**Nonlinear optics and two-level systems**

Ady Arie

School of Electrical and Computer Engineering,

Tel Aviv University, Tel Aviv, Israel

Nonlinear frequency mixing of optical waves is analogous to many other well-known processes in two level systems, including: the oscillation of two coupled pendula, the coupling of a two-level atom by an electromagnetic field and the precession of spin-1/2 particles in a magnetic field. Relying on the latter example, nonlinear optics can be used emulate spin currents in magnetic materials: The signal and idler complex amplitudes represent the two-dimensional spin vector, and the nonlinear coupling represents the material magnetization.

This analogy is used to observe new nonlinear optical effects [1], including the all-optical Stern-Gerlach effect [2], the topological Hall effect in skyrmions [3] and Anderson localization of spin currents in disordered spin glass [4].

Moreover, it enables to realize new optical devices, including spin valve - a spin-dependent beam splitter that can split signal-idler beam according to the relative phase between them and spin waveguide that can guide in-phase only signal-idler beams.

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[2] O. Yesharim et al, *Nature Photonics* **16**, 582 (2022).

[3] A. Karnieli, S. Tsesses, G. Bartal and A. Arie, *Nature Comm.* **12**, 1092 (2021)

[4] S. Izhak, A. Karnieli, O. Yesharim, S. Tsesses and A. Arie, *Phys. Rev. Lett.* **134**, 123803 (2025)