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Realization of Massive Relativistic Spin-3/2 Rarita-Schwinger Quasiparticle in Condensed Matter Systems FENG TANG[1], National Laboratory of Solid State Microstructures and School of Physics, Nanjing University, Nanjing 210093, China, XI LUO, CAS Key Laboratory of Theoretical Physics, Institute of Theoretical Physics, Chinese Academy of Sciences, Beijing 100190, China , YONGPING DU, Department of Applied Physics, Nanjing University of Science and Technology, Nanjing 210094, China, YUE YU[2], State Key Laboratory of Surface Physics, Center for Field Theory and Particle Physics, Department of Physics, Fudan University, Shanghai 200433, China, XIANGANG WAN[3], National Laboratory of Solid State Microstructures and School of Physics, Nanjing University, Nanjing 210093, China — Very recently, there has been significant progress in realizing high-energy particles in condensed matter system (CMS) such as the Dirac, Weyl and Majorana fermions. Besides the spin-1/2 particles, the spin-3/2 elementary particle, known as the Rarita-Schwinger (RS) fermion, has not been observed or simulated in the laboratory. The main obstacle of realizing RS fermion in CMS lies in the nontrivial constraints that eliminate the redundant degrees of freedom in its representation of the Poincaré group. In this Letter, we propose a generic method that automatically contains the constraints in the Hamiltonian and prove the RS modes always exist and can be separated from the other non-RS bands. Through symmetry considerations, we show that the two dimensional (2D) massive RS (M-RS) quasiparticle can emerge in several trigonal and hexagonal lattices. Based on *ab initio* calculations, we predict that the thin film of CaLiX (X=Ge and Si) may host 2D M-RS excitations near the Fermi level.

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