Real space fluctuations of effective exchange integrals in high T c cuprates

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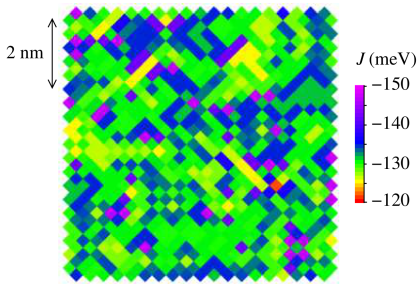
Recently, the question of spatial (in)homogeneities of the superconducting state in cuprates has attracted a lot of attention. The improvement of tunnel- ing microscopy techniques, such as Scanning Tunneling Spectroscopy (STS), allows access to spatial imaging of quantities such as the density of states and the superconducting gap. Using these techniques, nanoscale spatial inhomo- geneities of the gap amplitude in $Bi_2Sr_2CaCu_2O_{8+\delta}$ were observed with strong fluctuations of the superconducting gap or even suppression of the supercon- ductivity within islands of nanometer typical size. The origin of these gap inhomogeneities is quite controversial however crucial, since some models link the high value of Tc to electronic phase separation or disorder. The controversy opposes authors defending the idea that it is an intrinsic feature of the superconducting state, to authors defending the idea of an extrinsic origin, linked to the chemical inhomogeneities. The present work studies the fluctuations of the effective exchange in- tegral J as a function of the chemical and structural disorder in the $(Ca_xLa_{1-x})(Ba_{1.75-x}La_{0.25+x})Cu_3O_y$ (CLBLCO) copper oxides family. Indeed, this family present two determinant characteristics, (i) the effect of hole doping and of chemical disorder is decoupled (ii) structural informations on the local distortions as a function of the chemical disorder are available. We found that (i) the critical temperature in optimally doped compounds is proportional to the average exchange integral (in agreement with Keren et al experimental work) supporting a direct link between superconductivity and magnetism and (ii) in a specific material the counter-ions chemical disorder strongly influences the exchange values. The related spatial inhomogeneities are of nanometer typical size. These spatial inhomogeneities of J could thus explain the observed spatial inhomogeneities of the superconducting gap.



Real-space map of magnetic exchange obtained for a random distribution of the Ba and La ions in the YBCO Ba sites in the $(Ca_{0.4}La_{0.6})(Ba_{1.35}La_{0.65})Cu_3O_{7.174}$ compound.