P12: Only one Electron at a Time? – Studying Temporal Correlations of Continuous Field Emission in the TEM

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There is the hitherto common notion in transmission electron microscopy (TEM) that for a decent beam current of a few pA to some nA, i.e., tens of millions to tens of billions of electrons per second, and a typical acceleration voltage of 200 kV, there is, on average, only one electron present in the column at a time or at least that successive electrons are well separated in space and time.
However, recent findings on a laser-driven field emission tip (FEG) inside an ultra-fast TEM suggest the contrary [1]. Peculiar Coulomb-correlated multi-electron states have been observed under pulsed laser beam irradiation of an underheated FEG.
Here, electron-electron correlations are investigated in a TEM equipped with a continuous beam FEG using a time correlator setup similar to the one used in [2]. With the high angular annular dark field detector (HAADF) replacing the avalanche diodes, whereas the HAADF is decisively driven in the single electron detection regime employing beam currents well below 50 fA. Preliminary results of the temporal statistics of electron arrival show deviations from the expected uncorrelated Poissonian distribution.
Besides fundamental interest in the electron emission process of field emitters, electronic correlations are at the heart of multiple physical questions like superconductivity and charge ordering and may help to tackle questions on the coherence times in elastic/inelastic scattering processes [3] and the understanding of beam damage mechanisms in radiation sensitive samples [4].

References:

[1] R. Haindl et al. arXiv:2209.12300v1
[2] M. Scheucher et al., Ultramicroscopy, 241, 113594 (2022)
[3] P. Schattschneider et al., Ultramicroscopy, 190, 39–44 (2018)
[4] H. Choe et al., DOI: https://doi.org/10.1101/2020.05.15.099036

Poster P12 *Thu. 17:00-18:00*