“Extremely short optical pulses and their interaction with matter”,

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Presented works are devoted to solving the actual problem of extremely short single-cycle, sub-cycle and unipolar light pulses generation in optics. Research of R.M. Arkhipov belongs to the rapidly developing field of modern optics - nonlinear photonics of few-cycle optical pulses. The study of the corresponding phenomena is important both for the development of the fundamental concepts of “extreme” nonlinear optics, and for the development of principles for creating a new generation of “ultrafast” optical devices.

Work has been ongoing since 2012. The results of the study were published in 23 articles in high-ranking journals included in the Scopus database and summarized in 3 reviews (the list of works is attached). In the most articles R.M. Arkhipov is the first author, which emphasizes his role in obtaining and presenting these results.

A key feature of the cycle of theoretical work R.M. Arkhipov, presented for the St. Petersburg State University Prize for scientific works in the category “For Contribution to the Science of Young Researchers” is their focus on the practical implementation of his methods for obtaining ultrashort light pulses. Original articles were written by in such a way as to make them completely accessible to the understanding of experimentalists and to set up experiments. The author and colleagues theoretically analyzed the ways of creating compact and ultrafast coherent photonics devices operating in the regime of coherent light-matter interaction and contributed to the theory of interaction with matter of optical wave packets with extreme properties. Note that some of the presented works were previously awarded the third degree prize of the Academic Council of the Faculty of Physics of St. Petersburg State University for scientific works for young scientists in 2019.

The author investigated the generation of short pulses in lasers due to the phenomenon of self-induced transparency, which in principle allows the generation of few-cycle optical pulses. For the first time in the works of R.M. Arkhipov et al. such a regime was obtained experimentally recently. Further development of these studies should lead to the creation of compact sources of extremely short pulses with an ultrahigh repetition rate.

Note that the physics of the formation of extremely short optical pulses, unipolar light pulses, and their interaction with matter has not yet developed, and in the literature. For example, the possibility of generating unipolar optical pulses including a DC component is sometimes questioned. The result of R.M. Arkhipov demonstrated not only this possibility of unipolar pulse generation, but also the ability to control the shape and duration of unipolar optical pulses. Moreover, the author showed the possibility of effective non-resonant effects on quantum objects using unipolar pulses of ultra-small duration. Of particular note is the recently discovered previously unknown law of conservation in electrodynamics of continuous media, which has not yet received an established name and is still called the "rule of conservation of electric area" of short pulses during propagation in media with dissipation. Recognition of these results was the publication of an article in the journal “Uspekhi Fizicheskikh Nauk” in December 2018 in connection with the 100th anniversary of Vavilov State Optical Institute.

Presented works of R.M. Arkhipov also include other interesting results. Among them is the possibility of creating of the population density gratings in resonance media by few-cycle optical pulses coherently interacting with the medium. In contrast to the traditional approach, when the interference of overlapping beams in a medium is used to create such gratings, the proposed approach does not require such overlapping. This method allows controlling gratings at times of the order of the pulse duration (a few femtoseconds) and opens up new possibilities in creating ultrafast optical switches and deflectors. Thus, R.M. Arkhipov actually laid the physical foundations of a number of new approaches to creating ultrafast nonlinear photonics systems based on the coherent interaction of light with matter.