de Haas – van Alphen oscillations of graphene and graphite

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Quantum oscillations of the magnetic moment, so called de Haas - van Alphen (dHvA) oscillations, are a powerful tool for the investigation of the Fermi surface. In graphene with a fixed carrier density, the magnetic moment undergoes a sawtooth-like oscillation as function of increasing perpendicular field B every time the uppermost Landau level empties out, yielding the characteristic 1/B dependence. To date, it has been challenging to measure the equilibrium magnetic moment of isolated samples of graphene. In graphite a more complex oscillation sequence is observed, due to its complicated Fermi surface with both majority and minority electron and hole carriers. Historically graphite was one of the first materials in which dHvA oscillations were studied, but recently interest was revived due to an observation of carriers with relativistic dynamics. We have used cantilever torque magnetometry to study diamagnetism and dHvA oscillations of isolated samples of graphene and graphite between 400 mK and 20 K. An exfoliated graphene sample encapsulated in an h-BN sandwich, or a small flake of graphite, is placed on a silicon microcantilever. In graphite, we observe dHvA oscillations which are analyzed to extract the composition and nature of carriers. In graphene, we obtain a preliminary result on an ungated sample and discuss it in relation to relativistic dispersion and disorder.