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Abstract:

Spintronics, where the spin of electrons is used to carry information, is a rapidly growing area of research^{1,2}. There are several techniques for generating pure spin currents^{3,4,5,6,7,8,9,10}; however, there is no method that can directly detect them, largely because they carry no net charge current and no net magnetization. At present, studies of pure spin currents rely on measuring the induced spin accumulation with either optical techniques^{5,11,12,13} or spin-valve configurations^{14,15,16,17}. However, spin accumulation does not directly reflect the spatial distribution or temporal dynamics of the pure spin current, and therefore does not give a real-time or real-space measurement. Here we demonstrate a second-order nonlinear optical effect of the pure spin current that has never been explored before, and show that it can be used for the non-invasive, non-destructive and real-time imaging of pure spin currents. The detection scheme can be applied in a wide range of materials with different electronic band structures because it does not rely on optical resonances. Furthermore, the control of nonlinear optical properties of materials with pure spin currents may have potential applications in photonics integrated with spintronics.

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