

# Optical Physics Advances on Spiraling Glass Fibers Provide New Way to Control Behavior of Light

July 1 2004

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By twisting fiber optic strands into helical shapes, researchers have **created unique structures that can precisely filter, polarize or scatter light**. Compatible with standard fiber optic lines, these hair-like structures may replace bulky components in sensors, gyroscopes and other devices.

While researchers are still probing the unusual properties of the new fibers, tests show the strands impart a chiral, or 'handed', character to light by polarizing photons according to certain physical properties. Victor Kopp of Chiral in Clifton, N.J., and his colleagues describe the new fibers in the July 2 issue of Science.

Several of these fibers, and their applications, are being developed in part with funds from the National Science Foundation Small Business

Innovation Research program.

In conventional optical fibers, light is transmitted from one end to the other through a round core housed within a concentric outer cladding. But, because a circular core does not develop handedness when twisted, the research team wound rectangular-core fibers to create a double helix.

When the team tested the twisted fiber, they discovered that some photons left the core and entered the cladding. Photons with the same handedness as the fiber entered the cladding whereas photons with handedness opposite that of the fiber remained in the core.

With only a relatively loose twist—roughly 100 microns to form a complete turn—photons with a handedness that coincides with the fiber's twist scatter out of the core at a shallow angle and are trapped in the cladding. With a tighter twist, photons with the same handedness as the fiber scatter at a wider angle, allowing the photons to escape from the cladding into the surrounding space. Only light of a single polarization remains in the fiber (see animation). At the tightest twists, roughly one-millionth of a meter to complete a turn, photons with the same handedness as the structure are reflected backwards in the core.

Because the environment surrounding the fiber affects the wavelength of the light embedded in the cladding, "loosely" twisted fibers can serve as sensors for pressure, temperature, torque and chemical composition.

With moderately twisted fibers, researchers can manipulate the resulting polarized light in useful ways, leading to a range of applications such as gyroscopes for navigation systems, current meters for electric power stations, and chemical and materials analysis equipment.

For tightly wound fibers, the amount of twist determines the precise wavelength of the light remaining in the fiber, producing light that is

ideal for filter and laser applications.

Chiral Photonics is developing manufacturing processes for commercial production of the technology. Using a small filament oven, technicians soften the optical fibers while twisting them, which allows greater control of the process.

This research was funded both NSF and the National Institute of Standards and Technology Advanced Technology Program.

Comments from NSF:

"This technology could be one of the most significant recent advances in the field of polarization and wavelength control. Equally impressive is the innovative science that will be developed based on this new technology. This project should advance the current understanding in advanced fiber structures." — Winslow Sargeant, the NSF program officer who oversees the Chiral Photonics SBIR award.

"There is an enormous host of applications for which chiral fiber gratings could find markets. Fiber Bragg gratings (FBGs) are a well-established technology for transmitting data, but suffer from high cost due to the equipment and time required to craft them. Chiral fiber gratings can replace FBGs in some applications with the possible added advantage of low-cost production." — Winslow Sargeant

Comments from the researchers:

"We believe the creative process is only beginning as these photonic building blocks that add functionality into fiber are being introduced to the ingenuity of photonic designers and their applications." — Dan Neugroschl, President, Chiral Photonics.

"We have shown that chiral fibers with a wide range of twists can be created in a versatile continuous manufacturing process under computer

control. These fibers are the physical structure in which different states of a light wave can be coupled to perform useful functions." — Azriel Genack, CTO, Chiral Photonics.

"These fibers are unique because light moving along the fiber core with a specific wavelength and polarization can either be coupled to a more slowly moving wave in the cladding surrounding the fiber core, or be scattered out of the fiber or be sent backwards within the core." — Victor Kopp, Director of R&D

The original press release can be found [here](#).

Citation: Optical Physics Advances on Spiraling Glass Fibers Provide New Way to Control Behavior of Light (2004, July 1) retrieved 20 April 2024 from <https://phys.org/news/2004-07-optical-physics-advances-spiraling-glass.html>

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