Universität Basel

Swiss Nanoscience Institute

SNI SWISS NANOSCIENCE INSTITUTE
EINE INITIATIVE DER UNIVERSITÄT BASEL UND DES KANTONS AARGAU

Project P1505 A programmable e^- beam shaper for diffractive imaging of biological structures at Å resolution

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The purpose of this project is to manipulate the wave front of coherent free electron wave functions to realize a novel electron diffraction imaging method. Spatial phase modulators that synthesize arbitrarily pulse shapes in space and time are available for coherent electromagnetic waves but coherent manipulation of electron beam is much less explored. For example, the direct demonstration of the quantum mechanical nature of free electrons via Young's double-slit interference experiment as described by R. P. Feynman [1] was reported only recently [2,3], even though the electron wave interference has been demonstrated more than 50 years ago [4].

A particular emphasis of this project is the structural analysis of macromolecules and biological specimens at Angstrom resolution. A coherent, high-brightness electron beam offers great opportunities in this respect, but solving the molecular structure so far is only possible for special cases, as there is no general method to recover the phase information of the diffracted beams. This fundamental difficulty in the diffraction imaging method is what we intend to alleviate by phase-imprinting of the coherent electron wave probes by developing a novel device to introduce a local gauge phase to the electron wave function. As such, your task is to design and nanofabricate the novel electron phase shifters as a part of the team at the Laboratory for Micro- and Nanotechnology (LMN) and the Laboratory for nano-bio- diffraction at the Paul Scherrer Institut, as well as at the Biozentrum at the University of Basel. A state-of-the-art electron beam lithography tool and standard nanofabrication equipment are available for you at LMN. The successfully developed device will be integrated in the electron diffraction facility for biological specimens under development at the Paul Scherrer Institut. The project will be a breakthrough in computed holography and coherent control of electron diffraction. It will allow solving nanometer-scale biological structures to Angstrom resolution.

We seek a student with a degree in physics or related field, who is highly motivated to work in this interdisciplinary project. An experience in the nanofabrication or in electron nano-diffraction will be advantageous.

[1] R. P. Feynman, R. B. Leighton, M. Sands, *The Feynman Lectures on Physics* (Addition-Wesley, Menlo Park, CA, 1965), Vol. III. III, Ch. 1, section 1-5.
[2] S. Frabboni, G. C. Gazzadi, G. Pozzi, Young's double-slit interference experiment with electrons, Am. J. Phys. 75, 1053 (2007). [3] R. Bach, D. Pope, S.-H. Liou, H. Batelaan, Controlled double-slit electron diffraction, New J. Physics 15, 033018 (2013).
[4] C. Joensson, Elektroneninterferenzen an mehreren kuenstlich hergestellten Feinspalten, Z. Physik 161, 454 (1961).