Laser-based phase contrast and coherent manipulation of electrons

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Phase contrast can improve the image contrast of thin transparent specimens in transmission electron microscopy. A Zernike phase plate achieves that by retarding the unscattered wave relative to the scattered wave, but charging effects (patch potentials) have hindered efforts to develop such a device. We coherently control electron waves with a continuous-wave laser in a near-concentric Fabry-Pérot cavity. The intensity required to phase shift 300-keV electron beams is on the order of 100 GW/cm^2 [1] and has to be supplied by a continuous-wave laser if the phase plate is to be used with a conventional, unpulsed, electron microscope.

We are using a near-concentric optical cavity [2] with a Finesse of ~30,000 and an input power of ~10 W from a 10640-nm fiber laser and have so far realized up to ~50 GW/cm^2 intensity. Using it, we have demonstrated phase contrast in images of amorphous carbon film as well as biological specimens [3]. We will discuss latest results and prospects for use in routine transmission electron microscopy.

References:

[1] H Müller, J Jin, R Danev, J Spence, H Padmore, and R Glaeser, New J. Phys. **12,** 073011 (2010)
[2] O Schwartz, J J Axelrod, D R Tuthill, P Haslinger, C Ophus, R M Glaeser, and H Müller. Opt. Express **25,** 14453-14462 (2017)
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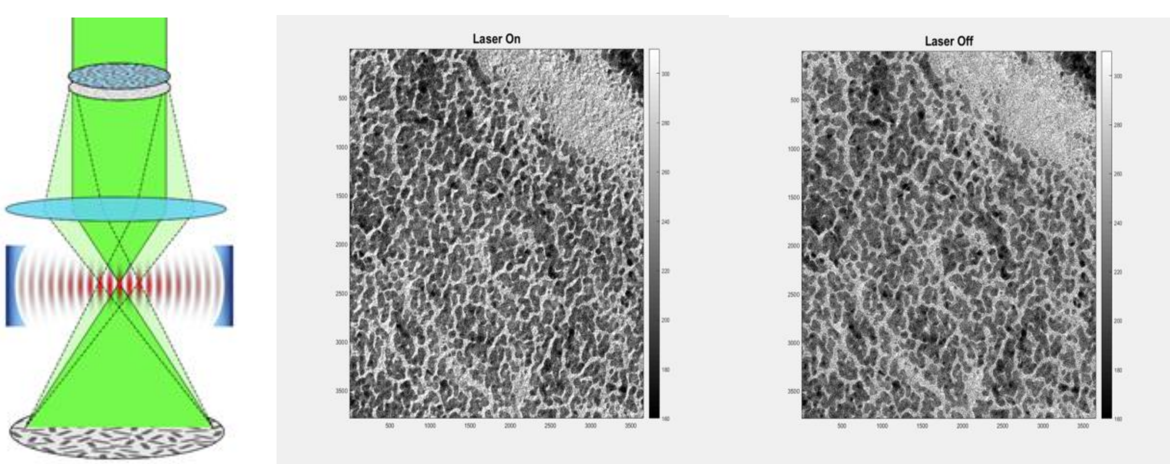

Figure 1. Left: Schematic. A high-power standing laser wave in an optical cavity, is introduced into the electron beam. **Right:** Phase-contrast imaging with a laser-based phase plate. A close-to-focus image of a gold-laced amorphous carbon film. Laser-based phase contrast leads to a pronounced increase of image contrast, in particular in the areas without gold that show little contrast otherwise.