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Electron optics with ballistic graphene junctions[1]

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Electrons transmitted across a ballistic semiconductor junction undergo refraction, analogous to light rays across an optical boundary. A *pn* junction theoretically provides the equivalent of a negative index medium, enabling novel electron optics such as negative refraction and perfect (Veselago) lensing. In graphene, the linear dispersion and zero-gap bandstructure admit highly transparent *pn* junctions by simple electrostatic gating, which cannot be achieved in conventional semiconductors. Robust demonstration of these effects, however, has not been forthcoming. Here we employ transverse magnetic focusing to probe propagation across an electrostatically defined graphene junction. We find perfect agreement with the predicted Snell's law for electrons, including observation of both positive and negative refraction. Resonant transmission across the *pn* junction provides a direct measurement of the angle dependent transmission coefficient, and we demonstrate good agreement with theory. Comparing experimental data with simulation reveals the crucial role played by the effective junction width, providing guidance for future device design. Efforts toward sharper *pn* junction and possibility of zero field Veselago lensing will also be discussed.

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