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THE CONCEPTUAL DEFECT OF THE LAW OF UNIVERSAL GRAVITATION OR 'FREE FALL': A DIALECTICAL REASSESSMENT OF KEPLER'S LAWS:

Abdul Malek
TECHNOLOGIE DMI
980 Rue Robert, Brossard, Québec
J4X 1C9, Canada
E-mail: abdulmalek@qc.aibn.com

ABSTRACT

The concept of the Universal Gravitation or "Free Fall" common to both Newton's Law and the Theory of General Relativity (GR) of Albert Einstein is one-sided, idealistic and an anti-dialectical notion in cosmology. It is also in violation of the successful principle of Newton's Third Law of "equal and opposite reaction" and the impossibility of the existence of a single isolated force in terrestrial mechanics. This conceptual defect of the theories of gravity as one-sided universal attraction leads to the abstract notions of superluminal velocity of free falling mass points, cosmic paradoxes, singularities, "Big Bang", "Black Holes", "dark matter" and other such cosmic mysteries. A dialectical perspective of Kepler's laws and of the general dynamics of the cosmic objects may overcome these perceived mysteries in astrophysics and cosmology.

Indexing terms/Keywords

Conceptual defects, Universal Gravitation, "Free Fall", Kepler's Laws, Singularities, Dialectical Contradiction..

Academic Discipline And Sub-Disciplines

Physics, Astrophysics, Dialectical Philosophy.

SUBJECT CLASSIFICATION

Physics, Philosophy

TYPE (METHOD/APPROACH)

Provide examples of relevant research types, methods, and approaches for this field: E.g., Historical Inquiry; Quasi-Experimental; Literary Analysis; Survey/Interview

Dialectical Materialism

Johannes Kepler (1571 – 1630 A.D.) proposed his following three laws of the motion of the planets in the solar system (the last one in 1618) based on the painstakingly visual observation by Tycho Brahe (1546 – 1601 (A.D.):

1. The Law of Orbits: All planets move in elliptical orbits, with the sun at one focus.

2. The Law of Areas: A line that connects a planet to the sun sweeps out equal areas in equal times.

3. The Law of Periods: The square of the period of any planet is proportional to the cube of the semi-major axis of its orbit.

Kepler's laws are not only valid for the planetary system, but also for the motions of natural and artificial satellites as well as to non-powered spacecraft in orbit near planets (1). These laws are independent of the possible secondary gravitational interactions (as perturbing effects) of the various planets on each other.

Isaac Newton (1642 – 1727 A.D.) combined his own three laws of motion with Kepler's laws of the planetary system to formulate his theory of gravity. Newton derived his law of gravitation directly from the Law of Periods of Kepler by adding a proportionality constant, in the following form:

$$T^2 = \frac{4\pi^2}{G\,(M+m)}\,a^3$$

Where T is the period of rotation in earth years, ***a*** is the semi-major axis of the ellipse, ***M*** and ***m*** are respectively the mass of the sun and the planet and ***G*** is the gravitational constant. Newton put the suitable constant ***G*** to the Law of Period of Kepler to quantitatively define the force of gravity in the following form:

$$F = G\,\frac{Mm}{r^2}$$

According to Newton's idea, gravitation is a universal attractive force ***F***, which is directly proportional to the product of the masses of the two bodies and inversely proportional to the squire of the distance (***r***) between them and is characterized by

universal attraction of bodies towards each other. Newton based his theory on the notion of absolute space and time as the objective reality, defined by Euclidean geometry.

Newton's three laws of motion along with the law of gravitational force form the fundamental basis of terrestrial mechanics and have found extensive validation in historical/social practice and technology. Even the lunching and the control of the orbital motions of the earth satellites can be manipulated with reasonable accuracy based on these laws (1).

Newton's law of gravitation as a universal attractive force retained its acceptance for about four centuries, as a reasonable and approximate explanation of the motion of the planets in the solar system and other bodies at or near the surface of the earth. But some major problems such as the unknown nature of the gravitational force, the reason for universal attraction and "free fall", and the question why the gravitational mass and kinetic mass were equivalent along with some other minor issues like the exact description of the advance of the perihelion of the planets etc. remained unresolved.

By the turn of 20th century, Albert Einstein sought to improve on Newton's theory of gravity, while keeping the latter's primary notion of universal gravitation as "free fall", but eliminating the concept of "force" as a characteristic of universal gravitation. Einstein did not address, but rather skirted the main conceptual problems of Newtonian universal gravitation by covering them under sophisticated idealized mathematics. This was done by negating the long held notion of materialism and natural science that matter and motion are the primary attributes of objective reality (2). With the help of his teacher Hermann Minkowski, Einstein made a radical change in the concept of hitherto abstract space and time; in terms of a compounded "spacetime" geometrical manifold with physical attributes. Gravitational "free fall" was then ascribed to a modification (warping) of "spacetime" in presence of matter/energy. Einstein's GR as a substitute for the theory of gravity inherited the conceptual problems, especially gravitational "free fall"; but at the same time negated the useful concepts of matter, motion, momentum, force etc., of Newtonian physics in particular and materialism in general.

Newton' laws of gravity were limited in scope as it was concerned with the dynamics of the solar system and the terrestrial realm. GR on the other hand assume much higher implications about the nature of reality, the origin and the extension of the universe etc. Moreover, because of the axiomatic and esoteric nature of GR and its negation of the concept of Newtonian force, GR leads to the concepts of fantastic cosmic objects and phenomena, which have no parallel in terrestrial practice and experience.

Newton's laws of motion and gravity have gained reasonable validity in the terrestrial realm, but the same can not be said about the motion of the planets and other cosmic bodies. The idea of the transference and the unlimited extension of the laws, specially the idealized mathematics based theory of GR developed at or near terrestrial sphere to the cosmic realm is fraught with difficulties. The abject failure of these laws in the quantum realm of the microcosm should be a warning against the unlimited extension of terrestrial based laws to the macrocosm of the cosmic realm; because the origin of motion and the nature of the forces between the cosmic bodies are not well understood. Moreover, the concept of gravitation as a one-sided universal attractive force violates Newton's third law of motion in the realm of the cosmos; but the one, which is so vital in the understanding and the functioning of terrestrial dynamics.

We are not concerned here with the description of the theories of gravitation of either Newton or Einstein; or with their relative merits, but solely with some of the conceptual defect they share, particularly, the question of "free fall" in universal gravitation. Despite major conceptual problem with free fall, GR is generally accepted in natural science as a better theory of gravity for periods spanning about a century. But the conceptual problems were bound to come to the fore one day. W.W. Engelhardt (3) in a recent publication brought attention to the major anomaly that "free falling" mass points may attain superluminal velocities depending on their initial velocity at infinity, in both Newton's and Einstein's theories of gravity. Also, Einstein's claim that GR gives a quantitative description of the advance of the perihelion of the planet Mercury and that this constitutes a major proof of his theory of relativity has also come into question (3).

The only criticism of the conceptual defect of Newton's law of universal gravitation and the idea of "free fall" came not from scientists but from dialectical philosophy in the persons of G.W.F. Hegel (1770 – 1831 A.D.) and Karl Marx (1818 – 1883 A.D.). Both contended that Newton's 'proof' of the law of gravitation had added nothing to Kepler's laws. They particularly objected to the one-sided and anti-dialectical aspect of universal attraction in gravitation. The criticism by Hegel and later Marx came due to the fact that Newton only added one proportionality constant to Kepler's Law of Periods and essentially failed to take into a proper account of Kepler's Law of Orbits and the Law of Areas, the First and Second Laws respectively. These involve the lack of understanding by Newton why the orbits of the planets should be elliptical, what are the origin and the nature of planetary motion, and the one-sided view of universal attraction, which violates his Third Law of terrestrial mechanics. Most of all Newton's gravitational law of universal attraction violate the law of "the unity of opposites" and contradictions of dialectics. Whatever the nature of the gravitational attraction is, it must have its opposite; as a repulsive force, for cosmic bodies to remain separated from each other. As a dialectical necessity, the cosmic bodies must have both "universal free motions" along with bondage (gravity). Free motion cannot have external or contingent causes, but must be explained from matter itself (2).

Newton arbitrarily assumed that the elliptical motion of a body will result if it is attracted to another 'central' body by a force inversely proportional to the square of the distance between them, provided that the body has an initial velocity that is not too large or too small, and not directly toward or directly away from the central body. This situation involves only a single force on the body, which, is the central force of gravity from the sun. Also, Newton had no notion of the source of motion or inertia of the heavenly bodies, simply attributing it as an impulse from God.

That seemed to Hegel as a case of mere one-sided contingency and not associated with a dialectical necessity. Hegel posited that the elliptical orbits of the planets discovered by Kepler represented a dialectical contradiction and the motion of a planet is a direct result of that contradiction. Marx following Hegel particularly focused his criticism of Newton's law based on the elliptical orbit of the planet Mercury. This was also the time when in 1859 the French astronomer Le Verrier

announced (based on many years of careful observations and calculations) that the perihelion of the planet Mercury evidently undergoes precession, at a slightly faster rate than can presumably be accounted for, by Newtonian mechanics, given the known distribution of the planets and the other objects in the solar system. It is worthy to note that Kepler's laws are satisfied for any particular planet without taking into account the effects from other existing ones.

Marx like Hegel before him attributed the elliptical orbit as well as gravity for the tendency of two bodies to "continuously fall into each other" to the tendency to same extent "just as constantly fly away from the other" (4) – correctly reflecting dialectical laws and Newton's Third Law of "equal and opposite reaction" in the cosmic realm. The elliptical orbits of planetary motion are a situation where the dialectical "contradictions create a form within which they can move themselves"; are 'solved' [*losen*] but not overcome [*aufheben*]. Overcoming [*aufhebung*] in dialectics leads to a development – when the old set-up breaks into new formations. This stage precedes an intensification of the old contradiction of "the unity of the opposites" in which the two opposites attains absolute polarity and totally excludes each other before the break-up like the division of living cells, to new dialectical relation or "the negation of the negation". The views of Hegel and Marx on the dialectics of the elliptical motion of the planet Mercury have been discussed by T. Weston (5) in a thorough review and in the references there in. Weston also discussed the motion of the planet Mercury in the context of Marx's ideas.

We will now re-evaluate qualitatively, Kepler's and Newton's laws of the planetary motions in the solar system in view of the dialectical perspective and from some astrodynamical considerations using recent data from the "Planetary Fact Sheet" from NASA (6) sources. For simplicity, the orbits of a planet around the sun will be treated as two-body systems with the secondary effects from the mass of the other planets considered negligible compared to that of the sun. Because of the two contradictory equal and opposing forces working on a planet in an orbit, the planet will be set to motion along the orbital path even with zero initial velocity, as long as the two bodies are in a dialectical relationship. This contradiction then leads to a motion necessarily in an elliptical orbit, because of the dynamic and the fluctuating nature of the two opposing forces acting on the planet along the orbital path. For dialectics, motion, change etc. arises due to contradictions. A Goldilocks type exact and matching "free falling" inertia of a planet for stable orbit around the sun required in one-sided attractive force of Newton's or Einstein's theories, is not necessary for the dialectical view.

The opposite tendencies of a planet and the sun "falling into each other" and of "flying away from each other" are in mutual contention and in an inner struggle without overcoming (aufhebung) the contradiction. An equal and opposite magnitude of force opposing the one directed towards the centre of the sun must therefore, be distributed among the kinetic - rotational and spin motion of the planet for it to be able to remain in a stable and closed orbit around the sun. If we ignore the spin of the planet, the force opposing the gravitational pull towards the sun must be distributed between the observed angular momentum of the planet along the orbit as the orbital velocity and the latent escape velocity of the planet at any position along the orbit. This distribution of the anti-gravity force along with the physical state (size, solid, liquid or gas etc.) will determine the size and the nature (i.e., oblateness, eccentricity etc.) of the closed orbit as long as they are in dialectical contradiction.

The minimum orbital velocity $\boldsymbol{V_O}$ of a planet around the sun will be given by the following relation (1).

$$\sqrt{\frac{GM}{r}\left(2-\frac{(1-e^2)}{1+e\cos\theta}\right)}$$

Where $\boldsymbol{G}$ is the gravitational constant, $\boldsymbol{M}$ is the mass of the sun, r is the radial distance, e is the eccentricity of the elliptical path and θ is the angle between the radial vector and tangential vector at any particular point along the elliptical path of the planet.

The escape velocity $\boldsymbol{V_E}$ of the planet will be given (1) as:

$$\sqrt{2\frac{GM}{r}}$$

The actual velocity $\boldsymbol{V}$ of a planet at a particular position on the orbit will depend on r, e and θ values in the orbital and the escape velocities at that position and will therefore have to balance and fluctuate between the escape velocity and the minimum orbital velocity given by the following relation:

$$\boldsymbol{V_O < V < V_E}$$

In this contradiction of the of the orbital motion of the planets, $\boldsymbol{V_O}$ and the angular momentum associated with it that satisfy Kepler's First and Second Law; represent the passive part of the anti-gravity force necessary to oppose the gravitational pull towards the sun and to keep the planet in orbit. This passive part of the contradiction like a dynamic chemical equilibrium will remain stable unless a dramatic major change in the setup takes place due to external or internal factors, such as a major collision with other cosmic objects or a major change in the sun, for examples.

The latent escape velocity $\boldsymbol{V_E}$ represents the potential active part of the contradiction that lead to secondary effects such as the change in the position or the precession of the orbital path, specially the advance of the perihelion where $\boldsymbol{V_E}$ is the maximum; slow dispersion of the outermost planets or the in-falling of the innermost ones into the sun etc. The same

consideration probably applies to other cosmic systems like the star clusters or the galaxies and their clusters (7) etc. A dialectical perspective combined with modified Newtonian mechanics may, therefore, be suitable tools for gaining positive knowledge of the universe in general; without the need of Einstein's theories of relativity..

Table 1 shows some recent data (6) on the mass, eccentricity, orbital and escape velocities of the solar planetary bodies and some calculated parameters from this data. The ratio of the orbital and escape velocity (V_O / V_E) per unit mass x 10^{24} kg; the orbital kinetic energy K_O, the escape kinetic energy K_E, the ratio of K_O/K_E per unit mass x 10^{24} kg of the planet and the total kinetic energy (neglecting spin) **E** per unit mass x 10^{24} kg were calculated from the NASA data. The very high V_O / V_E and K_O / K_E ratio for Mercury and Pluto along with the high eccentricity of their orbits reflects the accentuated contradiction in their orbital motion. In both these cases, the major portion of the force countering the strong gravitational pull had to be converted to the orbital velocity at the cost of escape velocity to keep the planets in their stable orbits. The gravitational pull from the rest of the planets in the case of Mercury, probably helped somewhat to counter the gravitational attraction from the sun, while in the case of Pluto it added to the gravitational pull from the sun. This accentuation of the contradiction and the orbital motion of these two planets are reflected in the higher eccentricities and the higher precession rate of their orbits.

The contradiction in the planetary motion can only be overcome by either the planet falling into the sun or going out of the gravitational sphere of influence of the sun. These two opposing tendencies of the contradiction will be most acute with the planet closest to the sun and the one far away from it respectively because of the possible predominance of either one or the other of the two opposite tendencies of "free fall" or "flying away" of the planets. The exceptionally high total kinetic energy ($K_O + K_E$) of Mercury and Jupiter compared to the other planets reflects their greater orbital instability.

The nature of the repulsive force will only be known when the nature of the gravitational attraction is understood. The solar system of course is not a permanent system and the contradiction will be resolved by its break-up, in which some of the planets near the sun will eventually fall into it and the others in the periphery will break away. Some planets may change their relative distance from the sun depending on the acuteness of this contradiction as was reportedly the case with Neptune, which migrated (8) 10 AU further from the sun from a distance of 20 AU to 30 AU.

Conclusion

The main limitation of hitherto known physics, astrophysics in particular, that of Newton and Einstein included; is that these are based on causality mediated formal (Aristotelian) logic, which has limited validity in epistemology; as is evident specially after the quantum phenomena and the evolution in Nature was recognized. After G.W.F. Hegel (1770 – 1831 A.D.) it is increasingly being realized that Nature, history, society and thought is mediated by dialectical contradictions of chance and necessity rather than deterministic cause and effect of formal (Aristotelian) logic.

Newtonian mechanics works reasonably well in terrestrial Nature because, even if in a limited way, the dialectical contradiction was recognized in Newton's Third Law of motion. But in the celestial mechanics of both Newton and Einstein, dialectical contradiction is eliminated along with Newton's Third Law of motion. This is replaced with the concept of universal harmony, gravitational attraction, "free fall" etc. This is an unrealistic and idealist proposition that is bound to lead to fantastic phenomena and objects, wild speculations, paradoxes, singularities etc. that is so much prevalent in modern cosmology.

Only a dialectical approach can help modern physics to continue to progressively gain positive knowledge of the cosmos on the one hand and of the quantum world on the other. For example, in the light of this work, the advance of the perihelion of the planets, the high orbital motion of the stars at the periphery of the galaxies and of galaxies at the periphery of the clusters etc. and other cosmic phenomena (9) may probably be accounted for without the necessity of fantastic "spacetime" warping or hypothetical dark matter, black holes etc.

Table 1. Some Data (6) and Calculated Parameters of the Solar Planetary System

Planet	Mass (10^24kg)	Orbital Eccentricity	Orbital Velocity (V_O) (km/s)	Escape Velocity (V_E) (km/s)	V_O/ V_E Per unit Mass (10^24kg)	Orbital KE Kg.km^2/s^2x10^24	Escape KE Kg.km^2/s^2x10^24	Orbital KE / Escape KE	Total KE per unit Mass (10^24kg)
MERCURY	0.33	0.21	47.40	4.30	368.22	370.72	3.05	121.51	1,132.63
VENUS	4.87	0.01	35.00	10.40	2.33	2,982.88	263.37	11.33	666.58
EARTH	5.97	0.02	29.80	11.20	1.19	2,650.80	374.44	7.08	506.74
MARS	0.64	0.09	24.10	5.00	36.19	186.44	8.03	23.23	302.91
JUPITER	1,898.00	0.05	13.10	59.50	0.00	162,857.89	3,359,697.30	0.05	1,855.93
SATURN	568.00	0.06	9.70	35.50	0.00	26,721.56	357,911.00	0.07	677.17
URANUS	86.80	0.05	6.80	21.30	0.00	2,006.82	19,690.15	0.10	249.97
NEPTUNE	102.00	0.01	5.40	23.50	0.00	1,487.16	28,164.75	0.05	290.71
PLUTO	0.01	0.24	4.70	1.30	895.27	0.16	0.01	13.07	11.89

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