Simulating chiral dynamics in quantum optics

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Abstract: Topological or chiral physics have been vastly investigated in electrons, photons and phonons. In electrons, large magnetic field and low temperature are usually necessary. Topological photonic and acoustic structures require exotic methods to synthesize gauge field. I will introduce a momentum-space lattice composed by timed Dicke states (single photon superradiant states) [1], based on which the chiral edge currents are observed in atoms at room temperature [2]. This quantum optical system requires neither magnetic field nor low temperature and can be extended to simulate the Haldane model [3]. A variation of the Haldane model can also be realized in a cavity QED system, which involves with synthetic spin-orbit coupling and effective magnetic fields for photons in a Fock-state lattice [4]. We experimentally realized a similar scheme in superconducting qubits, where anti-symmetric spin exchange interaction (also known as the Dzyaloshinskii-Moriya interaction) was synthesized and dynamics of chiral spin clusters were observed [5].