Berry's phase atomic interferometers in graphene

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Topological defects in waves is a concept introduced by Nye and Berry to explain the dislocations observed in some radio-echos sounding the ice sheet of Antartica [1]. It relies generically on the phase singularities of a complex scalar field. Here we shall discuss it in the context of scanning tunnelling microscopy (STM) images of the electronic interferences around H adatoms chemisorbed on graphene (cf. Fig. 1 (a)). If intravalley scattering is known to induce $2q_F$-wave-vector Friedel oscillations in the electronic density [2,3], we shall see that intervalley scattering is the source of extra oscillations that do not relate to the Fermi wave vector q_F. When selecting a specific intervalley-scattering wave vector, these oscillations reveal a couple of edge dislocations in the interference pattern (cf. Fig. 1 (b)). We shall show that such topological defects appear as a real-space manifestation of the Berry's phase π that characterises the phase singularities of the wave functions at the Dirac points in momentum space. This demonstrates the ability of STM to image the geometrical phases of wave functions through static interferences; thus suggesting a new approach to probe the nodal band structures and topological gapped phases of condensed matter.

[1] J. F. Nye and M. V. Berry, Proc. R. Soc. Lond. A **336**, 165 (1974)
[2] J. Friedel, Phil. Mag. **43**, 153 (1952)
[3] I. Brihuega et al., Phys. Rev. Lett. **101**, 206802 (2008)

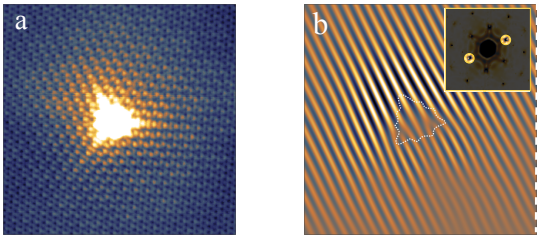

Figure 1: (a) STM image of a H adatom chemisorbed on graphene. (b) Filtered image of (a) showing edge dislocations in the scattering interferences of electronic standing waves.