Spontaneous Symmetry Breaking of an Optical Polarization State in a Nonlinear Resonator

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Polarization self-rotation (PSR) is a nonlinear optical phenomenon which consists of the rotation of the polarization pattern of an elliptically polarized field propagating through a centrally-symmetric nonlinear medium. This phenomenon has been extensively studied in atomic vapor and turned out to be a useful tool for squeezing light.

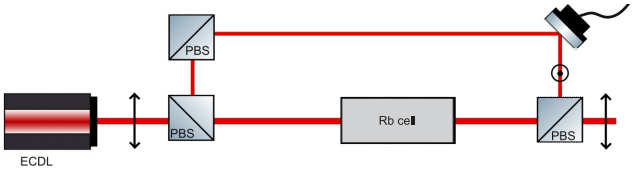

Figure 1: Experimental setup featuring a polarization-selective resonator

In this work, we utilize PSR to observe spontaneous symmetry breaking of a polarization pattern. An atomic vapour cell is placed into a polarization-selective cavity, in which only the vertical polarization is resonated. The cell is pumped with horizontal polarization. Vacuum fluctuations in the vertical polarization component give rise to microscopic ellipticity, which is rotated in the vapor cell. The resulting vertically polarized field becomes amplified thanks to multiple passes through the resonator and repeated self-rotation in the same direction. This results in a bistable macroscopic elliptical polarization pattern: the helicity and axis angle of the polarization ellipse randomly converges to one of the two values determined by the sign of the initial vacuum fluctuation.

This phenomenon can be utilized to construct an all-optical coherent Ising machine.