

CEIPEX BUT TOPIC 11

Položka / Field	Obsah / Content
CEIPEX RESEARCH TOPIC LEVEL 1	Advanced Nano & Micro technologies
CEIPEX RESEARCH TOPIC LEVEL 2	Advanced Electron Microscopy and Spectroscopy
NAME OF THE RESEARCH GROUP	Advanced Electron Microscopy and Spectroscopy (RG-1-19)
SUPERVISOR	Dr. Andrea Konečná
PROPOSED RESEARCH TOPIC TITLE	Quantum Correlations in Free-Electron–Photon Interactions: Theoretical Foundations and Experimental Protocols
RESEARCH TOPIC DESCRIPTION	The interaction between fast free electrons and optical modes provides a unique platform for bridging particle physics and concepts of quantum optics. This postdoctoral research project aims to establish a comprehensive theoretical description of these interactions, focusing on the correlations and hybrid quantum entanglement generated between scattered relativistic electrons and photons emitted into the far field - either through cathodoluminescence or direct coupling via optical microcavities. By mapping the bipartite states of the electron-photon pairs, we will model the full quantum statistics and properties governing this hybrid system. Building on the theoretical framework, we will formulate protocol designs that directly leverage these quantum correlations to advance resolution limits and mitigate beam damage in electron microscopy. Specifically, we will develop schemes for hybrid electron-photon ghost imaging and coincidence spectroscopy, enabling spatial and spectral characterization of sensitive materials. Complementing these theoretical insights, the project will yield explicit designs for realistic experimental platforms that we will explore with experimental collaborating groups.
KEYWORDS	electron spectroscopy, electron microscopy, electron-light-matter interaction
INTERDISCIPLINARY DIMENSION	We assume collaboration with the group "Fabrication and Characterization of Nanostructures".
WEBPAGE OF THE RESEARCH GROUP	https://www.ceitec.eu/advanced-electron-microscopy-and-spectroscopy/rg399/about-us