LINEAR AND NON-LINEAR WAVES IN MICROSTRUC-TURED OPTICAL MEDIA

Moscow Institute of Physics and Technology (National Research University)

Degree or qualification is awarded: **PhD (Candidate of Science)**

Language of study: **English**
Mode of study: **full-time**
Duration: **4 years**
Availability of free education: **no**
Price: **375 000 RUB**

Programme curator: **Denis Ustyuzhaninov**
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Entry requirements:

- Master's degree / equivalent in a related field
- B2 level of English
- Good track record of publications related to the topic of the intended research
- Strong research proposal 1,500 - 3,500 words

Research supervisor:
Yaroslav Kartashov
PhD, DSc

Supervisor's research interests:

- New soliton states and approaches to control of the propagation of light in optical lattices.
- Multidimensional and surface solitons.
- Non-diffracting beams.
- Effects of spin-orbit interaction in optics and physics of Bose-Einstein condensates.
- Nonlinear topological insulators.
- Polariton condensates.

In the works of Y.V. Kartashov, various types of solitons with previously unknown symmetries in optical lattices, local and nonlocal nonlinear media were introduced. He predicted new unusual propagation regimes of high-intensity light beams in periodic media, discovered parabolic and spiral propagation trajectories, resonant transverse oscillations of solitons, complete suppression or enhancement of diffraction spreading, resonant transformations of the spatial structure of beams. His works on the induction of optical gratings using different classes of non-diffracting beams are well known. He predicted and experimentally observed three-dimensional spatiotemporal solitons – light bullets. Surface waves are predicted at the boundaries between periodic media with different physical properties. In a series of works on nonlinear topological insulators, edge topological solitons in polariton condensates, Bose-Einstein condensates, and also topological Floquet solitons were introduced.

Research highlights:
Our laboratory of nonlinear optics studies nonlinear optical waves in spatially inhomogeneous media,

selfaction effects for radiation with high peak intensities, solitons, and the physics of topological insulators. The work is connected with the experimental observation and theoretical description of the propagation of topological solitons, self-consistent non-diffracting high-intensity light beams, in nonlinear topological insulators – unique optical structures based on arrays of helicoidal optical fibers. Topological solitons propagate only along the boundary of such a structure, without penetrating into its depth, and do not scatter even at significant defects in the structure, that opens unique possibilities for transmitting excitations in such structures without radiative or scattering losses, designing topological lasers whose characteristics are not subject to fluctuations. Studies of nonlinear topological insulators are at the forefront of modern nonlinear optics. The group works closely with experimentalists from the Institute of Photonic Sciences (Barcelona), the University of Rostock (Germany), Shanghai Zhao Tong University (China), the University of Lisbon (Portugal) and other groups.

Supervisor's specific requirements:

- Knowledge of the fundamentals of nonlinear optics, theoretical and mathematical physics.
- Programming skills in Fortran, Matlab, or C ++.
- Experience with modern data visualization packages, such as Origin.
- Experience of experimental work will be considered as an advantage of candidate.
- Good knowledge of English.

Supervisor's main publications:

- Y.V. Kartashov, D.V. Skryabin, "Modulational instability and solitary waves in polariton topological insulators," Optica, vol. 3, n. 11, p. 1228-1236 (2016).
- Y.V. Kartashov, G.E. Astrakharchik, B.A. Malomed, L. Torner, "Frontiers in multidimensional selftrapping of nonlinear fields and matter," Nature Reviews Physics, vol. 1, p. 185-197 (2019).
- P. Wang, Y. Zheng, X. Chen, C. Huang, Y.V. Kartashov, L. Torner, V.V. Konotop, F.Ye, "Localization and delocalization of light in photonic moiré lattices," Nature, vol. 577, n. 7788, p. 42-46 (2020).
- S.K. Ivanov, Y.V. Kartashov, A. Szameit, L. Torner, V.V. Konotop, "Vector topological edge solitons in Floquet insulators," ACS Photonics, vol. 7, n. 3, p. 735- 745 (2020).
- Z. Zhang, R. Wang, Y. Zhang, Y.V. Kartashov, F. Li, H. Zhong, H. Guan, K. Gao, F. Li, Y. Zhang, M. Xiao, Observation of edge solitons in photonic graphene, Nature Communications, vol. 11, paper 1902 (2020).

Specializations within this programme