Bike Wheel Gyroscope Demonstration

<u>Learning goals:</u>

-Understand conservation of angular momentum qualitatively

-Be able to relate this concept to other phenomena

-Become familiar with the term gyroscope

<u>Materials:</u>

-Spinning stool

-Bike wheel with central axle

-2 demonstrators!

Note: http://www.exploratorium.edu/snacks/bicycle_wheel_gyro.html is an excellent reference for this demo.

<u>Procedure</u>

Begin by discussing the issues of tops falling with students. Spend a minute asking students what they did during the fall term to help their top stay up for longer. Tell them that today you'll show them something like a top that won't fall.

Have 1 demonstrator sit on the spinning stool and have the wheel spun by the 2nd demonstrator. Go through the demo that the kids will later repeat by sitting on the stool and 1 demonstrator spinning: the wheel gets spun and as you try to tilt the wheel, you instead turn, so that the gyro resists a change in direction.

Tell students that an instrument such as this is known as a **gyroscope**. Ask them why they think it's happening. After a few guesses, start off by saying that it has nothing to do with gravity because on the space shuttle, astronauts had the same results as what they just saw. The reason that the bike wheel didn't follow the demonstrators direction is that it was spinning. As long as the wheel is spinning, it won't fall in the direction it's being tilted and instead will move around the demonstrator. As it runs out of steam and stops spinning, it follows your lead like any normal object would. This is a situation like the top that was just spun. When you applied a force to it, there was nothing spinning on or within it to prevent it from falling. Basically it's another set of something rotating that allows the top or you to keep going around a little bit longer. Different things about the spinning change how long the bike wheel can stay up. How fast you spin the wheel, where the mass of the wheel is centered, and how much the wheel weighs will change what happens. To see what I mean, one of you should sit on the wheel and try this. We'll spin the wheel at different speeds and hold it out at different lengths to watch what happens. Everyone will get a chance at sitting on the wheel and trying this out.

Let students take turns with the demo. Make sure a demonstrator, not a student, spins the wheel.

As they do or after they do, depending on noise levels, etc., talk about how this tendency to continue to spin, known as **angular momentum** relates to daily life and especially astronomy. For example, watching an ice skater on tv, you see that she brings in her arms which makes her goes faster. This is how galaxies get formed. Disks of matter spin and as the center gets denser from things like stars forming, all of the matter begins to spin even faster.

Handouts

Conservation of Angular Momentum

Have you ever noticed how a figure skater executes spins?

The figure skater starts off rotating slowly with arms and legs stretched out.

The figure skater brings in the arms and legs, resulting in a very fast spin.[1]

You can try this out yourself by using a chair that can spin. Start off by extending your arms and have someone spin the chair. Bring your arms and feel the effects of *angular momentum conservation*.

What exactly is angular momentum? And what does it mean for it to be conserved?

Angular momentum measure an object's tendency to continue to spin. Essentially, **angular momentum = mass x velocity x distance** and this amount does not change, or in other words, stays conserved. That's why when a figure skater brings in his or her arms (shortening the distance), the spin becomes faster.

Spinning neutron stars

A typical big star has a spinning core. During a supernova (a stellar explosion), the outer layers are blown off and the radius of the core shrinks. Just like the figure skater, the core spins faster, but the change in speed is dramatic. A star can originally have a radius of 100,000's kilometers. After a supernova, the core can shrink to 10 kilometers – a change by factors of 10,000's. That means the spin speed must increase by 10,000's of times. One of the fastest neutron stars recently discovered spins at a rate of approximately 700 times per second!

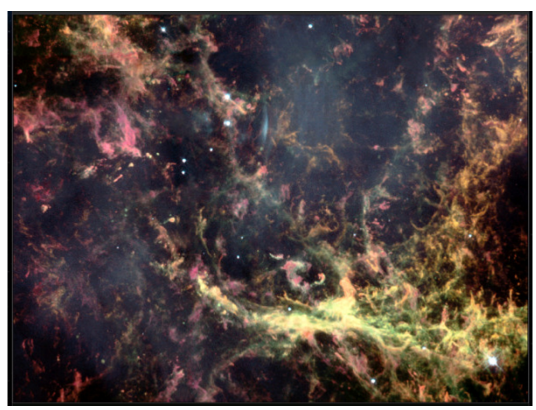


Figure 1 Crab Nebula: Neutron star spinning 30 times per second, heating its surroundings which creates the ghostly diffuse gas cloud. [NASA's image gallery]

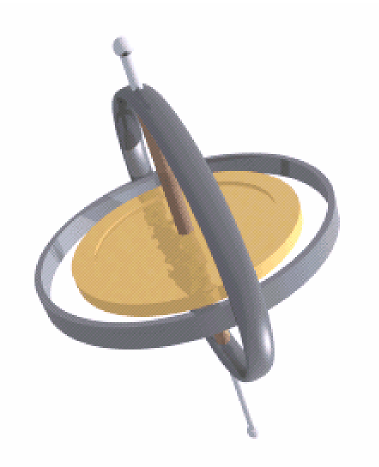
Galaxy Formation

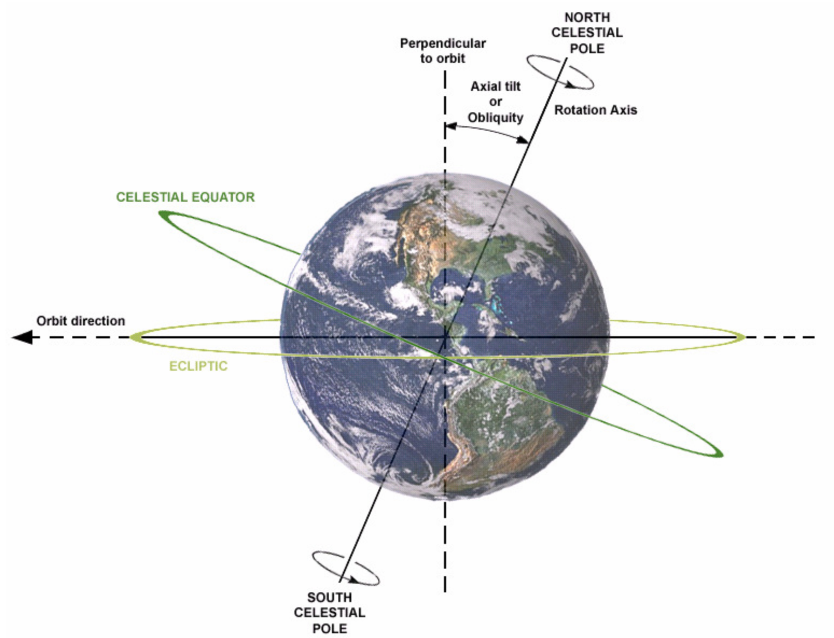
A galaxy originally starts as a huge slowly spinning cloud of gas. Over time, the gas cloud collapses and the denser inner parts form stars. As it collapses, the spin speed increases, again due to conservation of angular momentum.

Figure 2 Galaxy M51: A spiral galaxy located about 30 million light years from Earth [NASA's Image Gallery]

Gyroscopes

The earth is tilted 23.4° away from the perpendicular to its orbital plane. How come the tilt doesn't change, say to 40°? This can be investigated by observing a gyroscope. You will find that the gyroscope does not change its tilt. The earth is just a giant gyroscope.





You might notice the gyroscope wobbles a little. This is called nutation. The earth in fact also nutates.