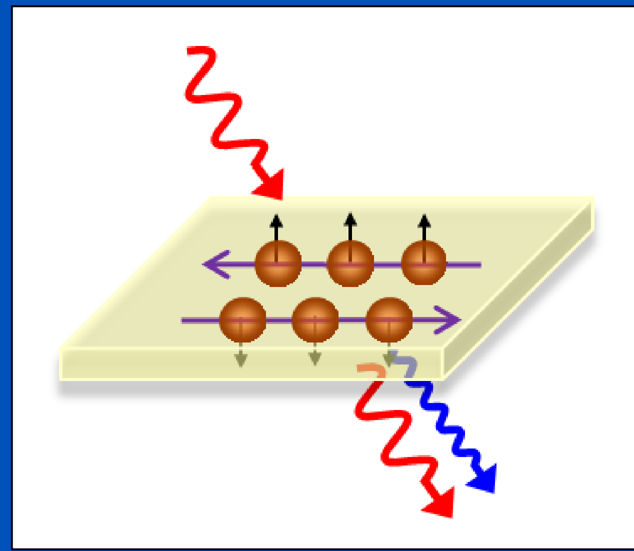
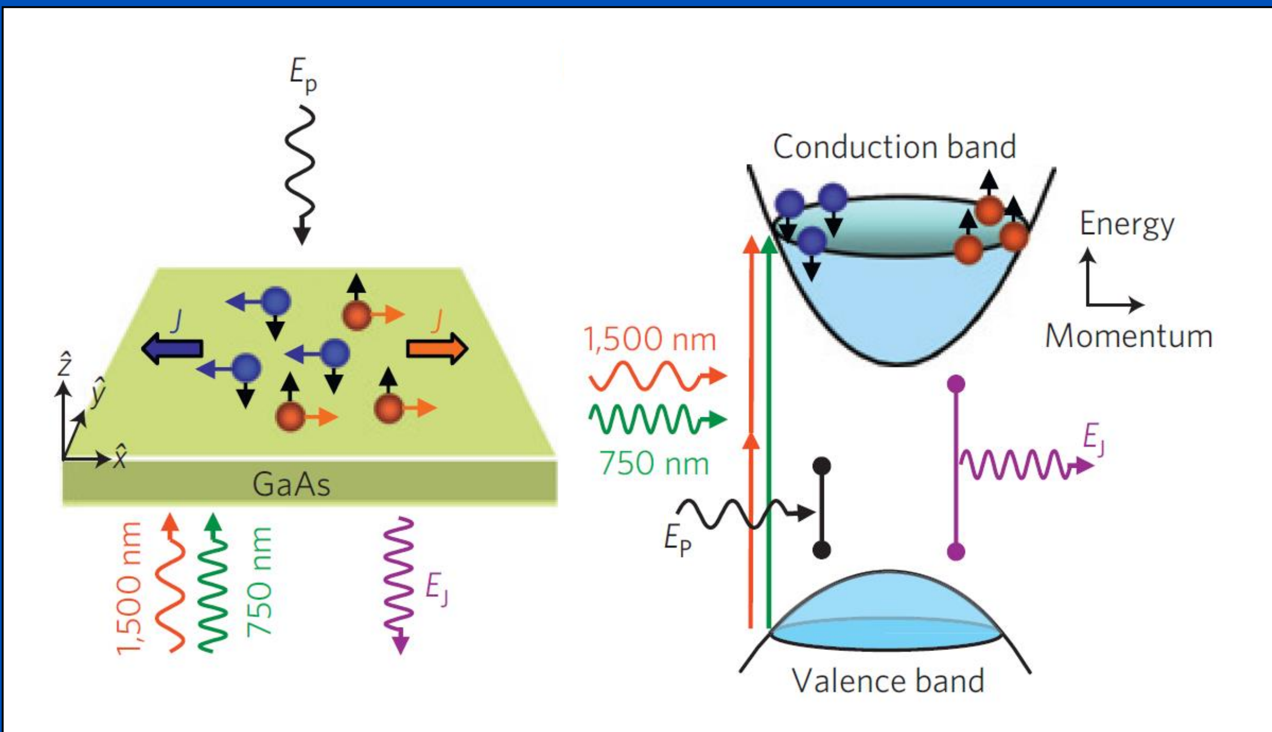
Nonlinear Optical Effect of Spin Currents

Extensive efforts are currently being devoted to developing a new electronic technology, called spintronics, where the spin of electrons is explored to carry information. However, there is still no method available to detect spin currents. This imposes severe constraints on research in this field. We demonstrate a second-order nonlinear optical effect of spin currents, and show that this effect can be used for the non-invasive, non-destructive, and real-time imaging of spin currents.



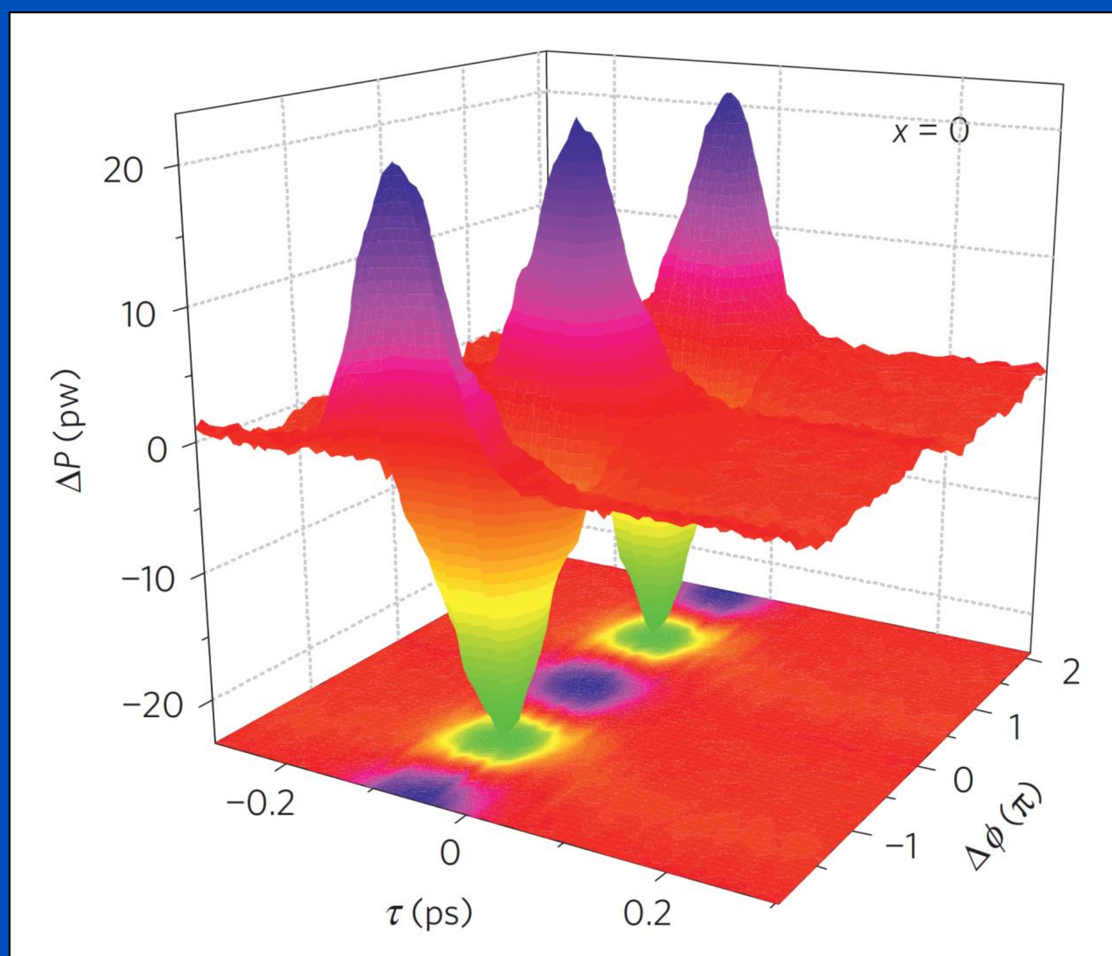


Experimental Approach

The sample is simultaneously illuminated by two laser pulses (red and green waves). Quantum interference between the transition pathways driven by the two pulses causes electrons with opposite spins to be excited to energy states with opposite momenta. The nonlinear optical effect of the injected spin current is studied by detecting second-harmonic generation (E_J) from a probe pulse (E_P).

Main Results

- Second-harmonic generation (P) induced by the spin current is measured as a function of the probe delay, , and the relative phase, $\Delta\phi$, of the two current-injecting pulses.
- The signal is a sinusoidal function of $\Delta\phi$, showing the second-order susceptibility is proportional to the spin current density.
- The signal decays rapidly, shows the ultrashort lifetime of the injected spin currents.
- Additional measurements show the second-harmonic power also scales with the pump laser power, and the spin current lifetime decreases with the carrier density.



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PUBLISHED ONLINE: 8 AUGUST 2010 | DOI: 10.1038/NPHYS1742

Observation of second-harmonic generation induced by pure spin currents

Lalani K. Werake and Hui Zhao*

National Science Foundation
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August 24, 2010

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