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The Centrifugal Force Argument

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***Abstract*. The modern teaching is that centrifugal force only exists as a fictitious force in a rotating frame of reference, and that the only force acting in an inertial frame of reference when a body undergoes circular motion is an inward acting centripetal force. On the contrary however, it is here proposed that a rotating frame of reference, rather than creating a fictitious centrifugal force, actually masks the existence of a very real inertial centripetal force that has gone unrecognized in the literature. When the books are correctly balanced, it will be demonstrated that centrifugal force is a real force, closely related to kinetic energy, and observable in any frame of reference.**

The Inertial Path

I. Consider a particle moving in an inertial frame of reference. We write the position vector of this particle relative to any arbitrarily chosen polar origin as,

$$\mathbf{r} = r\hat{\mathbf{r}} \qquad \textbf{(1)}$$

where the unit vector $\hat{\mathbf{r}}$ is in the radial direction, and where r is the radial distance. Taking the time derivative and using the product rule, we obtain the particle's velocity,

$$\dot{\mathbf{r}} = \dot{r}\hat{\mathbf{r}} + r\dot{\theta}\hat{\boldsymbol{\theta}} \qquad \textbf{(2)}$$

where $\hat{\boldsymbol{\theta}}$ is the unit vector in the transverse direction, and where $\dot{\theta}$ is the angular speed about the polar origin. Taking the time derivative again we obtain the expression for the particle's acceleration in the inertial frame,

$$\ddot{\mathbf{r}} = \ddot{r}\hat{\mathbf{r}} + \dot{r}\dot{\theta}\hat{\boldsymbol{\theta}} + \dot{r}\dot{\theta}\hat{\boldsymbol{\theta}} + r\ddot{\theta}\hat{\boldsymbol{\theta}} - r\dot{\theta}^2\hat{\mathbf{r}} \qquad \textbf{(3)}$$

which can be rearranged as,

$$\ddot{\mathbf{r}} = (\ddot{r} - r\dot{\theta}^2)\hat{\mathbf{r}} + (2\dot{r}\dot{\theta} + r\ddot{\theta})\hat{\boldsymbol{\theta}} \qquad \textbf{(4)}$$

(†see the note at reference **[1]** regarding Maxwell's equation (77) and equation **(4)** above)

In the case of uniform straight-line motion in an inertial frame of reference, the acceleration is zero, therefore,

$$\ddot{r} - r\dot{\theta}^2 = 0 \qquad \textbf{(5)}$$

The term $\ddot{r}$, being positive, is the inertial centrifugal acceleration, while the negative term $-r\dot{\theta}^2$ must be an equal and opposite inertial centripetal acceleration. The centrifugal acceleration acts to change the radial speed whereas the inertial centripetal acceleration acts to rotate the radial direction. Likewise, in the transverse direction, the two terms cancel each other with one of the terms acting to change the transverse speed while the other term acts to change the transverse direction, hence conserving angular momentum. These observations, combined with the fact that the choice of polar origin is entirely arbitrary, points to an inertial mechanism involving a sea of tiny vortices pressing against each other with centrifugal force while striving to dilate and which would cause a velocity dependent inertial pressure to act uniformly all around a body **[1], [2], [3], [4], [5]**. This inertial pressure must be the same thing as kinetic energy, because we know that centrifugal force is the radial gradient of transverse kinetic energy. See the article ***"Straight Line Motion"*** **[6]**.

If we swing a weight on the end of a string, the inertial centrifugal force acting on the weight causes the string to become taut. This induces a reactive tension in the string that causes a centripetal force to act on the weight, which in turn cancels the inertial centrifugal force. Hence, we are left with a net inertial centripetal force $-mr\dot{\theta}^2$ which causes the weight to undergo circular motion.

Planetary Orbits

II. In planetary orbits, conservation of angular momentum causes the transverse term in equation **(4)** to vanish. This is recognized in Kepler's second law, which is the law of areal speeds. Meanwhile the gravity sinks distort the inertial mechanism. Gravitational tension undermines the centrifugal pressure forces that are measured relative to the gravitational centres, and so the problem reduces to an interplay between gravity and centrifugal force along the radial line. Since the inertial centripetal force is always equal and opposite to the centrifugal force, we can now reduce the problem to a scalar equation in the radial distance, with the centrifugal term taking the form $+r\dot{\theta}^2$. The relevant scalar equation becomes,

$$\ddot{r} = -k/r^2 + r\dot{\theta}^2 \qquad \textbf{(6)}$$

first presented by Leibniz in the form

$$\ddot{r} = -k/r^2 + l/r^3 \qquad \textbf{(7)}$$

where k is the gravitational constant and l is the angular momentum constant. The interplay between the gravitational inverse square law attractive force and the inverse cube law centrifugal repulsive force involves two different power laws and this leads to stable orbits that are elliptical, circular, parabolic, or hyperbolic.

Conclusion

III. With respect to any arbitrarily chosen polar origin in an inertial frame of reference, a body moving in uniform straight line motion will experience a pair of equal and opposite inertial forces, in both the radial and the transverse directions, hence implying that an equal pressure, which has been induced by the motion, exists all around the body. This pressure is better known as kinetic energy [7].

In the case of large planetary bodies, the surrounding gravity sinks distort the inertial mechanism. Gravitational tension undermines the centrifugal pressure on the inner side between the two gravitational centres, and hence the inertial centripetal force curves the path of motion into an ellipse, a circle, a parabola, or a hyperbola. The inertial centripetal force is of course a centrifugal force pushing from behind the planets. The centrifugal forces to the gravitational centres are angular momentum dependent, totally independent of gravity, and so they are not in general equal to gravity in magnitude. The action reaction-pairs in an orbital system are between two equal and opposite centrifugal forces, two equal and opposite gravitational forces, and two equal and opposite inertial centripetal forces. The latter, which are actually centrifugal forces in substance, are equal and opposite to the inner centrifugal forces that interact with gravity. Centrifugal force is never part of an action-reaction pair with gravity.

In the special case of a circular planetary orbit, the centrifugal force does however exactly cancel with the force of gravity, but this doesn’t make these two forces into an action-reaction pair. In a circular orbit, with gravity and centrifugal force both cancelled, we can see that the net centripetal force must be the inertial centripetal force, but no such inertial centripetal force exists in the physics literature, which is why there is so much confusion surrounding this topic. It's the absence of inertial centripetal force in the literature which is the sole cause of the controversy over whether or not centrifugal force is a real force.

In the case of a weight that is being swung around on the end of a string and undergoing circular motion in an inertial frame of reference, there is a net inertial centripetal force acting on the weight. This net inertial centripetal force, normally hidden from view in the inertial path, is unmasked because the equal and opposite inertial centrifugal force is cancelled by the reactive centripetal force which it induces in the string.

The inverse cube law relationship that appears in centrifugal force when angular momentum is conserved, hints at dielectric origins since the inverse cube law in distance is characteristic of a dipole field. The tiny aether vortices that fill all of space, and which serve as the medium for the propagation of light, are therefore likely to be dipolar. Gravity on the other hand is due to a largescale flow of aether that flows through this sea of tiny vortices. The fact that the vortices are dipolar means that the gravitational field will exert a torque on them, causing them to precess about an axis that is aligned along the gravitational lines of force, hence inducing centrifugal force at right angles to these lines of force. A simple mechanical analogy to a single gravitational line of force would be a row of freely rotating propeller blades. When the wind causes the blades to rotate, some air is flung sideways. The cushion of pressurized air, which would therefore exist in the space between two such neighbouring rows of rotating propeller blades, corresponds to the centrifugal pressure that exists between adjacent gravitational lines of force, and which sustains the planets in their stable orbits.

As the large scale aether flow of gravity percolates through the dense sea of tiny aether vortices, these will absorb any large-scale vorticity, hence ensuring that the gravitational field is predominantly irrotational.

References

[1] Clerk-Maxwell, J., ***"On Physical Lines of Force"***, Philosophical Magazine, Volume XXI, Fourth Series, London, (1861)
http://vacuum-physics.com/Maxwell/maxwell_oplf.pdf
† Equation (77) in this paper is Maxwell's electromotive force equation and it exhibits a strong correspondence to equation **(4)** above. The centrifugal and Coriolis terms in equation **(4)** correspond to the compound centrifugal term $\mu\mathbf{v} \times \mathbf{H}$, while the other transverse term corresponds to $-\partial\mathbf{A}/\partial t$. Gauss's law, which is also in Maxwell's equation (77), then appears in equation **(6)** above.

[2] Tombe, F.D., ***"The Double Helix Theory of the Magnetic Field"*** (2006)
Galilean Electrodynamics, Volume 24, Number 2, p.34, (March/April 2013)
http://gsjournal.net/Science-Journals/Research%20Papers-Mathematical%20Physics/Download/6371

[3] O'Neill, John J., ***PRODIGAL GENIUS***, ***Biography of Nikola Tesla****, Long Island, New York, 15th July 1944*
http://www.rastko.rs/istorija/tesla/oniell-tesla.html
"Long ago he (mankind) recognized that all perceptible matter comes from a primary substance, of a tenuity beyond conception and filling all space - the Akasha or luminiferous ether - which is acted upon by the life-giving Prana or creative force, calling into existence, in never ending cycles, all things and phenomena. ***The primary substance, thrown into infinitesimal whirls of prodigious velocity,*** *becomes gross matter; the force subsiding, the motion ceases and matter disappears, reverting to the primary substance".*

[4] Lodge, Sir Oliver, ***"Ether (in physics)"***, Encyclopaedia Britannica, Fourteenth Edition, Volume 8, Pages 751-755, (1937)
http://gsjournal.net/Science-Journals/Historical%20PapersMechanics%20/%20Electrodynamics/Download/4105
In relation to the speed of light, *"The most probable surmise or guess at present is that* ***the ether is a perfectly incompressible continuous fluid, in a state of fine-grained vortex motion,*** *circulating with that same enormous speed. For it has been partly, though as yet incompletely, shown that such a vortex fluid would transmit waves of the same general nature as light waves— i.e., periodic disturbances across the line of propagation—and would transmit them at a rate of the same order of magnitude as the vortex or circulation speed"*

[5] Whittaker, E.T., ***"A History of the Theories of Aether and Electricity"***, Chapter 4, pages 100-102, (1910)
"All space, according to the younger Bernoulli, is permeated by ***a fluid aether, containing an immense number of excessively small whirlpools.*** *The elasticity which the aether appears to possess, and in virtue of which it is able to transmit vibrations, is really due to the presence of these whirlpools;* ***for, owing to centrifugal force, each whirlpool is continually striving to dilate, and so presses against the neighbouring whirlpools****."*

[6] Tombe, F.D., ***"Straight Line Motion"*** (2018)
https://www.researchgate.net/publication/325472420_Straight_Line_Motion

[7] Tombe, F.D., ***"The Significance of the Inertial Forces"*** (2019)
https://www.researchgate.net/publication/332912193_The_Significance_of_the_Inertial_Forces