Dottorato di Ricerca in Fisica dell'Università degli Studi di Messina

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V.le F. Stagno d'Alcontres 37, S. Agata, Messina

Optical Properties of Carbon-based Materials

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Carbon nanotubes (CNTs), and more recently graphene, have been at the center of nanotechology research, with the search for new technologies based on their mechanical and electrical properties ever increasing. Graphene, a two-dimensional honeycomb lattice of carbon atoms, can be thought of as the "building block" of other carbon allotropes: it can be "wrapped" into fullerenes, "rolled" into CNTs or "stacked up" into graphite, with many of their properties deriving from graphene.

In this presentation we discuss different aspects of the photonic response of graphene and CNTs. After a brief introduction to the basic electronic structure and optical properties of graphene, we discuss recent advances in understanding interference-enhanced (IERS) and surface-enhanced Raman scattering (SERS) phenomena in graphene. Especially in terms of SERS, graphene provides the ideal prototype two-dimensional test-material for its investigation. We discuss recent SERS experiments on graphene and develop a quantitative analytical and numerical theory for its description.

Next, we investigate the photonic properties of two-dimensional CNT arrays for photon energies up to 40eV and unveil the physics of two distinct applications: deep-UV photonic crystals and total visible absorbers. We find three main regimes: for small intertube spacing of 20-30nm, we obtain strong Bragg scattering and photonic band gaps in the deep-UV range of 25~35 eV. For intermediate spacing of 40-100nm, the photonic bands anti-cross with the graphite plasmon bands resulting into a complex photonic structure, and a generally reduced Bragg scattering. For large spacing >150nm, the Bragg gap moves into the visible and decreases due to absorption. This leads to nanotube arrays behaving as total optical absorbers. These results can guide the design of CNT-based photonic applications in the visible and deep UV ranges.