Theoretical Studies on Superconductivity in Metallic Cluster Systems

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Since the experiments by Ralph et al.[1, 2], superconducting properties of grains have been much attracted great interest from both experimental and theoretical viewpoints. Properties of ultrasmall superconducting grains have been theoretically investigated by many groups. In ultrasmall Al grains, the bulk gap has been discussed in relation to physical properties in ultrasmall grain such as the parity gap, condensation energy, electron correlation etc. with the dependence of level spacing of samples.

Very recently, a semiclassical theory of the BCS theory has been presented[3, 4]. The framework of the BCS theory has been extended by a semiclassical techniques to permit a systematic analytical evaluation of the low energy spectral properties of superconducting nanograins in terms of their size and shape.

In this study, we present a semiclassical approach for two-gap superconductivity of metallic grains. First, in the case of the conventional single band superconductivity, we discuss the level density and the level spacing in a semiclassical approach in relation to the spectral density in the Thomas-Fermi approximation and the trace formula in the semiclassical techniques. The gap equation is derived in the framework of semiclassical theory. The semiclassical approach is extended to two-gap superconductivity of nanoparticles with a sublevel model and their level densities. Gap equations for two-gap superconductivity of metallic grains are also derived by the semiclassical approach. Finally, we discuss the superconductivity in cluster systems by the viewpoint from Fermi energy level, free electrons in the metallic cluster.

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[3] Garc´ıa-Garc´ıa A M, Urbina J D, Yuzbashyan E A, Richter K, Altshuler B 2008 Phys. Rev. Lett. 100 187001.

[4] Olofsson H, Aberg S, Leboeuf P 2008 Phys. Rev. Lett. 100 037005.