Quasiparticle interference in mono- and bilayer graphene

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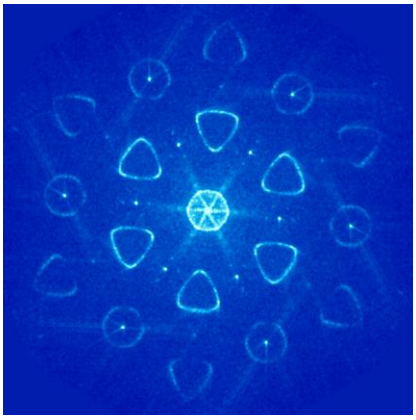
Scanning tunneling microscopy (STM) is a powerful method to determine the atomic structure and the morphology of 2-dimensional materials, while scanning tunneling spectroscopy (STS) gives access to their local density of electronic states. However, this determination alone does not directly yield the dispersive band structure, and certainly does not give access to more advanced electronic properties like the pseudospin of the quasiparticles or the localization of states in different layers of van der Waals materials. This problem can be overcome by using STS to study quasiparticle interference (QPI) in scattering processes of charge carriers: Fourier-transformed spectroscopic maps (see figure.) contain a wealth of information by providing the principal scattering vectors and their intensity.

We present direct experimental evidence of broken chirality in doped monolayer graphene [1] by analysing electron scattering processes at energies ranging from the linear (Dirac-like) to the strongly trigonally warped region. Our data show a very good agreement with theoretical calculations for free-standing graphene. We identify a new intravalley scattering channel activated in case of a strongly trigonally warped constant energy contour, which is not suppressed by chirality. Finally, we compare our experimental findings with T-matrix simulations with and without the presence of a pseudomagnetic field and suggest that higher order electron hopping effects are a key factor in breaking the chirality near to the van Hove singularity.



Scattering pattern in strongly doped graphene: Fourier transform of a spectroscopic map of gr/Cs/Ir(111) at U=-50 mV. Triangular scattering features around the K poins and hexagonal features around the Γ point are visible.

We study chemically gated bilayer graphene [2], where gating is achieved by intercalating Cs between bilayer graphene and Ir(111), thereby shifting the conduction band minima below the chemical potential. Scattering between electronic states (both intraband and interband) is detected via quasiparticle interference. However, not all expected processes are visible in our experiment. We uncover two general effects causing this suppression: first, intercalation leads to an asymmetrical distribution of the states within the two layers, which significantly reduces the scanning tunneling spectroscopy signal of standing waves mainly present in the lower layer; second, forward scattering processes, connecting points on the constant energy contours with parallel velocities, do not produce pronounced standing waves due to destructive interference. We present a theory to describe the interference signal for a general n-band material.

References:
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