DOCTORAL STUDIES COURSE UNIT DESCRIPTION

Name of subject	Scientific Field	Faculty	Center/Institute/ Department
Quantum Optics (8 ECTS credits)	Physics N 002	Faculty of Physics	Institute of Theoretical Physics and Astronomy
Student's workload	Hours	Student's workload	Hours
Lectures	30	Consultations	10
Individual study	160	Seminars	

Course annotation
The aim of the course is to provide to PhD students a basic knowledge of Quantum Optics. The course will cover the following specific topics: 1. Classical electromagnetic field and Maxwell equations. 2. Normal mode expansion of radiation. 3. Quantum harmonic oscillator. 4. Quantization of the EM field. 5. Photon number states. 6. Coherent states. 7. Squeezed states. 8. Quadrature components of electromagnetic radiation. 9. Ground state of quantum radiation (Heisenberg relations, vacuum fluctuations). 10. Pure, mixed and entangled quantum states of radiation. 11. Mach-Zehnder interferometer. 12. One-photon wave-packet. 13. Hamiltonian for quantized field interacting with the matter. 14. Absorption, spontaneous emission and induced emission. 15. Rayleigh, Thomson, resonant and Raman scattering. 16. Jaynes-Cummings model. 17. Purcell effect for spontaneous emission. 18. Two-photon interference: Hong-Ou-Mandel experiment. 19. Spectral lines (homogeneous/inhomogeneous broadening; Schawlow-Townes limit). 20. Laser cooling and trapping of atoms. 21. Coherent population trapping.
List of literature
1. R. Loudon, The quantum Theory of Light (Oxford University Press, Oxford, 2000). 2. M. Fox, Quantum Optics: An Introduction (Oxford University Press, Oxford, 2006) 3. Gilbert Grynberg, Alain Aspect and Claude Fabre, Introduction to Quantum Optics: From the Semi-classical Approach to Quantized Light (Cambridge University Press, Cambridge, 2010).

Consulting teachers	Scientific degree	Pedagogical name	Main scientific works published in a scientific field in last 5 year period
Gediminas Juzeliūnas	Ph. D., habil. Dr.	Prof.	1. H. R. Hamedi and G. Juzeliūnas, Phase-sensitive Kerr nonlinearity for closed-loop quantum systems, Phys. Rev. A 91, 053823 (2015).

			2. E. Anisimovas, M. Račiūnas, C. Sträter, A. Eckardt, I. B. Spielman, G. Juzeliūnas, Semi-synthetic zigzag optical lattice for ultracold bosons, Phys. Rev. A 94, 063632 (2016). 3. H. R. Hamedi and G. Juzeliūnas, Phase-sensitive atom localization for closed-loop quantum systems, Phys. Rev. A 94, 013842 (2016). 4. V. Novičenko, E. Anisimovas and G. Juzeliūnas, Floquet analysis of a quantum system with modulated periodic driving, Phys. Rev. A 95, 023615 (2017). 5. J. Armaitis, J. Ruseckas, and G. Juzeliūnas, Omnidirectional spin Hall effect in a Weyl spin-orbit-coupled atomic gas, Phys. Rev. A 95, 033635 (2017). 6. H. R. Hamedi, V. Kurdiašov, J. Ruseckas and G. Juzeliūnas, Azimuthal modulation of electromagnetically induced transparency using structured light, Opt. Express 26, 338194 (2018). 7. H. R. Hamedi, J. Ruseckas and G. Juzeliūnas, Exchange of optical vortices using an electromagnetically-induced-transparency-based four-wave-mixing setup, Phys. Rev. A 98, 013840 (2018). 8. V. Novičenko and G. Juzeliūnas, Non-Abelian geometric phases in periodically driven systems, Phys. Rev. A 100, 012127 (2019). 9. H. R. Hamedi, J. Ruseckas, E. Paspalakis, and G. Juzeliūnas, Transfer of optical vortices in coherently prepared media, Phys. Rev. A 99, 033812 (2019). 10. V. Galitski, G. Juzeliūnas and I. B. Spielman, Artificial gauge fields with ultracold atoms, Physics Today 72(1), 38 (2019).
Certified during Doctoral Committee session 02/02/2022, protocol No. (7.17 E) 15600-KT-32			
Committee Chairman prof. S. Juršėnas			