Strong Magnetic Fields Generated by THz Plasmons in Graphene Disks

Pavlo Sai[1], Dmytro But[1], Jeong Woo Han[2], Stephan Winnerl[3], Thomas E. Murphy[4], Wojciech Knap[1] and Martin Mittendorff[2]

[1] CENTERA Laboratories, Institute of High Pressure Physics PAS, 01-142 Warsaw, Poland
[2] Universität Duisburg-Essen, Fakultät für Physik, Lotharstr. 1, 47057 Duisburg, Germany
[3] Helmholtz-Zentrum Dresden-Rossendorf, Dresden 01328, Germany
[4] University of Maryland, College Park MD 20740 MD, USA

Graphene plasmonic elements can strongly enhance the light-matter interaction and therewith also the nonlinear optical properties. This nonlinearity is dominated by thermal effects, though also strong electric fields can induce a nonlinear effect [1]. Furthermore, the plasmonic motion can hybridize with the cyclotron motion in magnetic fields [2], allowing efficient tuning of the nonlinear effects [3]. Here we show that illuminating graphene discs with circularly polarized radiation induces plasmonic currents around the discs that induce strong out-of-plane quasistatic magnetic fields [4].

Graphene disks with a diameter of 1.2 µm and a plasmon frequency of 3.5 THz were illuminated resonantly with circularly polarized THz pulses from the free-electron laser FELBE at Helmholtz-Zentrum Dresden-Rossendorf. To probe the magnetic field in the vicinity of the disks, the Faraday rotation was probed with a linearly polarized pulse. The pump-induced Faraday rotation as a function of the time delay is shown in Fig. 1 (a). As a calibration experiment, we measured the Faraday rotation in static magnetic fields, the corresponding field strength is shown on the right side of Fig. 1 (a). To analyze the data and to characterize the spatial distribution of the magnetic field in the vicinity of the disks, we performed finite-element simulations as shown in Fig. 1 (b).

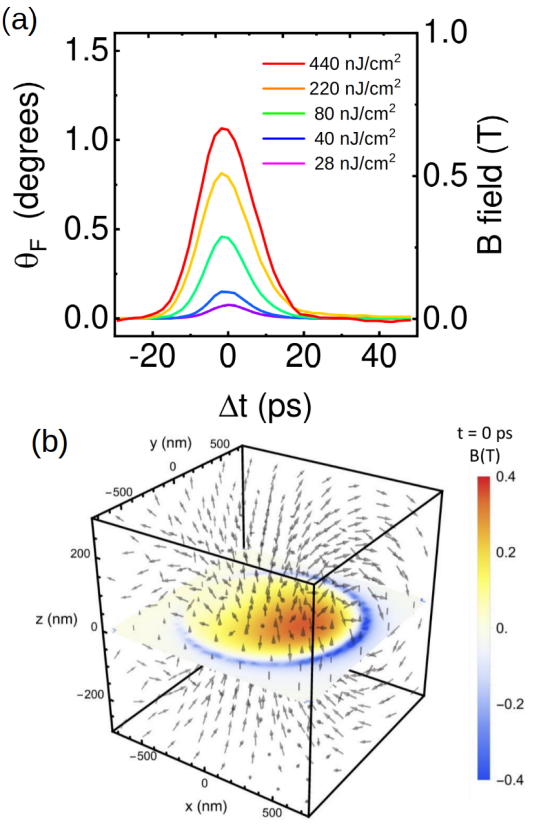

Fig. 1. (a) Pump-induced Faraday rotation as a function of the time delay between pump and probe pulse. (b) Magnetic field distribution around the graphene disk, the field strength at the position of the graphene disk is color coded (taken from [4]).

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[3]. M. L. Chin et al., J. Phys. Photonics **3**, 01LT01 (2021).
[4]. J. W. Han et al., Nat. Commun., 7493 (2023).