Abstract

We propose to launch a comprehensive program into a new field of interdisciplinary research: Relativistic Quantum Nonlinear Dynamics and Chaos (RQNDC). The traditional field of quantum chaos, the study of quantum manifestations of classical chaos, has focused on nonrelativistic quantum systems. Recent years have witnessed a growth of interest in Dirac materials (e.g., graphene and topological insulators) with applications to nanoscale electronic devices and circuits. A common feature among these materials is that the electronic motions obey relativistic quantum mechanics, leading to physical properties and dynamical behaviors that are not usually seen in conventional semiconductor materials. It is conceivable that future military systems would employ components made of Dirac materials. We aim to uncover, understand, and exploit fundamental phenomena arising from the interplay between nonlinear dynamics and relativistic quantum mechanics. The specific research thrusts include (but are not limited to): mathematical theory of relativistic quantum chaos, relativistic quantum phenomena at large scales, relativistic quantum chaos with many-body interactions, interplay between chaos and spin, and topological light propagation and scattering in relativistic non-Hermitian pseudo PT-symmetric systems. In terms of basic science, the research will generate a new paradigm at the disciplinary boundaries of nonlinear dynamics, relativistic quantum mechanics, and solid-state physics. Practically, the research will result in new methodologies of exploiting relativistic quantum nonlinear dynamics and chaos for next generation's nanoscale electronics, spintronics, and photonics to benefit future military systems. It will also lead to novel approaches to engineering light propagation and revolutionizing optics. PI's group made pioneering contributions to RQNDC and had a track record of strong collaboration with DoD scientists. PI will lead a team of a post-doctoral fellow and four Ph.D. students to diligently continue, strengthen, and extend the collaboration in nonlinear dynamics and on any scientific problems of common interest.