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Incommensurate charge density fluctuations in underdoped YBCO detected by resonant x-ray scattering

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A key issue in high T_c superconductivity is the short and mid range ordering of spin and charge degrees of freedom when doping disrupts the long range antiferromagnetic order of parent compounds. Cu sites are the main, although not the only, actors in the play. Inelastic and elastic scattering of x rays, when performed at the Cu L_3 absorption resonance, can be used to map the spin and charge excitation spectra and, simultaneously, to unveil the presence of spatial modulations in the charge or spin densities. We have used angle-resolved resonant inelastic soft x-ray scattering (RIXS) and resonant elastic soft x-ray scattering (REXS) to identify two-dimensional charge fluctuations with an incommensurate periodicity of ~ 3.2 lattice units in the copper oxide planes of the superconductors (Y,Nd)$Ba_2Cu_3O_{6+x}$ with hole concentrations $0.09 < p < 0.13$ per planar Cu ion [G. Ghiringhelli et al, Science 337, 821 (2012)]. The intensity and correlation length of the fluctuation signal increase strongly upon cooling down to the superconducting transition temperature, T_c; further cooling below T_c abruptly reverses the divergence of the charge correlations. In combination with prior observations of a large gap in the spin excitation spectrum, these data indicate an incipient charge-density-wave instability that competes with superconductivity. Further measurements on an Ortho III sample have confirmed that the charge fluctuations are independent of the chain ordering [A. J. Achkar et al, Phys. Rev. Lett. 109, 167001 (2012)]. Put into perspective, these results show that often elastic and inelastic x-ray scattering experiments should be ideally performed jointly, to explore with the greatest sensitivity charge and spin fluctuations [L. Braicovich et al, Phys. Rev. Lett. 104, 077002, (2010)].