

# Spectroscopies of superconducting collective modes: new advances and open questions

Spontaneous symmetry breaking across the superconducting critical temperature is characterized by the emergence of a finite order parameter and by collective electronic excitations connected to its fluctuations. The amplitude fluctuations are usually named Higgs mode for their analogy with the massive boson of the standard model, while phase fluctuations identify the Goldstone massless excitation expected when the broken symmetry is a continuous one. Their description requires to go beyond BCS theory, which nonetheless explains with great accuracy the conventional spectroscopies in standard superconductors, where these excitations are spectroscopically inert. However, in the last few years a consistent experimental evidence has been accumulating that these collective excitations become visible in low-dimensional, disordered systems, and can be detected via both conventional and unconventional (time-resolved) spectroscopies. In this talk I will review our theoretical work on the description of the collective superconducting modes and their interaction with light, and I will provide concrete examples of applications of our ideas to several emerging systems.