the general science journal

The Centrifugal Force Paradox

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27th March 2011

Abstract. **It is commonly taught nowadays that centrifugal force doesn't exist, except as a fictitious force that is only observable from a rotating frame of reference. This belief is based on Newton's law of inertia which states that a body undergoing straight line motion at constant speed experiences no net force, and that curved path motion involves only a centripetal force. However, if we split the net zero force of straight line constant speed motion into polar components, we find that one of these is a centrifugal force component which can physically react with constraints, hence revealing an underlying pressure associated with inertia. Further evidence that centrifugal force is a real physical force arises when inertial pressure becomes asymmetrical, as happens in a radial gravitational field or in a solenoidal magnetic field.**

Newton's First Law of Motion

I. When an object moves in a straight line with constant speed, the net force acting upon it will be zero, yet if we consider the motion relative to any point origin that does not lie on the trajectory, we will observe an acceleration that is directed radially outwards from that origin. This acceleration is the centrifugal acceleration which can be shown to obey an inverse cube law with respect to the radial distance from the origin. However, there will be an equal and opposite acceleration relating to the rotation of the line connecting the object to the origin, and the resultant acceleration will be zero. Hence it is believed by some that the outward centrifugal acceleration is merely a fictitious effect which can only be observed from the rotating frame of reference.

Reaction with Constraints

II. An object moving in a horizontal plane and tied to a tethered string will pull the string taut, hence resulting in circular motion. Likewise a 'wall of death' rider pushes against a surface resulting in curved path motion. In both these situations, the inertia physically reacts with the constraint and induces a centripetal force. The component of the inertia that reacts with the constraint to cause curved path motion is of course the centrifugal force, and it is quantified by the product of mass and centrifugal acceleration. These situations are a rotational analogy to when

the force of gravity pulls on a weight on the end of a fixed string, or pushes a weight against a horizontal surface. Both gravity and centrifugal force share in common the fact that neither of them are physically felt until there is a reaction. The magnitude of the reaction, which is the apparent weight, will be determined by the degree to which the constraint yields or opposes. For example, in an elevator that is accelerating downwards, or in an elliptical 'wall of death' where the rider is moving away from the origin, the yield will make the apparent weight less than the causative force. The opposite will be the case when the constraint is opposing.

The fact that the centrifugal force component of inertia can physically react, means that, just like gravity, it is a real force and not a fictitious force. Inertia involves an actual kinetic pressure, and in the case of an object moving in a straight line at constant speed, the kinetic pressure will be equal all around the object. Since the inertia of a moving object is also a measure of its kinetic energy, it would seem therefore that kinetic energy is actually a pressure. This idea would be further confirmed by the fact that the transverse kinetic energy in a rotating system is equivalent to the centrifugal potential energy.

Centrifugal Force in a Radial Field

III. While Sir Isaac Newton (1642-1727) is credited with having discovered the inverse square law relationship for gravity, what is not so well known is the fact that his arch rival Gottfried Leibniz (1646-1716) independently discovered this relationship too, as well as also discovering the inverse cube law relationship for centrifugal force, and hence the complete radial planetary orbital equation [1],

$$d^2r/dt^2 = -\mathfrak{k}/r^2 + \mathfrak{l}^2/r^3 \qquad \textbf{(1)}$$

where $\mathfrak{k}$ is the gravitational constant and $\mathfrak{l}$ is related to the angular momentum. The two body planetary orbit is where gravity and centrifugal force come face to face, and it involves two gravitational fields which don't mix. On the nearside between the two planets, the field lines meet laterally and spread outwards. On the far side of the two planets, the field lines extend backwards in a long tail. The gravitational tails mean that the centrifugal pressure, in the shear region where the two gravitational fields meet, only acts to push the planets apart. This asymmetry exposes the centrifugal force as a real inverse cube law force acting outwards. It acts in competition with the inward inverse square law

force of gravity, and the two different power laws give rise to stable equilibrium nodes, and hence provide the basis for orbital stability. Since gravity and gravitational potential energy are a tension, whereas centrifugal force and kinetic energy are a pressure, an elliptical planetary orbit shows some degree of rotational analogy with a mechanical spring that oscillates between tension and pressure.

Centrifugal Force in a Solenoidal Field

IV. James Clerk-Maxwell (1831-1879) utilized the concept of centrifugal force in order to explain magnetic repulsion [2]. He believed space to be filled with tiny aethereal vortices pressing against each other with centrifugal force. These vortices would be mutually aligned such that their rotation axes trace out the magnetic lines of force. Hence if an object moves perpendicularly across magnetic lines of force, the mutual speed as between the moving object and the edge of the surrounding aethereal vortices will be different at each side of the object, bearing in mind that all the vortices are spinning in the same direction. This will lead to an asymmetry in the centrifugal pressure in the direction transverse to the motion, and hence the object will be deflected. This compound centrifugal force will actually be a centripetal force which makes the object move in a circle or a helix. The magnetic field strength is a measure of the vorticity **H** of the aethereal vortices, which is directly related to the angular speed **ω** of the ensuing circular or helical motion through the equation,

$$\textbf{centrifugal force} = m\mathbf{v}\times\boldsymbol{\omega} = -q\mathbf{v}\times\mathbf{H} \qquad (2)$$

The large scale centrifugal force will of course be totally undetectable as such, being absorbed in the centripetal force [3], [4].

Conclusion

V. Unfortunately the centrifugal force paradox has been exacerbated by the fact that in some of the modern literature, the fictitious force in the rotating frame of reference has been extrapolated by bad mathematics to apply to all objects in the rotating frame, whether or not those objects are co-rotating. This has reduced centrifugal force to a false system of accountancy which is used to describe motion in a rotating frame of

reference, and which has lost all connection with the physical effects of inertia which it is supposed to be describing. It is case of mathematical physics having become de-railed from the actual physics. And the situation has been further confused by the fact that in other parts of the literature the concept of centrifugal force is seldom considered outside of the particular context of circular motion. And in such circular motions in which the inward centripetal force is supplied by a constraint, the physical reaction is rightfully acknowledged, but the centrifugal force is wrongly said to be the equal and opposite reaction to the centripetal force, as per Newton's third law of motion, even though the centrifugal force is clearly the pro-active force in the circumstances. Newton himself was largely responsible for this error. Leibniz's equation in section **III** above makes it quite clear that the centrifugal force and the centripetal force are not an action-reaction pair. They are not even the same magnitude in general. Planetary orbits are still solved today using Leibniz's equation, albeit that the identification of the inverse cube law term with centrifugal force is very much played down in the modern literature. Newton's erroneous ideas about centrifugal force arose as a reaction to Leibniz's equation. It is believed that Newton knew fine well that Leibniz was correct, but due to the intense rivalry between the two, Newton could not bring himself to support Leibniz's equation. Newton objected to Leibniz's equation on the false grounds that the centrifugal force in the equation was not in general equal to the centripetal force, and he then went on to wrongly claim that the centrifugal force is the equal and opposite reaction to the centripetal force as per his third law of motion. So Newton's law of inertia and Newton's own application of his third law to explain centrifugal force lie at the root of two of the conflicting explanations for centrifugal force which appear in the modern literature, both of which are wrong.

References

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