There's more than one way to spin a photon: quantised fractional angular momentum of light.

Beams of light can carry both spin angular momentum, S, associated with the polarisation, and orbital angular momentum, L, associated with the angular dependence of the phase. While spin is pictured as the rotation of the electric field at each point, orbital angular momentum is due to the rotation of the beam as a whole around its centre. For uniformly polarized beams with rotationally symmetric intensity profiles the spin, orbital, and total angular momentum of a photon are conserved. In a quantum theory, each of these quantities occurs in integer multiples of Planck's constant, due to light being composed of photons, which are bosons. Thus these quantities provide a discrete state space which can be probed in quantum optics experiments and may be useful for encoding quantum information.

We derive the conservation laws and quantisation conditions in more general cases where the polarisation varies across the beam, using beams generated by conical diffraction in biaxial crystals as examples. In the paraxial limit, which deals with beams propagating in a specified direction with small angular deviation from this direction, the total angular momentum $J = L + S$ is not unique and other linear combinations of L and S may be considered. We show that these quantities split into two classes, one with integer quantisation and the other with half-integer, or fermionic quantisation.

The conserved angular momentum of such polarisation profiles derives from their symmetry under combined rotations of field and phase. The total angular momentum can be measured interferometrically or mechanically. We calculate the shot noise in the associated angular momentum current, and hence provide a way to measure the quantum of angular momentum in such beams.