Crazy Case

More Details

What is behind it?

Or in this case: what is inside? When you place the case in its holder you can hear a noise. This is the drive that sets a disc inside the case in motion – similar to a hamster wheel that rotates up to 50 times per second! When you lift the case out of its holder, you are in fact lifting a very fast rotating disc. From a physical point of view, this is nothing more than a gyroscope in a package.

The secret is angular momentum

The faster the disc rotates, the larger its angular momentum and the more stable it rotates around its axis of rotation. As soon as one tries to change the direction of the axis of rotation and the angular momentum, the disc does not play along but tries to counteract the change. This is quite irritating when moving the case. As long as one just carries it straight ahead nothing happens, because the disc's axis of rotation does not change. However, as soon as one carries the case around the corner or tilt it, the direction of the axis of rotation changes – therefore one really needs to fight the disc to achieve the desired movement. At this very moment, the case suddenly seems to develop a will of its own.

Precession

Of course, neither case nor disc act on a whim. Rather, through the wild movement of the case, there is a complicated interaction between the force of gravity acting on the disc, the forces that one exerts on the case, their varying points of application, and the conservation of angular momentum. The forces acting on the rotating disc when the case is tilted lead to a tumbling motion – the "precession": the disc's axis of rotation – and with it the disc and the case – begin to revolve around another axis. The rotating axis of rotation describes a cone (Fig. 1).

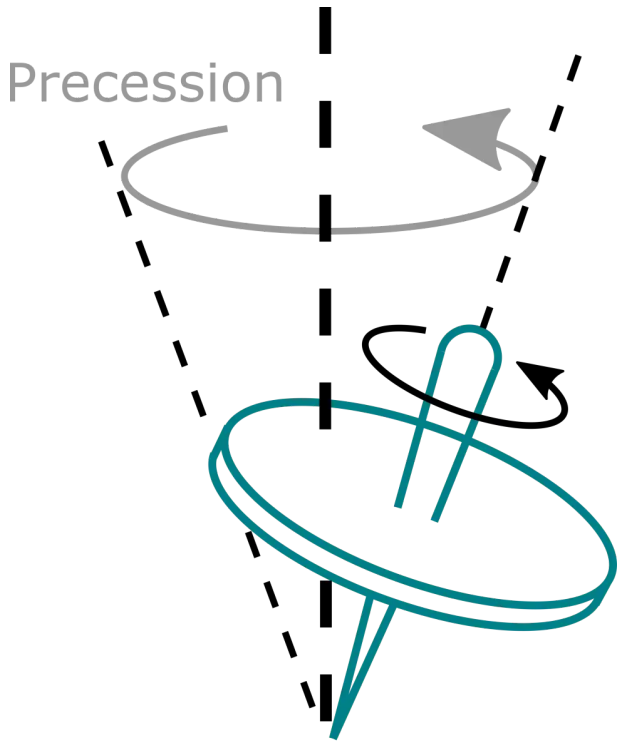

Fig. 1: Precession of a gyroscope.

Footballs, bicycles, and our earth

Gyroscopes that make a case go crazy do not appear too often in everyday life, whereas gyroscopes and gyroscopic effects occur quite often. It starts with a frisbee disc: only when it rotates quickly does the angular momentum stabilize the flight path and the frisbee arrives where it should. With a little spin, a football also becomes more stable when it is crossed. Bicycles automatically have stability, when one rides reasonably quickly, because the wheels' angular momentum facilitates a stable and safe journey, even when riding no-handed!

A large angular momentum is often desirable, but mechanical engineers dread precession. Precession caused by an imbalance in rotating machine parts can easily lead to breakage and malfunction.

By the way, there are gyroscopic motions even on a large scale: the impact of the sun and moon have turned the earth into a giant gyroscope. However, it takes more than 25,000 years to precess once around the corresponding axis! The earth's axial precession affects the development of the seasons by determining when the earth, in its elliptical orbit, is at its closest point to the sun. For example, if this happens in winter in the Northern Hemisphere, the winter is milder (Fig. 2(a)). Additionally, during these years the earth is at its farthest point from the sun during summer in the Northern Hemisphere, making the summer more moderate. In the Southern Hemisphere, both seasons are more extreme. The earth is currently aligned in this way.

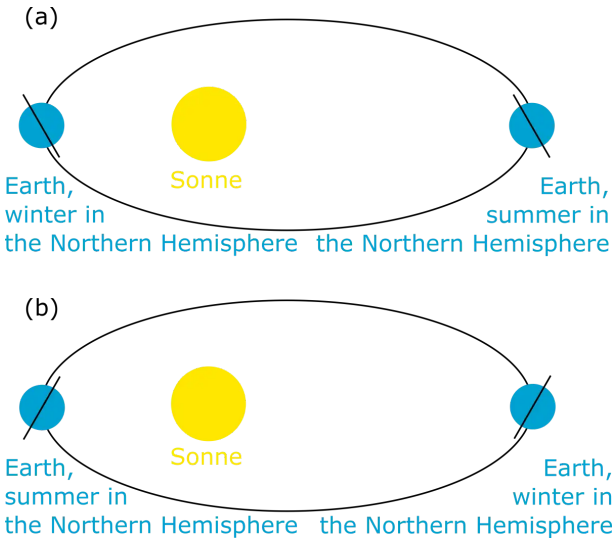

Fig. 2: Effect of the earth's axial precession on the development of the seasons: winter in the Northern Hemisphere is milder when the earth is at the point closest to the sun (a) than when it is located at the point farthest away from the sun (b).