Competition between orbital and spin angular momenta of light at the antiferromagnetic resonances and Landau level transitions

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Circularly polarized light with spin angular momentum is one of the most valuable probes of magnetism. Recently we demonstrated that light beams with orbital angular momentum (OAM), or vortex beams, can also couple to magnetism exhibiting dichroisms in a magnetized medium. Terahertz (THz) vortex beams with various combinations of the orbital angular momentum $l=\pm1$, ±2, ±3, and ±4 and spin angular momentum $\sigma = \pm1$, or conventional circular polarization, were used for studies of the magnon spectra at the antiferromagnetic resonance conditions in $TbFe_3(BO_3)_4$ and Ni_3TeO_6 single crystals. In both materials we observed strong vortex beam dichroism for the magnon doublet, which is split in an external magnetic field applied along the spin ordering direction. The absorption conditions at the magnon frequencies depend on the total angular momentum of light *j* that is determined by the combination of the spin and orbital angular momenta: $j=\sigma+l$. For the higher orders of *l*, the selection rules for AFM resonances dictated by *l* completely dominate over that for conventional circular polarization. Our results demonstrate the high potential of the vortex beams with OAM as a new spectroscopic probe of magnetism in matter. In addition to the results for AFM materials, we will also discuss our recent experiments with vortex beam spectroscopy of the Landau level resonances in 2DEG semiconductor heterostructures.

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