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Fachbereich Physik, Universität Stuttgart
Max-Planck-Institut für Festkörperforschung
Max-Planck-Institut für Intelligente Systeme

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Dirac single particle and plasmon excitations in topological insulators

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Abstract

Topological Insulators (TIs), like Bi2Se3 and Bi2Te3, are one of the most intriguing issues at focus in Condensed Matter Physics. TIs exhibit a band gap in the bulk like ordinary insulators, but have intrinsic 2D conducting states on their edge and surface. This means that the topology, associated with the electronic wave functions of the system, changes discontinuously when passing from the bulk to the surface. The edge states arise from a strong spin-orbit coupling, and they are backscattering protected, i.e. not sensitive to disorder (except that coming from magnetic impurities). Such as graphene, TIs surface charge transport is carried out by Dirac fermions, with a very high surface carrier density ($n \geq 10^{13}$ cm^{-2}), compared to typical values on metal surfaces. Apart single particle excitations, Dirac fermions in TIs sustain exotic plasmonic (collective) modes whose properties of tunability and temperature dependence can be used for photonics applications at the nanoscale. Moreover, unlike plasmons in metals, Dirac plasmons in TIs are expected to be strongly affected by an external magnetic field B due to fact that the cyclotron frequency is comparable to the plasmon frequency, in particular when plasmons are engineered in the terahertz region of the electromagnetic spectrum.

In this talk, after a general review on the properties of Topological Insulators, I will discuss the terahertz linear response of Dirac plasmons in TIs and their behavior under a strong magnetic field up to 30 T. The appearance of strong non-linear optical effects, when the THz electric field reaches values on the order of 1 MV/cm, will be also discussed. In the second part of the talk, I will discuss the sub-ps dynamics of Dirac single-particle and collective excitations as measured by optical-pump THz-probe experiments. Both the steady state and time-resolved experiments provide a unifying picture of single particle and collective electronic excitations in Topological Insulators.