Physicists control the polarization of the light, lowering its speed up to 10 times

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So-called spatial light modulators that serve as a base for all LCDs, among other things, can be arranged so that each pixel can switch the light quickly, making it brighter or weaker by rotating the polarization of light. According to Tatyana Dolgova, senior researcher of the Laboratory of Nanophotonics and Metamaterials, Faculty of Physics, MSU, these fast, new spatial light modulators can be used when creating holographic memory, three-dimensional displays, as well as the accurate refractive index sensors and magnetic field sensors.

The recording speed in the three-dimensional holographic memory is directly dependent on the spatial light modulator's switching speed. This speed is highly limited in liquid crystals, as they rotate the LCD molecule itself, which takes tens of milliseconds. Scientists have proposed to carry out the rotation not by a mechanical turn, but by the Faraday effect. Its essence lies in the fact that the plane of polarization of the light is rotated as it passes through a magnetized material.

In 1998, one of the authors of the article, Japanese physicist Mitsuteru Inoue, proposed the concept of spatial light modulators based on new nanostructures—magnetophotonic crystals. These micro crystals contain optical resonators, a system of two parallel mirrors. Today, its primary use is to "slow down" the light significantly. A photon caught in such a resonator moves between the mirrors and comes out after a significant delay. So if polarized light passing through the crystal is directed to the magnetic field, the Faraday effect increases with each pass from mirror to mirror, and ultimately becomes much more noticeable.

"We worked on magnetophotonic crystals together with Professor Inoue, and during these 15 years, have learned a lot about these amazing nanostructures," says Tatyana Dolgova. "And finally, we achieved ultra-fast light modulation. In our experiments with the real crystals, we ensured that the light is about 10 times slower than normal. And it increases the Faraday rotation by an order of magnitude."

According to Dolgova, there is no paradox between "slowing down" the light and the resulting ultrafast modulation. "The 'slow' light is actually only relatively slow compared to the normal speed of light in a vacuum, but it is still incomparably fast compared to the speed of the liquid crystal molecules rotation."

In their experiments, the MSU physicists ensured that the plane of polarization of the "slow" light is turned so quickly that it is significantly different even between the beginning and the "tail" of a 200-femtosecond laser pulse. Dolgova said that the magnitude of the observed effect is still insufficient for practical use. However, the limitations are not fundamental. Physicists have shown clearly that ultrafast modulation of light in magnetophotonic crystals is possible and has good prospects.

Despite the fact that the liquid crystal modulation rate is enough for conventional screens, the super switching speed is necessary in nanophotonics, where photons are used instead of electrons to perform some logic or counting, photonic switching, optical recording—namely, for the prospect of photonic computers. A group working with Professor Inoue now demonstrates 3-D holographic memory and displays for playback of 3-D images and video, working with fast magnetophotonic spatial light modulators.

More information: A. I. Musorin et al, Ultrafast Faraday Rotation of Slow Light, *Physical Review Applied* (2016). DOI:

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