MAR15-2014-008805

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

The Higgs Mode in Disordered Superconductors Close to a Quantum Phase Transition[1]

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The Higgs theory, which generates mass for elementary particles, was inspired by screening of magnetic fields in superconductors. The same theory also predicts an amplitude mode whose high-energy-physics analogue is the famous Higgs particle. It is somewhat disappointing that in superconductors, the Higgs-amplitude mode has not yet been observed, partially because it can rapidly decay into unpaired electrons. Nevertheless, recent theories show that if the Higgs mass could be softened below the pairing gap it should be visible in two dimensions. Such conditions can be met by tuning a superconducting film towards a quantum critical point (QCP). I will report on spectroscopic studies in the terahertz frequency regime of thin superconducting films for which the superconductor to insulator transition (SIT) is tuned by disorder. Tunneling spectroscopy determines the pairing gap 2Δ which remains finite on both sides of the SIT. In contrast, the threshold frequency for dynamical conductivity, which in BCS theory is associated with the gap, vanishes critically toward the SIT. The excess optical spectral weight below 2Δ is identified as an unambiguous observation of the Higgs mode in a superconductor.

[1]Supported by GIF grant # I-1250-303.10/2014.