Generalized plasma waves in layered metals and superconductors

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In a layered metal with weakly coupled planes the propagation of electromagnetic waves along the planes or perpendicular to them is characterized by two well separated energy scales, connected to a large in-plane and to a small out-of-plane plasma frequency. Whenever the system becomes superconductor, as it is the case e.g. for layered cuprates, the gap opening makes the out-of-plane mode undamped, and leads to interesting effects connected to Josephson non-linearity of the interlayer superconducting phase dynamics. Despite the wide interest in the detection and manipulation of plasma waves by means of different experimental protocols, ranging from strong-field THz spectroscopy to EELS, a unified description of plasma waves valid at arbitrary energy and momentum, accounting for both linear and non-linear effects, is still lacking. Here I will review our recent progresses in the theoretical description of the nature and the spectroscopic visibility of generalized plasma waves in layered cuprates. First, I will show how a gauge-invariant description in terms of the superconducting phase[1] allows one to identify two intertwined hybrid light-matter modes with mixed longitudinal and transverse character, while a purely longitudinal plasmon is only recovered for wavevectors larger than the crossover scale set in by the plasma-frequencies anisotropy. Second, I will discuss how these excitations emerge in different spectroscopies, with particular focus on recent experiments with strong THz field polarized either perpendicular or parallel to the CuO_2 planes[2] and to EELS spectroscopies measuring the density response at arbitrary energy and momenta in the metallic state. [3].

References

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This work has been supported by EU under program MORE-TEM ERC-SYN (grant agreement No 951215)