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Positron annihilation measurements across the superconducting transition in $Y_1Ba_2Cu_3O_{7-x}$

C S SUNDAR, A K SOOD, A BHARATHI and Y HARIHARAN
Materials Science Laboratory, Indira Gandhi Centre for Atomic Research, Kalpakkam 603 102, India

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Abstract. Positron lifetime and Doppler broadened annihilation radiation lineshape measurements have been carried out in $Y_1Ba_2Cu_3O_{7-x}$ as a function of temperature in the range of 300 K to 58 K. The positron lifetime and the peak parameter of the annihilation radiation lineshape are observed to decrease on lowering the temperature without showing any discontinuous change across the superconducting transition temperature of 90 K as determined by susceptibility measurements. The variation of positron annihilation parameters with temperature in the superconducting state is significantly larger than that in the normal state. This is qualitatively explained in terms of the dimerization of oxygen ions in the superconducting state of $Y_1Ba_2Cu_3O_{7-x}$.

Keywords. Positron lifetime; Doppler-broadened lineshape; temperature dependence; YBCO; superconductivity.

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The recent discovery of high T_c in the oxide superconductors (Bednorz and Muller 1986; Wu *et al* 1987) has stimulated an enormous research activity to understand the superconductivity in these systems. Several experimental techniques have been used to obtain information on various aspects of the oxide superconductors such as their structure, electronic properties, phonon spectrum etc. Positron annihilation spectroscopy (PAS) is an established method to probe the electronic structure and defect properties of materials (Hautojarvi 1979; Brandt and Dupasquier 1983). The annihilation characteristics of a positron in a medium are determined by the overlap of the positron and electron wavefunctions. For example, the lifetime is determined by the electron density at the site of the positron while the angular correlation of annihilation photons and Doppler broadening of annihilation radiation lineshape (DBARL) are governed by the electron momentum distribution. Because of its sensitivity to electronic structure, PAS is expected to be useful in the study of superconducting transition. However previous positron annihilation experiments on lead and niobium alloys (Green and Madansky 1956; Briscoe *et al* 1966) did not indicate any change in the annihilation characteristics across the superconducting transition. This has been rationalised as arising due to the fact that the formation of Cooper pairs affects a small region near the Fermi surface whereas the annihilation characteristics of the positron are determined by both the valence and the core electrons. An increase in the smearing of the Fermi surface in the superconducting state of Nb_3Sn has been observed in two-photon angular correlation experiments (Faraci and Spaddoni 1969). In the present paper, we report the results of positron lifetime and Doppler-broadened