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# Engineering Dirac points with ultracold fermions in a tunable optical lattice

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## Résumé

Dirac points lie at the heart of many fascinating phenomena in condensed matter physics, ranging from massless electrons in graphene to the emergence of conducting edge states in topological insulators. At a Dirac point, two energy bands intersect linearly and the particles behave as relativistic Dirac fermions. A highly flexible approach to studying Dirac points is to create model systems using ultracold fermionic atoms trapped in the periodic potential of interfering laser beams. In our setup we have realized an optical lattice of tunable geometry, ranging from square, triangular, honeycomb, dimer to different one-dimensional structures. For the case of the honeycomb lattice, we probe the band structure using momentum resolved interband transitions and observe the appearance of Dirac points. The possible appearance of Stückelberg interference when double-passing the two Dirac points is studied. Additionally, we exploit the unique tunability of our lattice potential to adjust the effective mass of the Dirac fermions and to move their position inside the Brillouin zone until they merge and annihilate each other. We map out this topological transition and find excellent agreement with ab-initio calculations. Our results not only pave the way for using cold atoms to model materials where the topology of the band structure plays a crucial role, but also provide the possibility to explore many-body phases resulting from the interplay of complex lattice geometries with interactions.

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