Active spintronic-metasurface terahertz emitters with tunable chirality

***Zhensheng Tao*[1*] , Changqin Liu [1], Shunjia Wang[1], Sheng Zhang[1], Qingnan Cai[1], Peng Wang[1], Chuanshan Tian[1], Lei Zhou[1] and Yizheng Wu[1,2]**

[1] *Department of Physics and State Key Laboratory of Surface Physics, Fudan University, Shanghai 200433, China*
[2] *Shanghai Research Center for Quantum Sciences, Shanghai 201315, China*
*E-mail: zhenshengtao@fudan.edu.cn

The ability to manipulate the electric-field vector of broadband terahertz waves is essential for applications of terahertz technologies in many areas, and can open up new possibilities for nonlinear terahertz spectroscopy and coherent control. Here, we propose a novel laser-driven terahertz emitter, consisting of metasurface-patterned ferro- and non-magnetic multilayer heterostructures (see Figure 1) [1]. Such hybrid terahertz emitters can combine the advantages of spintronic emitters for being ultrabroadband, efficient and flexible, as well as those of metasurfaces for the unique capability to manipulate terahertz waves with high precision and degree of freedom. Taking a stripe-patterned metasurface as an example, we demonstrate the generation of broadband terahertz waves with tunable chirality driven by a compressed Yb-femtosecond laser. The high-efficiency and high-quality pulse compression is enabled by all-solid-state soliton management in periodic layered Kerr media [2,3]. Based on experimental and theoretical investigations, we study the interplay between the laser-induced spintronic-origin currents and the metasurface-induced transient charges and currents in the metasurface-patterned spintronic emitters, revealing the strong influence on the device functionality originated from both the light-matter interactions in individual metasurface units and the dynamic coupling between them. Our work not only offers a flexible, reliable and cost-effective solution for chiral terahertz wave generation and manipulation, but also opens a new pathway to metasurface-tailored spintronic devices for efficient vector-control of electromagnetic waves in the terahertz regime.

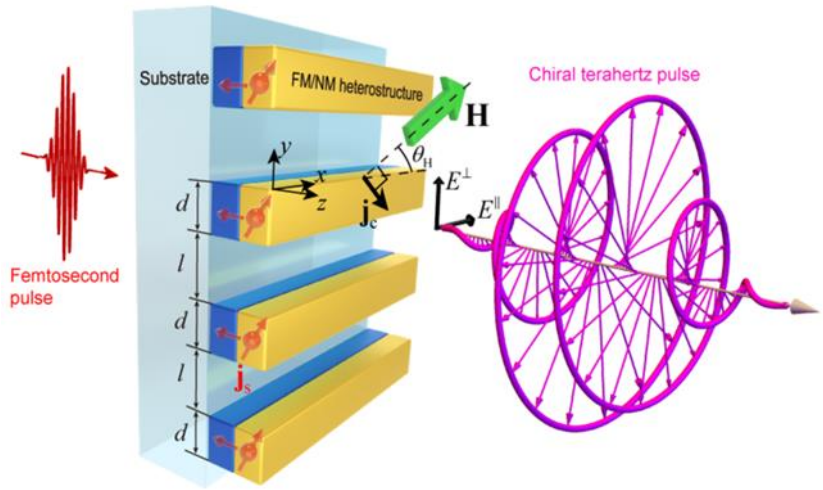

Figure 1: Illustration of the chiral terahertz-wave generation enabled by the metasurface-patterned spintronic terahertz emitter.

References:

[1] C. Liu, S. Wang, S. Zhang, Q. Cai, P. Wang, C. Tian, L. Zhou, Y. Wu, Z. Tao, arXiv:2105.11775 (2021)
[2] S. Zhang, Z. Fu, B. Zhu, G. Fan, Y. Chen, S. Wang, Y. Liu, A. Baltuska, C. Jin, C. Tian, Z. Tao, Light: Science&Applications **10**, 53 (2021)
[3] B. Zhu, Z. Fu, Y. Chen, S. Peng, C. Jin, G. Fan, S. Zhang, S. Wang, H. Ru, C. Tian, Y. Wang, H. Kapteyn, M. Murnane, Z. Tao, arXiv:2108.10737 (2021)