

## 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,

$$\mathbf{r} = r\hat{\mathbf{r}} \quad (1)$$

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,

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

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,

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

which can be rearranged as,

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

(†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,

$$\ddot{r} - r\dot{\theta}^2 = 0 \tag{5}$$

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 an all-pervading sea of tiny aethereal vortices pressing against each other with centrifugal force while striving to dilate, [1], [2], [3], [4], [5], and which would cause a disc-like velocity-dependent pressure field to form around all moving particles, perpendicular to their direction of motion. This inertial pressure field must be an extension of the particle's kinetic energy, because we know that centrifugal force is the radial gradient of transverse kinetic energy. See **Appendix I** and also the article entitled "*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 a planetary orbit, the gravity sinks surrounding the two planets are strong enough to distort the inertial mechanism and its associated disc-like centrifugal force fields, and so we are no longer working in an inertial frame of reference. Gravity now replaces the inertial centripetal force. Gravitational tension undermines the centrifugal pressure forces and so the problem reduces to an interplay between gravity and centrifugal force along the radial line connecting any two planets. Meanwhile Kepler's second law, the one relating to areal velocities, ensures conservation of angular momentum, and so we can ignore transverse effects. We can then reduce the problem to a scalar equation in the

radial distance, with the centrifugal term taking on the form  $+r\dot{\theta}^2$ . The relevant scalar equation becomes,

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

first presented by Leibniz in the form,

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

where  $k$  is the gravitational constant and  $l$  is a constant related to the angular momentum. 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.** A body moving in uniform straight-line motion will experience a disc-like centrifugal pressure field at right angles to its direction of motion. This pressure field will consist of concentric rings of force in the likeness of a magnetic field, and it is an extension of the moving body's kinetic energy, [7]. This is the inertial mechanism.

In the case of large planetary bodies, their gravitational sinks are strong enough to destroy the inertial mechanism. Between two mutually orbiting planets, gravitational tension undermines the centrifugal pressure at the interface between the two gravity sinks, while on the outer side, the gravitational tails destroy the inertial centripetal force that would have existed in the case of small terrestrial objects. 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 interplay between gravity and centrifugal force leads to orbits that are either elliptical, circular, parabolic, or hyperbolic, according to the ratio of the magnitudes of these two opposing forces. The action-reaction pairs in an orbital system are between two equal and opposite centrifugal forces and between two equal and opposite gravitational forces. 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.

Terrestrial objects don't have gravitational fields that are strong enough to significantly distort the inertial mechanism and so a centrifugal force field will completely surround a moving body at right-angles to its direction of motion. 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 inwards 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 by pulling the string taut. The absence of the concept of inertial centripetal force in the literature contributes greatly to the controversy over whether or not centrifugal force is a real force. The inertial centripetal force is of course just a consequence of the disc-like centrifugal force field when considered with respect to a point origin such that the effect is centripetally directed.

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 large-scale 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 much of the large-scale vorticity in the velocity field that is associated with the gravitational field.

## **Appendix I**

The tiny aethereal vortices will self-align such that their mutual rotation axes trace out concentric solenoidal lines of force around any moving object. This is exactly the same principle upon which Maxwell explained a magnetic field. The result is that the moving object experiences a constricting pressure pushing in on it sideways from all directions.

## References

- [1] 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.”*
- [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] Clerk-Maxwell, J., “*On Physical Lines of Force*”, Philosophical Magazine, Volume XXI, Fourth Series, London, (1861)  
[http://vacuum-physics.com/Maxwell/maxwell\\_oplf.pdf](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.
- [4] O’Neill, John J., “*PRODIGAL GENIUS, Biography of Nikola Tesla*”, Long Island, New York, 15th July 1944, Fourth Part, paragraph 23, quoting Tesla from his 1907 paper “*Man’s Greatest Achievement*” which was published in 1930 in the Milwaukee Sentinel,  
*“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”.*  
<http://www.rastko.rs/istorija/tesla/oniell-tesla.html>  
<http://www.ascension-research.org/tesla.html>
- [5] 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”*
- [6] Tombe, F.D., “*Straight Line Motion*” (2018)  
[https://www.researchgate.net/publication/325472420\\_Straight\\_Line\\_Motion](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](https://www.researchgate.net/publication/332912193_The_Significance_of_the_Inertial_Forces)