Dielectric response of atomically precise nanoribbons: band-gap effect vs low-dimensional confinement

Francesca Mazzei
Antonello Sindona
Dipartimento di Fisica, Università della Calabria, Via P. Bucci 30C I-87036 Rende (CS), Italy
Contact@E-mail (Century Gothic 10)

Nanoribbon based structures are promising prototypes for high-performance, atomically-compact and ultra-low power devices, whose functioning is controlled by charge density waves induced at the interface of the materials with the external dielectric environment. The associated plasmon modes are here scrutinized by looking at the frequency-dependent permittivity of a class of graphene, silicene, and germanene, nanoribbons, being 5 atoms wide, over the whole optical range, from the far-infrared to the near-ultraviolet.
Time-dependent density functional theory is used, with a specifically developed tool on the random phase approximation, which provides the diverse dielectric response of isolated (purely one-dimensional) nanoribbons and correlated (two-dimensional) nanoribbon arrays. Many-electron correlations are taken into account, at the level of the Bethe-Salpeter equation formalism.
The main technological interest is on the bulk plasmon, whose propagation and interplay with the edge plasmons are comprehensively analyzed down to the terahertz domain, which is expected to guide the implementation of novel graphene nanoribbon architectures.

References

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Figures

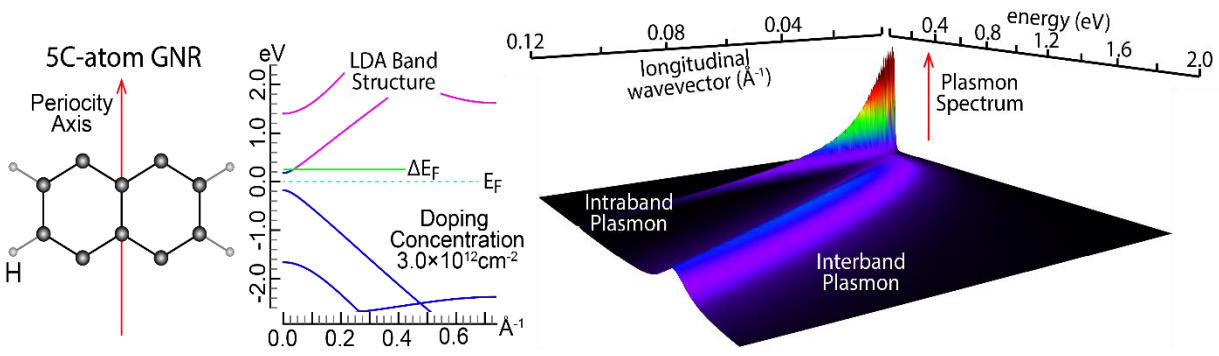

Figure 1: Geometry, Band Structure, and Plasmon Spectrum of a 5-carbon-atom-wide graphene nanoribbon with an induced Fermi energy shift of 0.25 eV (due to doping or gating)