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MEASURING THE ORBITAL ANGULAR MOMENTUM SPECTRUM OF AN ELECTRON BEAM

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Abstract

In this work, we propose, design, and demonstrate the performance of a device for measuring the azimuthal wavefunction of an electron beam, i.e. its orbital angular momentum (OAM) content [1]. Our device consists of two holograms fabricated with Focused Ion Beam (FIB) [2]. The device works as follows: inside a transmission electron microscope (TEM) an arbitrary electron beam impinges on the first hologram that performs a conformal mapping, unwrapping the azimuthal phase variations due to OAM into intensity variations along one Cartesian coordinate. The second hologram, placed in the reciprocal plane of the first one, corrects the phase distortions introduced by it. The result of this process is a spatial representation of the azimuthal phase components of the initial beam. We used this device to sort pure and superposition OAM states of electrons ranging within OAM values of -10 and 10; this set of measurements served as a calibrating procedure for the device. This implementation, though similar to its light optical counterpart [3], can also unveil further information of materials by exploiting the interactions that are distinctive of charged particles. We employed the device to analyse the OAM spectrum of electrons affected by a micron-scale cobalt magnetic dipole. A magnetic dipole introduces a phase term that depends on its magnetic moment; we were able to recover the magnetic moment of our cobalt dipole, in good agreement with the estimated value. Further developments of our device could aim to overcome the absorption due to the holograms, for instance by using structured electrostatic fields [4], and the use for atomic scale measurements or with scanning-TEM.

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