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Imaging Magnetic Focusing in a Two-Dimensional Electron Gas[1]

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Using a liquid-He cooled scanning probe microscope (SPM), we have directly imaged cyclotron orbits of electrons in a two-dimensional electron gas (2DEG) traveling between two side-by-side quantum point contacts (QPCs). The images show magnetic focusing when the spacing between the QPCs is an integer multiple of twice the cyclotron radius. An image is created by deflecting electrons away from their original trajectories using a capacitively coupled SPM tip, and recording the change in conductance as the tip is raster scanned above the surface. The cyclotron orbits are clearly visualized, as well as fringes that demonstrate the coherent nature of the flow. Classical and quantum simulations show how electrons are deflected by the tip to produce the image. With an applied magnetic field, the simulated images of magnetic focusing agree very well with the measured images. The simulations also show the effect of small angle scattering due to the ionized donor atoms. Fully quantum simulations show that interference fringes can be produced. Imaging and understanding the motion of electrons in magnetic fields is useful for the development of devices for spintronics and quantum information processing.

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