

World's smallest optical gyroscope developed

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Scientists have developed the world's smallest optical gyroscope - a device that helps vehicles, drones and handheld electronic devices know their orientation in 3D space. The new gyroscope, described in *Nature Photonics*, is 500 times smaller than the current best device.

Originally, gyroscopes were sets of nested wheels, each spinning on a different axis, said researchers from the California Institute of Technology in the U.S. However, today's cell-phones have microelectromechanical sensor, the modern-day equivalent, which measures changes in the forces acting on two identical masses that are oscillating and moving in opposite directions.

Sagnac effect

These MEMS gyroscopes are limited in their sensitivity, so optical gyroscopes have been developed to perform the same function

but with no moving parts and a greater degree of accuracy using a phenomenon called the Sagnac effect, named after French physicist Georges Sagnac.

The smallest high-performance optical gyroscopes available today are bigger than a golf ball and are not suitable for many portable applications, researchers said. As optical gyroscopes are built smaller and smaller, so too is the signal that captures the Sagnac effect, which makes it more and more difficult for the gyroscope to detect movement, they said. Up to now, this has prevented the miniaturisation of optical gyroscopes.

The device developed by Caltech engineers led by Ali Hajimiri can detect phase shifts that are 30 times smaller than the best systems currently available. The new gyroscope achieves improved performance by using a new technique called "reciprocal sensitivity enhancement."

In this case, "reciprocal" means that it affects both beams of the light inside the gyroscope in the same way. Since the Sagnac effect relies on detecting a difference between the two beams as they travel in opposite directions, it is considered nonreciprocal. Inside the gyroscope, light travels through miniaturised optical waveguides (small conduits that carry light).

Imperfections in the optical path that might affect the beams (for example, thermal fluctuations or light scattering) and any outside interference will affect both beams similarly. Professor Hajimiri's team found a way to weed out this reciprocal noise while leaving signals from the Sagnac effect intact. Reciprocal sensitivity enhancement thus improves the signal-to-noise ratio in the system and enables the integration of the optical gyroscope on to a chip smaller than a grain of rice.