Abstract

Jorge Rocca proposes to pursue basic research to investigate a new regime in which relativistic laser pulses of much shorter duration will penetrate engineered nanostructured materials, creating an environment in which electrons ripped from the nanowires will fill the gaps in the absence of ions and will be accelerated to produce relativistic beams, accelerating ions, and generating short bursts of x-ray and gamma ray radiation. Moreover, the ultrashort pulse duration will make relativistic intensities achievable using laser pulse energies that can be generated at high repetition rate, significantly increasing the possibility of translating fundamental findings into applications. The project will systematically study the most important fundamental aspects of the interaction of these ultrashort laser pulses of relativistic intensity with nanostructured materials by conducting experiments and fully relativistic 3D particle-in-cell simulations. Specifically the project will study: how the energy of intense laser pulses is coupled and transported into nanostructured materials as compared to uniform solids, how can ultra-high energy density plasmas and gigantic electromagnetic fields be most efficiently generated, how are electrons and ions accelerated in the process, and how the laser energy can be converted into directed x-ray and gamma ray radiation.

The fundamental understanding gained can lead to transformative technologies that can impact the ways in which materials can be engineered to control their interaction with ultraintense laser pulses, techniques to efficiently create ultra-high energy density matter, compact high average flux sources of directed high energy particles, and efficient bright sources of x-ray and gamma-rays. This exciting science offers excellent opportunities for training students and young scientists in laser-material interactions, high power ultrashort pulse lasers, bright x-ray generation, and particle acceleration. Moreover, we have the capability to develop in-house the necessary laser drivers and advanced diagnostics tools necessary to conduct the proposed research, creating a rich training environment in frontier research and in the development of a new generation instruments that will contribute to advance the science.