A Sub-relativistic Flywheel Design

John Kormylo

For some time I've been advocating a "relativistic flywheel" (a sychrotron optimized for beam mass) as a better power source than anti-matter. A particle traveling at about 86% the speed of light has twice the total enegy as its rest mass, but also twice the relativistic mass. The **increase** in mass is convertable to pure energy (same as anti-matter) and **not** in the form of gamma rays.

Recently I also suggested a "sub-relativistic flywheel" concept. This would consist of an iron ring suspended in a magnetic field spinning at about 3×10^5 meters/sec. The idea is that the magnetic field will keep the ring from flying apart, as well as keep it from touching the sides of the vacuum chamber.

Assume a ring with a cross section shaped like a pie slice of angle 2θ, with the pointy end toward the center or the ring. When the electromagnet pole faces are parallel to the faces of the wedge, the magnetic flux will be constant and normal to the faces (except near the edges).

The net force radially inward for a small slice of the ring (assuming that $r >> w$) is given by

$$\frac{df}{rd\phi} = \frac{B^2 w \sin\theta}{\mu}$$

where B is the magnetic flux density, w is the width (radius) of the pie slice, μ is the magnetic permeability of free space, and $(rd\phi)$ is the thickness of the slice. The mass for this slice is given by

$$\frac{dm}{rd\phi} = \rho\theta w^2$$

where ρ is the mass density. Holding the mass of this slice constant and substituting

$$w = \sqrt{\frac{dm/rd\phi}{\rho\theta}}$$

we get

$$\frac{df}{rd\phi} = \frac{B^2 \sin\theta}{\mu}\sqrt{\frac{dm/rd\phi}{\rho\theta}}$$

which is maximum when $\theta = 1.16556$ radians, or $66.78143°$.

Since

$$f = ma = \frac{mv^2}{r}$$

and therefore

$$\frac{df}{rd\phi} = \left(\frac{dm}{rd\phi}\right)\frac{v^2}{r} \quad ,$$

we can obtain the needed magnetic flux density using

$$B^2 = \frac{\mu v^2}{r\sin\theta}\sqrt{\rho\theta\frac{dm}{rd\phi}} \quad .$$

Since the total mass is given by

$$m = 2\pi r \left(\frac{dm}{r d\phi} \right) \quad ,$$

we can use

$$\begin{aligned} B^2 &= \frac{\mu v^2}{\sin\theta} \sqrt{\frac{m\rho\theta}{2\pi r^3}} \\ &= 0.4686643 \mu v^2 \sqrt{\frac{m\rho}{r^3}} \\ &= 5.22799 \times 10^{-5} v^2 \sqrt{\frac{m}{r^3}} \quad \text{henry kg}^{1/2}\ \text{m}^{-5/2} \end{aligned}$$

using 7,880 kg/m^3 for ρ (density of iron) and 1.256637×10^{-6} henry/m for μ.

So for a 1 kg ring, 100 m in radius, traveling at 3×10^5 m/sec, we need a magnetic flux density of

$$\begin{aligned} B^2 &= 4.705191 \times 10^3 \quad \text{newton henry / m}^3 \\ B &= 6.85944 \times 10^5 \quad \text{gauss} \end{aligned}$$

since

1 newton = 1 kg m / sec^2
1 gauss = 10^4 maxwell / m^2 = 10^{-4} volt sec / m^2
1 newton = 1 volt amp sec / m = 10^4 gauss amp m
1 henry = 10^4 gauss m^2 / amp
1 newton henry = 10^8 gauss^2 m^3 .

This is above the saturation flux of iron (2×10^4 gauss).

To reach 3×10^5 m/sec with a 1 kg ring would take a radius over 11 kilometers. With a 10 meter radius, the highest speed possible for a 1 kg ring is 1,213 m/sec, which corresponds to 7.35684×10^5 joules (20 killowatt hours).

Actually, 2×10^4 gauss is not a hard limit, just the limit of effectiveness for iron core magnets.

One could place three superconducting coils at the three corners of the wedge (going the long way around). The inside coil would run its current in the opposite direction from the two outside coils. You would still need a number of small electromagnets for relative position control, as the big coils would affect the whole ring as a unit and do nothing about wobbles. Also, I would move the position control electromagnets to the outside of the ring about 90° apart vertically. Remember, the wedge angle is 2θ, or about 134°.