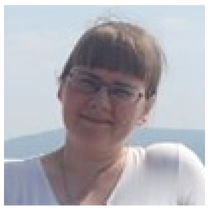
Localized light will help improve medical sensors

Scientists of Siberian Federal University, as part of an international scientific team, investigated a special state of light that occurs at the interface between a cholesteric liquid crystal and a layered medium. The researchers created a digital model of this phenomenon and showed how to change the lifetime of a bundle of light and its wavelength. It is assumed that in the future it will help to create effective sensors for conducting medical tests — including at home. An article with the primary results of the work was published in Crystals.

The optical Tamm state proposed by the scientific group is a localized state of light at the common interface of two media where multiple re-reflections occur and light turns out to be blocked between two media playing the role of mirrors.

> *'The waves that arise at the interface of different media are, for example, sea waves and waves that occur during an earthquake. Such waves are often found in optics. It is taught in school that reflection rays and refraction rays appear on the illuminated border of transparent materials. In case of the limiting angle of total reflection a beam appears and glides along the interface. This is a surface light wave. Unlike most surface waves, the Tamm state can be excited by a beam incident perpendicular to the surface. In this case, the wave stops and does not transfer energy along the interface. In 2006, we learned that opticians from St. Petersburg detected such a wave and I was curious to spin this wave like a spinning top, using a cholesteric crystal, for example. This crystal is a liquid that does not have mirror symmetry of optical properties because it consists of oriented elongated molecules whose direction twists in space like a helical spiral, similar to a DNA spiral. Finally, we managed to spin the wave and called it chiral optical Tamm state,'* — said **Stepan Vetrov**, the head of the scientific group, professor at the Department of Theoretical Physics and Wave Phenomena, leading researcher at the Laboratory of Nanotechnology, Spectroscopy and Quantum Chemistry, Department of Photonics and Laser Technologies, SibFU.

The scientists have specified which optical materials should be used to see the light spinning top.



> *'To get this bundle of light we need to lock a light wave in a very small space between two mirrors that will repeatedly reflect it. For one mirror we take a liquid crystal to spin the wave, and for the second mirror it is convenient to use the concept of polarization. Let us represent the light field as a vector (arrow) of electric tension, the base of which is at the illuminated point and the sharp end oscillates. If the arrow goes round in circles, then they say that the light has circular polarization. A cholesteric liquid crystal reflects light only when the polarization arrow goes round in circles in the direction where the liquid crystal molecules point.*
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> *The difficulty of using a conventional mirror is that when reflected from it, the wave changes the polarization direction. For example, the light of the right circular polarization incident on the mirror will be reflected already with the left circular polarization. After such a reflection, it is difficult to block the light wave because, changing the polarization, it constantly leaks out of this trap through the liquid crystal. However, if you take a layered structure resembling a Napoleon cake made up of identical uniaxial dielectric layers, alternating so that the optical axis of each subsequent layer is rotated 90 degrees from the axis of the previous one, then the problem will be solved! We called this multilayer a polarization-preserving anisotropic mirror. Over a hundred years ago, a stack of several dozen layers of mica was made, the thickness of*

each was less than a micrometer. If modern high-anisotropic polymers are used instead of mica, and a cholesteric liquid crystal is carefully applied to the surface of such a multilayer mirror, then a locked state we are interested in may arise at the interface,' — said **Natalia Rudakova**, an assistant professor of the Department of Physics, SibFU.

The researchers also noted that the resulting spinning top can be used for a whole range of photonics devices. Lasers with a swirling beam or biosensors that allow you to get an express result of a blood test in a few minutes are just some of the new innovations that can enter our reality thanks to the discovery of physicists.

'It is very important that the new state is relatively long-lived – it lasts picoseconds and during this time the light reflects from the mirrors thousands of times. We hope that our studies will help to create new types of microlasers and biosensors in the long run. Biosensor systems are assumed to be extremely highly sensitive and fast — it will be possible to conduct a blood test at home and get a quick and accurate result,' — said **Rashid Bikbaev**, a senior lecturer of the Department of Electrotechnology and Electrical Engineering, a researcher of the Laboratory of Nanotechnology, Spectroscopy and Quantum Chemistry, SibFU.

The scientific team also included scientists from L. V. Kirensky Institute of Physics, Federal Research Center, Krasnoyarsk Scientific Center, Siberian branch of the Russian Academy of Sciences and Chiao-Tong National University (Taiwan).

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