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Generalized Dirac points and topological surface states in a three-dimensional nonsymmorphic photonic crystal LING LU, CHEN FANG, TIMOTHY HSIEH, LIANG FU, JOHN JOANNOPOULOS, MARIN SOLJAČIĆ, Massachusetts Institute of Technology — In condensed matter physics, the three-dimensional (3D) Dirac equation describes low-energy excitations of spin-$\frac{1}{2}$ electrons in quantum materials ranging from topological insulators to Dirac semimetals. Here we discover, in photonic crystals, the existence of robust 3D linear point degeneracies between two pairs of band crossings with different velocities. Based on symmetry considerations, we demonstrate that such dispersion is governed by a generalization of 3D Dirac equation for *spin-1* photons propagating in a periodic medium. This 3D Dirac phase in photonic crystals represents a new topological phase of matter protected by nonsymmorphic crystal symmetry and exhibits novel two-dimensional surface states, which we characterize. Time-reversal symmetry is preserved but not required in our photonic system.

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