University of Crete
Department of Physics

Physics Colloquium

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Metamaterials, toroidal electrodynamics and space-time non-seperable pulses

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ABSTRACT

Toroidal excitations can exist both in matter, as represented by the toroidal multipoles, as well as in free-space in the form of "Flying Doughnuts". Toroidal multipoles provide significant contributions to the electromagnetic response of matter and together with the conventional electric/magnetic multipoles can lead to non-radiating configurations, termed anapoles. On the other hand, Flying Doughnuts are few-cycle electromagnetic pulses with non-trivial spatiotemporal coupling and toroidal configuration of electromagnetic fields that propagate in free-space at the speed of light. They are exact solutions to Maxwell's equations and exhibit strong longitudinal field components along the propagation direction. The spatial and temporal dependence of the Flying Doughnut pulse cannot be separated from one another, which results in a spatially varying frequency spectrum. This spatiotemporal coupling in combination with the doughnut-like arrangement of electromagnetic fields, leads to a complex topological structurein the form of spectrally broadband vortices. Flying Doughnut pulses can interact with matter in unique ways resulting in non-trivial field transformations upon reflection from perfectly conducting and dielectric interfaces, while their interaction with dielectric particles can lead to the excitation of toroidal resonances and non-radiating configurations.

In this talk, I will review the emerging field of toroidal electrodynamics with a focus on anapoles and doughnut pulses. I will discuss metamaterial-based schemes for the experimental generation of few-cycle optical Flying Doughnuts and its implications for the excitation and detection of toroidal modes and non-radiating configurations in matter.