Observation of an inelastic scattering mode by scanning tunneling spectroscopy on NdBa_2Cu_3O_x

Pintu Das, Michael R. Koblischka and Uwe Hartmann
Institute of Experimental Physics, University of Saarbruecken, P.O. Box 151150, D-66041 Saarbruecken, Germany.

The Bosonic mode to which electrons couple to form cooper pairs is central to the understanding of superconductivity. In conventional superconductors, the tunneling experiments provided information on phonon contribution, where the inelastic interaction of the tunneling electrons with phonons was clearly observed in the energy derivative of the conductivity data [1]. Stipe *et al.* have used scanning tunneling spectroscopy (STS) to perform inelastic electron tunneling spectroscopy (IETS) successfully to obtain the single molecule vibrational mode on metal surfaces [2]. Recently, Balatsky *et al.* and Zhu *et al.* showed that STS can be used to perform IETS to elucidate the bosonic mode in high-T_c superconductors [3,4]. Here, we report our results of IETS on the *ab* plane (*c*-axis tunneling) of a slightly underdoped as-grown twinned NdBa_2Cu_3O_x single crystal (T_c = 93.5 K) performed with a scanning tunneling microscope at T = 4.2 K. Out of different types of differential conductivity curves obtained, we identify the curves with typical dip and hump structures along with the coherence peaks as the superconducting curves which is shown in the left of Fig.1. In these curves, we also observed a small bias asymmetry of ~ 5 ± 2 meV in the peak positions. The energy derivatives (d^2I/dV^2) of these curves have a peak at (*delta* + *omega*) marked by arrows in the right of Fig. 1. *Delta* is the energy gap measured at the coherence peak positions. *Omega*, which we identify as the inelastic scattering mode energy, was found in our experiment to be 25 ± 2 meV. We discuss the possible origin of the underlying interaction between the tunneling electrons and the inelastic scattering mode.

Fig.1 : Typical differential conductivity curves obtained on the *ab* plane of a NdBCO single crystal at T=4.2 K have been shown. The curves have typical features like peak, dip and hump observed in *d*-wave superconductors.
Fig.2 : The figure in shows the energy derivative of the average of 40 differential conductivity curves having the IETS peaks marked by up and down arrows. The inelastic scattering mode energy is calculated by subtracting the superconducting gap value from the energy state of the peaks

References:

[1] J. M. Rowell, P. W. Anderson and D. E. Thomas, Phys. Rev. Lett. **10**, 334 (1963).
[2] B. C, Stipe, MA. Rezaei, and W. Ho, Science **280**, 1732 (1998).
[3] A. V. Balatsky, Ar. Abanov, and J.-X. Zhu, Phys. Rev. B **68**, 214506 (2003);
[4] J.-X. Zhu, A. V. Balatsky, T. P. Devereux, Q. Si, J. Lee, K. McEloy, and J. C. Davis, Phys. Rev. B **73**, 014511 (2006).