# Gradient-index electron optics in graphene p-n junctions

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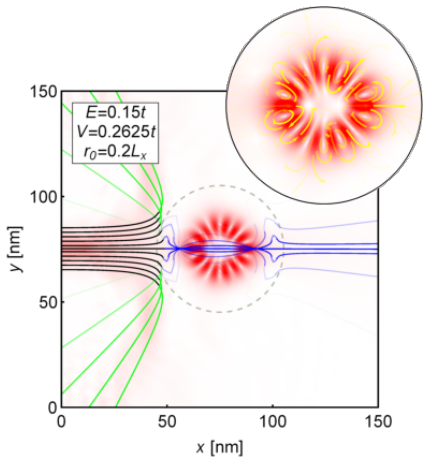
We investigate the electron transport in smooth graphene p-n junctions, generated by gradually varying electrostatic potentials with or without elastic deformations and calculate numerically coherent current flow patterns. We demostrate phenomena known from light propagating in media with a gradually changing refractive index such as Luneburg or Maxwell lenses. We observe that energetically forbidden regions appear which may increase reflections and generate pronounced interference patterns such as whispering gallery modes. All those patterns can be largely understood in terms of the semiclassical trajectories, obtained from the effective Dirac equation for electronic excitations in graphene, which demonstrates the feasibility of the gradient-index electron optics in graphene p-n junctions. The presented setups and techniques may have technological applications, for example, as electron beam splitters, focusers, or waveguides.

## REFERENCES

[1] E. Paredes-Rocha, Y. Betancur-Ocampo, N. Szpak, and T. Stegmann, Phys. Rev. B 103, 045404 (2021)

## FIGURES



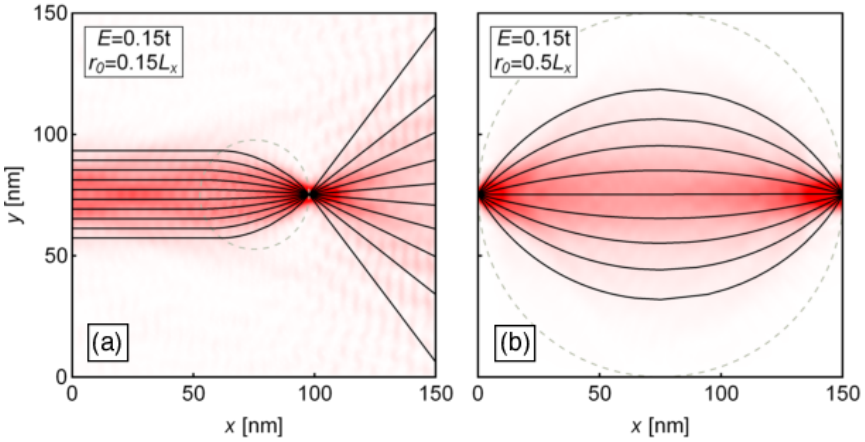




**Figure 1 (left):** Gradient-index electron optics in smooth circular p-n junctions. Strong interference patterns in the form of whispering gallery modes can be observed for specific parameters.

**Figure 2 (right):** Current flow in graphene with an electrostatic potential that generates a Luneburg lens (a) and a Maxwell's fish-eye lens (b).