Creating On-Demand Optomagnets from Polar Antiferromagnets

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On-demand spin orientation with a long polarized lifetime and an easily detectable signal is the ultimate goal for spintronics. However, there still exists a trade-off between controllability and stability of spin polarization, awaiting a significant breakthrough. Here, we demonstrate switchable optomagnet effects in $(Fe_{1-x}Zn_x)_2Mo_3O_8$, from which we can obtain tunable magnetization (spanning from −40% to 40% of a saturated magnetization) that is created from zero magnetization in the antiferromagnetic state without magnetic fields. It is accomplishable by utilizing circularly polarized laser pulses to excite spin-flip transitions in polar antiferromagnets that have no spin canting, traditionally hard to control without very strong magnetic fields. The spin controllability in $(Fe_{1-x}Zn_x)_2Mo_3O_8$ originates from its polar structure that breaks the crystal inversion symmetry, allowing distinct on-site d-d transitions for selective spin flip. By chemical doping, we exploit the phase competition between antiferromagnetic and ferrimagnetic states to enhance and stabilize the optomagnet effects, which result in long-lived photoinduced Kerr rotations. The present study creating switchable giant optomagnet effects in polar antiferromagnets sketches a new blueprint for the function of antiferromagnetic spintronics. [1]

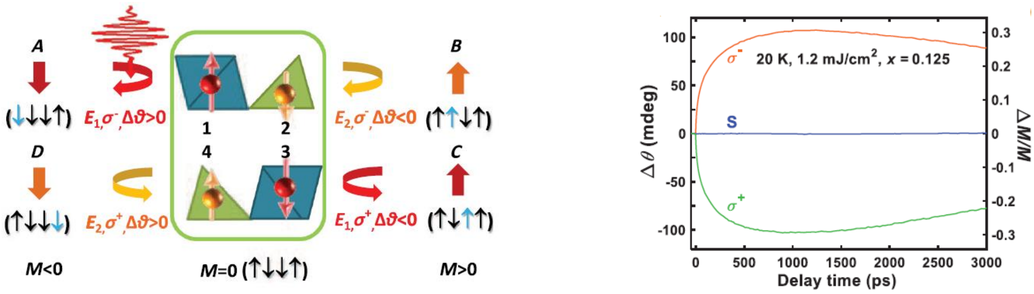

Figure 1: Left panel: Illustration of optomagnets created by optical helicities in a magnetic basis. Four distinct spin quantum states A, B, C, D can be selectively created from the zero-magnetization (M=0) state by flipping one of the sublattice spin moments (1; 2; 3; 4)=(↑↓↓↑) with the flipped moment color coded in each unique configuration. This optomagnet can be made possible through the on-site d-d optical transitions with combinations of pump photon energies $E_{1,2}$ and circularly polarized pumps $\sigma^{\pm}$. Combining the resultant magneto-optical Kerr rotations $\Delta\theta$, we can unambiguously discern the four distinct microscopic states that lead to two switchable magnetization directions macroscopically, right panel.

References:

[1] Y. M. Sheu*, Y. M. Chang, C. P. Chang, Y. H. Li, K. R. Babu, G.Y. Guo, T. Kurumaji, and Y. Tokura, "Picosecond creation of switchable optomagnets from a polar antiferromagnet with giant photoinduced Kerr rotations", **Physical Review X 9**, 031038 (2019).