments of electrons and their spin orientations will also have degrees of influence at the atomic scale. Although an extensive subject, it is inadequate in explaining external magnetic fields like those of the Earth and throughout the Universe. It is asserted that electron alignments are not the origin (or mediators) of magnetic forces.

3.5 Unification of Fundamental Forces

It can be concluded that, fundamentally, within the heterogeneity of matter, volume derives from the *static* consistent repulsion of the electrostatic force, and in equipollence, mass density derives from the *dynamic* attraction of the gravitational force. Further significance follows from a prospect that the respective symmetries and unifications of the gravitational, magnetic, and electrical fundamental forces will realize an integrated unification.

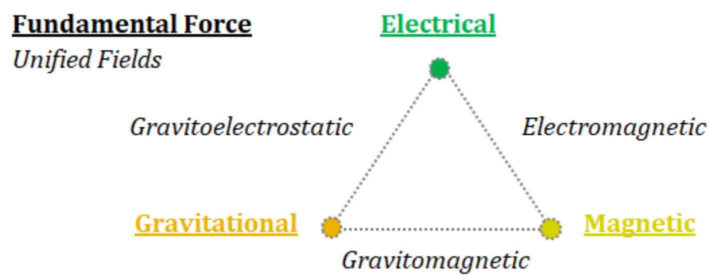

Figure 2: Integrated unification (3D)

This conceptual realization arose naturally following the 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 of quantum gravity were substantiated, the import would ultimately give rise to Quantum Magnetodynamics and, in placing it in between the well-established quantum field theories of QCD and QED, will advance the potential to realize further integrated unification/s and validity of nature's optimum formation and utilization of fundamental forces.

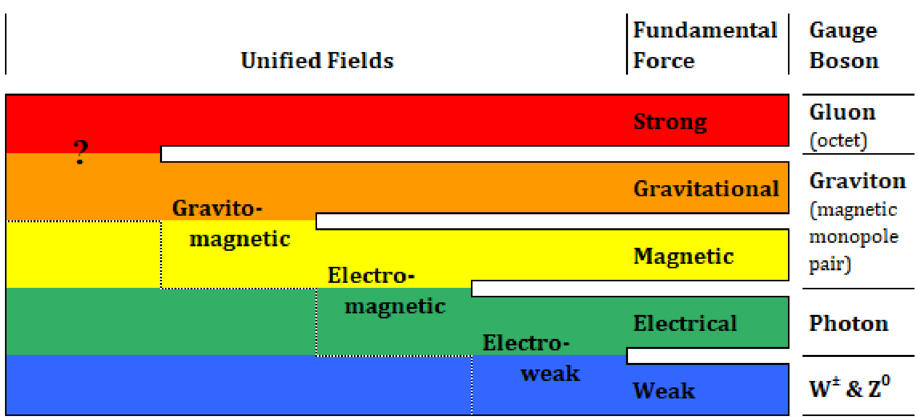

Figure 3: Fundamental model of forces (2D)

Annotation to Figure 3: The unification between the strong nuclear and gravitational forces, implied from extrapolation, emerges explicitly from the theoretical premise in which magnetic monopoles emanate from non-confinement in QCD – as a by-product of quark/gluon interactions, which optimizes 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	Element Atomicity 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 Distance $\langle d \rangle = \sqrt{MR_v}$ (nm)	Coulomb Interaction $\frac{e^2}{\pi\varepsilon_0 \langle d \rangle^2}$ (N)	Gravitational Interaction $-2GR_\rho$ (N)	Fraction of Continuous Gravity Strand Interactions $\frac{\langle r \rangle^2}{\langle d \rangle^2}$ as a %	Stiffness (N m^{-1})
Hydrogen (H_2)	H	1	0	1	1.007941	2	0.0899	0.045	22.424	12.451	5.95E-12	-5.95E-12	7.2%	0.0005
Helium	He	2	2	4	4.002602	1	0.1785	0.045	22.424	12.451	5.95E-12	-5.95E-12	7.2%	0.0005
Lithium	Li	3	4	7	6.940037	1	530	76.368	0.0131	0.301	1.02E-08	-1.02E-08	86.1%	33.9
Beryllium	Be	4	5	9	9.012182	1	1850	205.278	0.0049	0.184	2.74E-08	-2.74E-08	100.0%	149.3
Boron	B	5	6	11	10.811028	1	2340	216.446	0.0046	0.179	2.89E-08	-2.89E-08	100.0%	161.6
Carbon	C	6	6	12	12.010736	1	2260	188.165	0.0053	0.192	2.51E-08	-2.51E-08	100.0%	131.0
Diamond		6	6	12	12.010736	1	3520	293.071	0.0034	0.154	3.91E-08	-3.91E-08	100.0%	254.7
Graphene		6	6	12	12.010736	1	4120	343.026	0.0029	0.142	4.58E-08	-4.58E-08	100.0%	322.5
Nitrogen (N_2)	N	7	7	14	14.006743	2	1.251	0.045	22.393	12.443	5.96E-12	-5.96E-12	7.2%	0.0005
Oxygen (O_2)	O	8	8	16	15.999405	2	1.429	0.045	22.392	12.443	5.96E-12	-5.96E-12	7.2%	0.0005
Fluorine (F_2)	F	9	10	19	18.998403	2	1.696	0.045	22.404	12.446	5.96E-12	-5.96E-12	7.2%	0.0005
Neon	Ne	10	10	20	20.180046	1	0.900	0.045	22.422	12.451	5.95E-12	-5.95E-12	7.2%	0.0005
Sodium	Na	11	12	23	22.989770	1	970	42.193	0.0237	0.405	5.63E-09	-5.63E-09	70.6%	13.9
Magnesium	Mg	12	12	24	24.305052	1	1740	71.590	0.0140	0.311	9.56E-09	-9.56E-09	84.2%	30.7
Aluminium	Al	13	14	27	26.981538	1	2700	100.068	0.0100	0.263	1.34E-08	-1.34E-08	94.2%	50.8
Silicon	Si	14	14	28	28.085413	1	2330	82.961	0.0121	0.289	1.11E-08	-1.11E-08	88.5%	38.4
Phosphorus (White)	P	15	16	31	30.973762	1	1820	58.759	0.0170	0.343	7.84E-09	-7.84E-09	78.9%	22.9
Phosphorus (Red)	P	15	16	31	30.973762	1	2200	71.028	0.0141	0.312	9.48E-09	-9.48E-09	84.0%	30.4
Phosphorus (Black)	P	15	16	31	30.973762	1	2700	87.171	0.0115	0.282	1.16E-08	-1.16E-08	89.9%	41.3
Sulphur	S	16	16	32	32.066085	1	2070	64.554	0.0155	0.327	8.62E-09	-8.62E-09	81.4%	26.3
Chlorine (Cl_2)	Cl	17	18	35	35.452539	2	3.214	0.045	22.061	12.350	6.05E-12	-6.05E-12	7.2%	0.0005
Argon	Ar	18	22	40	39.947677	1	1.784	0.045	22.392	12.442	5.96E-12	-5.96E-12	7.2%	0.0005
Potassium	K	19	20	39	39.098301	1	860	21.996	0.0455	0.561	2.94E-09	-2.94E-09	56.8%	5.2
Calcium	Ca	20	20	40	40.078023	1	1550	38.675	0.0259	0.423	5.16E-09	-5.16E-09	68.6%	12.2
Scandium	Sc	21	24	45	44.955910	1	2990	66.510	0.0150	0.322	8.88E-09	-8.88E-09	82.2%	27.5
Titanium	Ti	22	26	48	47.866750	1	4540	94.847	0.0105	0.270	1.27E-08	-1.27E-08	92.5%	46.9
Vanadium	V	23	28	51	50.941472	1	6110	119.942	0.0083	0.240	1.60E-08	-1.60E-08	100.0%	66.7
Chromium	Cr	24	28	52	51.996138	1	7190	138.280	0.0072	0.224	1.85E-08	-1.85E-08	100.0%	82.5
Manganese	Mn	25	30	55	54.938050	1	7440	135.425	0.0074	0.226	1.81E-08	-1.81E-08	100.0%	80.0
Iron	Fe	26	30	56	55.845150	1	7874	140.997	0.0071	0.221	1.88E-08	-1.88E-08	100.0%	85.0
Cobalt	Co	27	32	59	58.933200	1	8900	151.018	0.0066	0.214	2.02E-08	-2.02E-08	100.0%	94.2
Nickel	Ni	28	31	59	58.693356	1	8900	151.636	0.0066	0.214	2.02E-08	-2.02E-08	100.0%	94.8
Copper	Cu	29	35	64	63.545644	1	8960	141.001	0.0071	0.221	1.88E-08	-1.88E-08	100.0%	85.0
Zinc	Zn	30	35	65	65.395567	1	7130	109.029	0.0092	0.252	1.46E-08	-1.46E-08	96.9%	57.8
Gallium	Ga	31	39	70	69.723072	1	5910	84.764	0.0118	0.286	1.13E-08	-1.13E-08	89.1%	39.6
Germanium	Ge	32	41	73	72.612759	1	5320	73.265	0.0136	0.307	9.78E-09	-9.78E-09	84.9%	31.8
Arsenic	As	33	42	75	74.921596	1	5780	77.147	0.0130	0.299	1.03E-08	-1.03E-08	86.3%	34.4
ά-Arsenic	As	33	42	75	74.921596	1	2000	26.695	0.0375	0.509	3.56E-09	-3.56E-09	60.6%	7.0
Selenium	Se	34	45	79	78.959389	1	4790	60.664	0.0165	0.338	8.10E-09	-8.10E-09	79.7%	24.0
Bromine (Br_2)	Br	35	45	80	79.903529	2	3120	19.524	0.0512	0.595	2.61E-09	-2.61E-09	54.6%	4.4
Krypton	Kr	36	48	84	83.799325	1	3.75	0.045	22.346	12.430	5.97E-12	-5.97E-12	7.2%	0.0005
Rubidium	Rb	37	48	85	85.467664	1	1532	17.925	0.0558	0.621	2.39E-09	-2.39E-09	53.1%	3.9
Strontium	Sr	38	50	88	87.616646	1	2540	28.990	0.0345	0.488	3.87E-09	-3.87E-09	62.3%	7.9
Yttrium	Y	39	50	89	88.905848	1	4470	50.278	0.0199	0.371	6.71E-09	-6.71E-09	74.9%	18.1
Zirconium	Zr	40	51	91	91.223647	1	6510	71.363	0.0140	0.311	9.53E-09	-9.53E-09	84.1%	30.6
Niobium	Nb	41	52	93	92.906378	1	8570	92.243	0.0108	0.274	1.23E-08	-1.23E-08	91.6%	45.0
Molybdenum	Mo	42	54	96	95.931292	1	10220	106.535	0.0094	0.255	1.42E-08	-1.42E-08	96.1%	55.8
Technetium	Tc	43	55	98	97.907216	1	11500	117.458	0.0085	0.243	1.57E-08	-1.57E-08	99.3%	64.6
Ruthenium	Ru	44	57	101	101.064945	1	12370	122.397	0.0082	0.238	1.63E-08	-1.63E-08	100.0%	68.7
Rhodium	Rh	45	58	103	102.905504	1	12410	120.596	0.0083	0.239	1.61E-08	-1.61E-08	100.0%	67.2
Palladium	Pd	46	60	106	106.415328	1	12000	112.766	0.0089	0.248	1.51E-08	-1.51E-08	98.0%	60.8
Silver	Ag	47	61	108	107.868151	1	10500	97.341	0.0103	0.267	1.30E-08	-1.30E-08	93.3%	48.8
Cadmium	Cd	48	64	112	112.411553	1	8650	76.949	0.0130	0.300	1.03E-08	-1.03E-08	86.3%	34.3
Indium	In	49	66	115	114.818086	1	7310	63.666	0.0157	0.330	8.50E-09	-8.50E-09	81.0%	25.8
Tin (White)	Sn	50	69	119	118.710111	1	7310	61.579	0.0162	0.335	8.22E-09	-8.22E-09	80.1%	24.5
Tin (Grey)	Sn	50	69	119	118.710111	1	5800	48.859	0.0205	0.376	6.52E-09	-6.52E-09	74.1%	17.3
Antimony	Sb	51	71	122	121.759788	1	6690	54.944	0.0182	0.355	7.33E-09	-7.33E-09	77.1%	20.7
Tellurium	Te	52	76	128	127.603125	1	6240	48.902	0.0204	0.376	6.53E-09	-6.53E-09	74.2%	17.4
Iodine	I	53	74	127	126.904468	1	4930	38.848	0.0257	0.422	5.19E-09	-5.19E-09	68.7%	12.3
Xenon	Xe	54	77	131	131.292481	1	5.9	0.045	22.253	12.404	6.00E-12	-6.00E-12	7.2%	0.0005
Caesium	Cs	55	78	133	132.905447	1	1870	14.070	0.0711	0.701	1.88E-09	-1.88E-09	49.0%	2.7
Barium	Ba	56	81	137	137.326886	1	3590	26.142	0.0383	0.514	3.49E-09	-3.49E-09	60.2%	6.8

Element	Periodic Table Symbol	Protons (Element: Atomic number)	Neutrons	Nucleon Number	Atomic Mass Units u	Element Atomicity 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 Distance $\langle d \rangle = \sqrt{MR_v}$ (nm)	Coulomb Interaction $\frac{e^2}{\pi\varepsilon_0 \langle d \rangle^2}$ (N)	Gravitational Interaction $-2GR_\rho$ (N)	Fraction of Continuous Gravity Strand Interactions $\frac{\langle r \rangle^2}{\langle d \rangle^2}$ as a %	Stiffness (N m^{-1})
Lanthanum	La	57	82	139	138.905449	1	6150	44.275	0.0226	0.395	5.91E-09	-5.91E-09	*71.8%*	*15.0*
Cerium	Ce	58	82	140	140.115722	1	6770	48.317	0.0207	0.378	6.45E-09	-6.45E-09	*73.9%*	*17.0*
Praseodymium	Pr	59	82	141	140.907648	1	6770	48.046	0.0208	0.379	6.41E-09	-6.41E-09	*73.7%*	*16.9*
Neodymium	Nd	60	84	144	144.236127	1	7010	48.601	0.0206	0.377	6.49E-09	-6.49E-09	*74.0%*	*17.2*
Promethium	Pm	61	84	145	144.912744	1	7220	49.823	0.0201	0.373	6.65E-09	-6.65E-09	*74.6%*	*17.9*
Samarium	Sm	62	88	150	150.366344	1	7520	50.011	0.0200	0.372	6.68E-09	-6.68E-09	*74.7%*	*18.0*
Europium	Eu	63	89	152	151.964336	1	5240	34.482	0.0290	0.448	4.60E-09	-4.60E-09	*66.0%*	*10.3*
Gadolinium	Gd	64	93	157	157.252119	1	7900	50.238	0.0199	0.371	6.71E-09	-6.71E-09	*74.8%*	*18.1*
Terbium	Tb	65	94	159	158.925343	1	8230	51.785	0.0193	0.365	6.91E-09	-6.91E-09	*75.6%*	*18.9*
Dysprosium	Dy	66	97	163	162.497030	1	8550	52.616	0.0190	0.362	7.02E-09	-7.02E-09	*76.0%*	*19.4*
Holmium	Ho	67	98	165	164.930319	1	8800	53.356	0.0187	0.360	7.12E-09	-7.12E-09	*76.4%*	*19.8*
Erbium	Er	68	99	167	167.256301	1	9070	54.228	0.0184	0.357	7.24E-09	-7.24E-09	*76.8%*	*20.3*
Thulium	Tm	69	100	169	168.934211	1	9320	55.169	0.0181	0.354	7.36E-09	-7.36E-09	*77.2%*	*20.8*
Ytterbium	Yb	70	103	173	173.037692	1	6970	40.280	0.0248	0.414	5.38E-09	-5.38E-09	*69.5%*	*13.0*
Lutetium	Lu	71	104	175	174.966718	1	9840	56.239	0.0178	0.351	7.51E-09	-7.51E-09	*77.7%*	*21.4*
Hafnium	Hf	72	106	178	178.484971	1	13310	74.572	0.0134	0.304	9.95E-09	-9.95E-09	*85.4%*	*32.7*
Tantalum	Ta	73	108	181	180.947876	1	16650	92.015	0.0109	0.274	1.23E-08	-1.23E-08	*91.6%*	*44.8*
Tungsten	W	74	110	184	183.841779	1	19300	104.982	0.0095	0.257	1.40E-08	-1.40E-08	*95.7%*	*54.6*
Rhenium	Re	75	111	186	186.206706	1	21000	112.778	0.0089	0.248	1.51E-08	-1.51E-08	*98.0%*	*60.8*
Osmium	Os	76	114	190	190.224861	1	22600	118.807	0.0084	0.241	1.59E-08	-1.59E-08	*99.7%*	*65.7*
Iridium	Ir	77	115	192	192.216054	1	22600	117.576	0.0085	0.242	1.57E-08	-1.57E-08	*99.4%*	*64.7*
Platinum	Pt	78	117	195	195.077791	1	21450	109.956	0.0091	0.251	1.47E-08	-1.47E-08	*97.2%*	*58.5*
Gold	Au	79	118	197	196.966552	1	19300	97.986	0.0102	0.266	1.31E-08	-1.31E-08	*93.5%*	*49.2*
Mercury	Hg	80	121	201	200.599149	1	13550	67.548	0.0148	0.320	9.02E-09	-9.02E-09	*82.6%*	*28.2*
Thallium	Ti	81	123	204	204.383317	1	11850	57.979	0.0172	0.345	7.74E-09	-7.74E-09	*78.5%*	*22.4*
Lead	Pb	82	125	207	207.216892	1	11350	54.774	0.0183	0.355	7.31E-09	-7.31E-09	*77.0%*	*20.6*
Bismuth	Bi	83	126	209	208.980383	1	9750	46.655	0.0214	0.385	6.23E-09	-6.23E-09	*73.0%*	*16.2*
Polonium	Po	84	125	209	208.982416	1	9300	44.501	0.0225	0.394	5.94E-09	-5.94E-09	*71.9%*	*15.1*
Astatine	At	85	125	210	209.987131	1	7000	33.335	0.0300	0.455	4.45E-09	-4.45E-09	*65.3%*	*9.8*
Radon	Rn	86	136	222	222.017570	1	9.73	0.044	22.818	12.560	5.85E-12	-5.85E-12	*7.2%*	*0.0005*
Francium	Fr	87	136	223	223.019731	1	1870	8.385	0.1193	0.908	1.12E-09	-1.12E-09	*41.2%*	*1.2*
Radium	Ra	88	138	226	226.025403	1	5000	22.121	0.0452	0.559	2.95E-09	-2.95E-09	*56.9%*	*5.3*
Actinium	Ac	89	138	227	227.027747	1	10070	44.356	0.0225	0.395	5.92E-09	-5.92E-09	*71.8%*	*15.0*
Thorium	Th	90	142	232	232.038050	1	11720	50.509	0.0198	0.370	6.74E-09	-6.74E-09	*75.0%*	*18.2*
Protactinium	Pa	91	140	231	231.035879	1	15400	66.656	0.0150	0.322	8.90E-09	-8.90E-09	*82.2%*	*27.6*
Uranium	U	92	146	238	238.028913	1	18950	79.612	0.0126	0.295	1.06E-08	-1.06E-08	*87.3%*	*36.1*
Neptunium	Np	93	144	237	237.048167	1	20200	85.215	0.0117	0.285	1.14E-08	-1.14E-08	*89.3%*	*39.9*
Plutonium	Pu	94	150	244	244.064198	1	19840	81.290	0.0123	0.292	1.09E-08	-1.09E-08	*87.9%*	*37.2*
Americium	Am	95	148	243	243.061373	1	13700	56.364	0.0177	0.350	7.52E-09	-7.52E-09	*77.8%*	*21.5*
Curium	Cm	96	151	247	247.070347	1	13500	54.640	0.0183	0.356	7.29E-09	-7.29E-09	*77.0%*	*20.5*

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 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

Compound (samples)

Compound	Formula	Protons	Neutrons	Nucleon Number	Atomic Mass Units	Atomicity	Mass Density	Specific Density	Molar Volume	Mean Interactive Distance	Coulomb Interaction	Gravitational Interaction	Fraction	Stiffness
Ice (273 K)	H_2O	10	8	18	18.015287	1	917	50.901	0.0196	0.369	6.79E-09	-6.79E-09	*75.2%*	*18.4*
Water (277 K)	H_2O	10	8	18	18.015287	1	999.973	55.507	0.0180	0.353	7.41E-09	-7.41E-09	*77.4%*	*21.0*
Steam (373.15 K)	H_2O	10	8	18	18.015287	1	0.60	0.033	30.025	14.408	4.45E-12	-4.45E-12	*6.5%*	*0.0003*
Air ($4N_2 + O_2$)	(Approx.)				14.405000	2	1.29	0.045	22.333	12.426	5.98E-12	-5.98E-12	*7.2%*	*0.0005*
Ozone (O_3)		8	8	16	15.999405	3	2.144	0.045	22.387	12.441	5.96E-12	-5.96E-12	*7.2%*	*0.0005*
Methane	CH_4	10	6	16	16.042500	1	0.716	0.045	22.406	12.446	5.96E-12	-5.96E-12	*7.2%*	*0.0005*
Ammonia	NH_3	10	7	17	17.030566	1	0.77	0.045	22.118	12.366	6.03E-12	-6.03E-12	*7.2%*	*0.0005*
Carbon dioxide	CO_2	22	22	44	44.009546	1	1.98	0.045	22.227	12.396	6.01E-12	-6.01E-12	*7.2%*	*0.0005*
Dimethyl ether (298 K)	CH_3OCH_3	26	20	46	46.068518	1	72.72	1.579	0.6335	2.093	2.11E-10	-2.11E-10	*23.6%*	*0.1*

Liquid Gas (samples)

Liquid Gas	Symbol	Protons	Neutrons	Nucleon Number	Atomic Mass Units	Atomicity	Mass Density	Specific Density	Molar Volume	Mean Interactive Distance	Coulomb Interaction	Gravitational Interaction	Fraction	Stiffness
Oxygen (90 K) (O_2)	O	8	8	16	15.999405	2	1140	35.626	0.0281	0.441	4.76E-09	-4.76E-09	*66.7%*	*10.8*
Methane (109 K)	CH_4	10	6	16	16.042500	1	464.54	28.957	0.0345	0.489	3.87E-09	-3.87E-09	*62.3%*	*7.9*

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}	kg·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 utilized in combination with the inverse mass density element from Eqn. B.1b. A dimensionless unit, u, was assigned to atomic mass units 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 currently 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 stipulation for Eqns. B.2a and B.2b they are equivalent in value. Therefore, u_{p}, Planck mass units can be derived by 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}	kg·m^{-3}·u^{-1}
Planck molar volume	P_v	5.51401999 x 10^{-55}	m^3·kmol^{-1}

Table B2: New Planck components

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

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

References

[1] Woit, P. (2007) Not Even Wrong ISBN 978-0-099-48864-4 Vintage Books London 138

[2] Eto, M., Nitta, M., Yamamoto, N. (2011) Confined Monopoles Induced by Quantum Effects in Dense QCD *Phys Rev* **D83** 085005 DOI:10.1103/PhysRevD.83.085005 arXiv:1101.2574v2

[3] Feynman, R.P. (2006) QED: The Strange Theory of Light & Matter ISBN 0-691-12575-9 Princeton University Press Princeton 131

[4] Penrose, R. (2016) Fashion Faith and Fantasy: in the New Physics of the Universe ISBN 978-0-691-11979-3 Princeton University Press Princeton 13

[5] Chaikin, P.M., Lubensky, T.C. (1995) Principles of Condensed Matter Physics ISBN 978-0-521-79450-3 Cambridge University Press Cambridge 1

[6] Gold, D.W. (2017) Precise Molality and Utilisation with Real Gases

[7] He, J., Pan, Z., Su, D. *et al* (2023) Magnetic-Field-Induced Sign Changes of Thermal Expansion in DyCrO4 *Chin. Phys. Lett.* **40** 066501 DOI:10.1088/0256-307X/40/6/066501