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DISTINCTIVE LOW- AND HIGH-TEMPERATURE DEPENDENCES OF THE UPPER CRITICAL MAGNETIC FIELD IN HIGH-TC CUPRATE SUPERCONDUCTORS

Experimental investigations of the temperature-dependent upper critical magnetic field Hc2(T) in various types of high-Tc cuprate superconductors have revealed very anomalous features [1-3]. The different anomalous features in Hc2(T) are: (i) the occurrence of the upward curvature in the temperature dependence of Hc2(T) in a wide temperature range below at the critical temperature Tc, (ii) the occurrence of the negative curvature in Hc2(T) at low temperatures below a certain characteristic temperature, (iii) a crossover between the two mentioned types of Hc2(T) curves and a sharp upturn in Hc2(T) near this characteristic temperature. The origins of anomalous features in Hc2(T) in high-Tc cuprates are poorly understood yet. The different shapes of Hc2(T) curves observed in various high-Tc cuprate superconductors have led to the dubious speculations that the two different Bardeen-Cooper-Schrieffer (BCS)-like order parameters result in the unconventional superconductivity. However, the application of the BCS-like theories of Fermi-liquid superconductivity to the high-Tc cuprate superconductors is problematic [4]. Therefore, other alternative theory of high-Tc superconductivity is necessary to understand all the observed anomalous behaviors of Hc2(T) in various types of high-Tc cuprate superconductors.

In this work, we investigate the distinctive low- and high-temperature dependences of Hc2(T) within the theory of a three-dimensional (3D) Bose-liquid superconductivity in high-Tc cuprates. We argue that the high-Tc cuprates exhibiting a λ-like superconducting transition at the critical temperature Tc are similar to the superfluid 4He. Using a new Bose-liquid approach to these unconventional superconductors, we show that the temperature dependence of the superconducting order parameter in these materials is different from the temperature dependence of the BCS-like order parameter. We find that the temperature dependence of a new superconducting order parameter in high-Tc cuprates is unusual and has a kink-like feature near a certain characteristic temperature below than Tc. By applying the theory of a 3D Bose-liquid superconductivity, we show that the temperature dependence of Hc2(T) in high-Tc cuprates directly reflects the anomalous kink-like temperature dependence of the superconducting order parameter. We found that the distinctive low- and high-temperature dependences of Hc2(T) in these superconductors are well explained by this theory and the kink-like feature in the temperature dependence of the superconducting order parameter somewhat below Tc in turn results in the anomalous kink-like temperature dependence of Hc2(T). Our theoretical results for Hc2(T) are compared with the existing experimental data on Hc2(T) in high-Tc cuprates. We explain all types of anomalous behavior of Hc2(T), such as the upward curvature in Hc2(T) in a wide temperature range below Tc, the negative curvature in Hc2(T) at low temperatures and the crossover between different low- and high-temperature dependences of Hc2(T) observed experimentally in the high-Tc cuprate superconductors.

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Section

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