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Observation of Terahertz-Induced Magnetooscillations in Graphene

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Almost twenty years ago, experiments on high-mobility GaAs/AlGaAs heterostructures revealed strong magnetoresistance oscillations excited by microwave illumination [2,3]. These oscillations are 2π-periodic in $B_{\rm CR}/B \equiv \omega/\omega_c$, and thus reflect commensurability between the photon energy $\hbar\omega$ and separation $\hbar\omega_c$ between neighboring Landau levels [4]. Despite superior quality of modern graphene devices, no counterpart of such effects (apart from physically related phonon-assisted resistance oscillations [5]) has been reported so far in this class of materials.

We demonstrate the emergence of a terahertz analogue of microwave induced resistance oscillations (MIRO) [2,3]
in high-mobility multi-terminal graphene devices, termed below as THz-induced magnetooscillations (TIMO) [1]. The linear spectrum of graphene results in non-equidistant spectrum of Landau levels (LLs). The spacing between LLs at the Fermi energy depends on the carrier density n as $\hbar\omega_c = eBv_{\rm F}/\sqrt{\pi n}$. We indeed observe that the fundamental frequency of TIMO $B_{\rm CR} = B\omega/\omega_c \propto \sqrt{n}$ is controlled by n and thus can be tuned by applying the gate voltage. We also find that, in line with previous observations in other materials [4], the nodes of TIMO in graphene occur at integer $B_{\rm CR}/B = 1, 2, \ldots$.

In sharp contrast to conventional MIRO in other materials, where oscillations become strongly suppressed already at liquid helium temperature, we demonstrate that TIMO in graphene persist above the liquid nitrogen temperature. Preliminary measurements at higher THz frequencies indicate that the amplitude of TIMO at $f = 1.63$ and 2.54 THz relative to $f = 0.69$ THz is larger than expected from predicted f^{-4} scaling [4]. The above peculiarities of TIMO in graphene require further focused studies. An almost linear power dependence of the amplitude of oscillations, with a weak tendency to saturation at highest input power of 20 mW, indicates that much stronger TIMO can be induced by more powerful THz sources.

The presented observations extend the family of radiation-induced nonequilibrium effects in graphene and offer opportunities for deeper understanding of the MIRO phenomenon as well as scattering and relaxation mechanisms in this material.

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