Pseudospin-1 Physics with Photonic Crystals

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Pseudospin is of central importance in governing many unusual transport properties of graphene and other artificial systems which have pseudospins of ½. These unconventional transport properties are manifested in phenomena such as Klein tunneling, and collimation of electron beams in one-dimensional external potentials. Here we show that in certain photonic crystals (PCs) exhibiting conical dispersions at the center of Brillouin zone, the eigenstates near the "Dirac-like point" can be described by an effective spin-orbit Hamiltonian with a pseudospin of 1. In addition, we found that a change of length scale of the PC can shift the Dirac-like cone rigidly up or down in frequency with its group velocity unchanged, hence mimicking a gate voltage in graphene. At the interface of two different potentials, the 3-component spinor gives rise to distinct boundary conditions, leading to new wave transport behaviors as shown in super Klein tunneling and supercollimation. For example, collimation can be more robust with pseudospin-1 than pseudospin-½. The special wave transport properties of pseudospin-1 photons, in conjunction with the discovery of the photonic potential, may offer new ways to control photon transport. We will also explore the difference between pseudospin-1 photons and pseudospin-½ particles when they encounter disorder.