Comparison of the optically measured vaporization energy by ultrafast laser spectroscopy and condensation energy determined from specific heat measurements in superconducting cuprates

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Condensation energy can be thought as the difference in ground state energy between the normal state and the superconducting state in a superconductor. In a way to understand and prove theory for superconducting transition, an accurate measurement of the condensation energy is needed [1]. The most common method for determination of condensation energy is by measuring the thermodynamical critical field and alternatively, condensation energy can be found by integrating the difference in specific heats in the normal and superconducting states from $T = 0$ to the superconducting transition temperature T_c [2,3]. With the use of femtosecond laser spectroscopy we can measure the absorbed light energy needed to destroy the superconducting condensate. The method relies on accurate measurement of the energy U_v needed to transform the superconducting state into the normal state (i.e. vaporize the condensate). By changing the laser pulse intensity, the superconducting state is destroyed, and the characteristic superconducting signal saturates, which can be determined very accurately. The accuracy of the deposited energy is thus limited only by the geometric factors related to the laser beam profile and optical absorption length λ_{op}. Recently, it was shown that the reflectivity of superconducting $La_{2-x}Sr_xCuO_4$ ($x = 0.1$, $x = 0.15$) changes significantly when ultrashort intense laser pulses cause a transition from the superconducting state to a normal state [4]. The first measurements in $La_{2-x}Sr_xCuO_4$ gave a vaporization energy U_v which was significantly higher than the condensation energy U_c determined from the specific heat measurements. Here we report on systematic measurements of the vaporization energy in a two different cuprates: $YBa_2Cu_3O_{7-\delta}$ and $La_{2-x}Sr_xCuO_4$ ranging from the underdoped to the overdoped region. It was found that the condensate vaporization energy U_v increases as a square power of T_c and it is approximately 16-18 times greater than condensation energy extracted from specific heat measurements, implying a significant heat capacity of the 'bosonic glue' responsible for its formation.

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