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Higgs Bosons in Superconductors

CHANDRA VARMA, University of California, Riverside

Spurred by some strange experimental observations in some superconductors, the theory of a new collective mode[1] in superconductors and how it can be experimentally found very easily under certain circumstances was provided in 1981. It was called the "Amplitude Mode" to distinguish it from the "Phase Modes" which provide Josephson effects and which in homogeneous superconductors are coupled to charge density fluctuations and are at the energies of the plasmons. More generally,[2] this mode is the amplitude mode of a particle-hole symmetric $U(1)$ field, i.e the model treated by Higgs and others in the1960's whose generalization have played an important role in the standard model of particle physics. Recently the amplitude or Higgs mode for d-wave superconductors have also been discussed,[3] where its various cousins may also be found. I will tell the story of the above and why such modes were missed in the theory of superconductivity for so long and the applications of the ideas to modes for cold bosons and fermions in optical lattices. I will also comment, as a very interested outsider and an enthusiast, on the Higgs in particle physics being discovered at LHC from the point of view of the theory of superconductivity.

[1]P.B. Littlewood and C.M. Varma, Phys. Rev. Lett. **47**, 811 (1981); Phys. Rev. B **26**, 4883 (1982).
[2]C.M. Varma, J. Low Temp. Phys., 126, 901 (2002).
[3]Y. Barlas and C.M. Varma, arXiv:1206.0400.