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Electromagnetism and the Rolling Wheel

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Abstract. A rolling wheel is driven forwards by virtue of the linear momentum in the upper half of the wheel. A closer examination of the forces involved will reveal the hand of the centrifugal force. The analysis also provides a visual aid to understanding the basic principles of electromagnetism.

Ampère's Circuital Law

I. When a wheel rolls on a horizontal surface, the Coriolis force will act to give the wheel a gyroscopic stability. When we compare the horizontal translational aspect of the motion to electric current, and the rotational aspect to the rotating electron-positron dipoles in the magnetic field, then we can see that a rolling wheel is in fact a large scale manifestation of Ampère's Circuital Law. The dipoles sit on the wire like wheels, and their rotation axes trace out solenoidal rings around the wire.

We have already seen in 'The Cause of Coriolis Force' at,

http://www.wbabin.net/science/tombe55.pdf

how the Coriolis force can only ever occur where a centrifugal force already exists. Centrifugal force will of course exist in the rotating wheel.

It is common to split the kinetic energy in a rolling wheel into the translational component and the rotational component. As such we might then only associate the centrifugal force with the rotational component.

However, for every element of vertical motion in a horizontally rolling wheel, we will have a perpendicular deflection in the direction of the horizontal translational motion.

This perpendicular deflection requires a force. And there can only be two sources for this force. On the leeward side of the rolling wheel, where the perpendicular motion is upwards, this deflecting force will be supplied by centripetal tension. On the windward side where the vertical motion is downwards, the deflecting force will be supplied by centrifugal pressure. This is the lost component of the centrifugal force that would have been involved in the rotational motion if the wheel had been spinning freely and not rolling. It is still however present in the system, but it is now involved in causing the linear translational motion. The same applies to the centripetal tension on the leeward side that was mentioned above. It would have been involved in the rotational motion if the wheel had been spinning freely and not rolling.

This suggests that all linear motion has an associated centrifugal pressure barrier in the electron-positron sea on the windward side of its motion, and an associated rarefaction in the electron-positron sea on the leeward side of its motion.

This has already been observed in the tangential component of motion in non-circular Keplerian orbits. Gravity has a tangential component which is cancelled mathematically by tangential centrifugal pressure in the form of a Coriolis force. See section **V** in 'The Cause of Coriolis Force' at,

http://www.wbabin.net/science/tombe55.pdf

In the radial component of a Keplerian orbit, outward centrifugal repulsive pressure operates in tandem with the inward centripetal attractive tension of gravity. The centrifugal pressure effect has not however been formally recognized in situations that exclusively involve radial motion. This would seem to be an effect which shows up in the Newton's cradle but which has been overlooked in Kepler's laws. This effect will be the essence of linear kinetic energy. It will be carried in front of a moving body as a pressure front, and transferred to another body on collision.

Faraday's Law of Electromagnetic Induction

II. If we linearly accelerate a rolling wheel, this will in turn give rise to an angular acceleration. This situation corresponds to the increasing magnetic field strength that accompanies an increasing electric current. Work will need to be done against the increasing linear and rotational inertia as per Lenz's law.

If we have a spinning wheel and we place it on a horizontal frictional surface, the tangential impedance will angularly decelerate the wheel as per the $-\partial\mathbf{A}/\partial t$ force, where **A** is the tangential velocity. This angular deceleration will be accompanied by a linear rolling motion which corresponds to an induced electric current.

If a powered wheel sits on a frictional surface, the wheel will angularly accelerate. But it will not angularly accelerate as much as if it had been suspended in space with no friction. Some of the input energy will be converted instead into a translational rolling motion.

As such, the accelerating rolling wheel involves the Coriolis force, the $\mathbf{v}\text{X}\boldsymbol{\omega}$ centrifugal force and also the $-\partial\mathbf{A}/\partial t$ angular force, just as in the case of electromagnetic induction. Work needs to be put in to overcome the rotational inertia and the mass of the wheel, or in the case of electromagnetism, to overcome the rotational inertia of the electron-positron dipoles and the mass of the electric current. Wherever angular acceleration is involved, Lenz's law is involved. Additional work will also need to be put in to overcome rolling friction in the case of the wheel, and to overcome electrical resistance in the case of electric current.

In part IV of Maxwell's 1861 paper 'On Physical Lines of Force' at,

http://vacuum-physics.com/Maxwell/maxwell_oplf.pdf

he said when remarking on the curl format of Ampère's Circuital Law (which is also seen in Faraday's Law of Electromagnetic Induction),

"It appears - - - - that the connexion between magnetism and electricity has the same mathematical form as that between certain pairs of phenomena, one of which has a linear *and the other a* rotatory *character"*