Light-by-light Stern-Gerlach Effect

A new research [1] proposes a method to deflect light beams in a nonlinear optical medium into two discrete angles, each corresponding to a different superposition of colors of which the light is composed. The concept is analogous to the famous Stern-Gerlach experiment in quantum mechanics, in which silver atoms were deflected by an inhomogeneous transverse magnetic field into only two discrete angles, thus revealing the quantized nature of the spin—the intrinsic angular momentum of the electron.

In the analogue experiment proposed by the authors, the light beam is composed of two wavelengths (with corresponding two colors) that are coupled by a transversely varying quadratic nonlinear interaction. Here the equivalent two-color spin is determined by the relative energies in each color, and the magnetic field equivalent is the nonlinear optical coupling.

This concept opens exciting new possibilities for utilizing the color degree of freedom of light. The all-optical control of the deflection angle by the pump beam can be useful for ultrafast light switching applications. Furthermore, if the input beam is a non-classical light, composed of only single photons at the two coupled wavelengths, this all-optical Stern-Gerlach scheme may enable to decompose, or project them into their two-color constituents.

![Diagram](image)

**FIG. 1.** (a) Setup of the original SG experiment. A beam of spin-1/2 silver atoms is deflected into two discrete directions due to a magnetic field gradient. (b) Setup of the all-optical SG experiment. An idler beam is incident on a pumped nonlinear crystal, and is deflected into two mutual beams, each composed of a superposition of the idler and signal waves. This deflection into two discrete directions occurs due to a transverse gradient in the nonlinear coupling.