Terahertz Spin-Light Coupling in Proximitized Dirac Materials

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The atomically thin nature of two-dimensional (2D) van der Waals materials makes them highly susceptible to the influence of their neighbours, thereby enabling the design of their electronic band structure by proximity phenomena. We investigate spin-light coupling phenomena in van der Waals heterostructures consisting of two-dimensional (2D) Dirac crystals proximitized by a magnetic layer. A strong magnetic proximity effect results in the modification of the 2D electron spectrum with the appearance of different spin-splitting terms and electron's equilibrium spin polarization [1]. Here, we reveal a remarkable terahertz (THz) spin-light interaction in 2D Dirac materials that arises from proximity effects of magnetic and spin-orbital character. We demonstrate theoretically that the electric dipole spin resonance (EDSR) of Dirac electrons displays distinctive features in the THz range, upon emerging spin-pseudospin proximity terms in the Hamiltonian. To capture the effect of fast pseudospin dynamics on the electron spin, we develop a mean-field theory and complement it with a quantum-mechanical treatment

. As a specific example, we investigate the THz response of a single graphene layer proximitized by a magnetic substrate, using realistic parameters. Our analysis demonstrates a strong enhancement of the THz-light absorption with the increase of the spin-pseudospin coupling, pointing towards promising prospects for THz detection and efficient generation and control of spins in spin-based quantum devices.

The derived features of THz spin-light coupling suggest that EDSR could be a powerful experimental probe in the studies of proximitized vdW layers and to elucidate spin-dependent phenomena. The EDSR framework allows one to quantify proximity induced spin splittings and gives a direct access to spin-relaxation mechanisms. The derived description of coupled spin-pseudospin dynamics could be implemented in graphene quantum dots and nanoflakes, the basic elements realizing qubits for quantum computing in THz range.

References

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