| ESRF | **Experiment title:** Doping dependence of magnetic excitations in electron-doped high-Tc cuprates studied by resonant inelastic x-ray scattering | **Experiment number**: HE-3750 |
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| **Beamline**: ID08 | **Date of experiment**: from: 25 July 2012 to: 01 August 2012 | **Date of report**: 31 August 2012 |
| **Shifts:** 21 | **Local contact(s)**: Kurt Kummer | *Received at ESRF:* |


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**Report:**

The proposed experiment aimed at studying systematic doping dependence of low-energy electronic excitations in the electron-doped high-Tc cuprates $Nd_{2-x}Ce_xCuO_4$ (NCCO) using resonant inelastic x-ray scattering (RIXS) at the Cu $L_3$-edge. Especially we focused on the magnetic excitations which were observed at a few hundreds meV.

Spin fluctuation is discussed as the most possible candidate to mediate high-Tc superconductivity of the oxides. Recently, significant improvement of the energy resolution enabled us to observe the magnetic excitations with RIXS [1]. In contrast to inelastic neutron scattering, we can measure the excitation spectra of small crystal and systematic study is possible. While the (para)magnon dispersion of hole-doped superconducting cuprates have been reported [2,3], nothing has been published so far on the RIXS of electron-doped cuprates for the study of the magnetic excitations. Since high-Tc superconductivity in cuprates occurs by either hole or electron doping into the antiferromagnetic Mott insulators, it is important to investigate the evolution of magnetic excitation in the parent Mott insulators upon electron doping to produce the superconductivity and clarify the asymmetry of the magnetic excitation between hole and electron doping.

The experiment was performed using the AXES spectrometer at ID08. Total energy resolution was about 250 meV. Single crystals of NCCO were cleaved in the air and installed in the spectrometer. Four concentrations, x = 0 (undoped antiferromagnet), x = 0.075 (underdoped antiferromagnet), x = 0.15 (optimally-doped superconductor), and x = 0.18 (overdoped superconductor) were measured. Excitation energy was selected at the peak of the x-ray absorption spectrum (933.43 eV). Temperature of the samples was kept at 20 K.

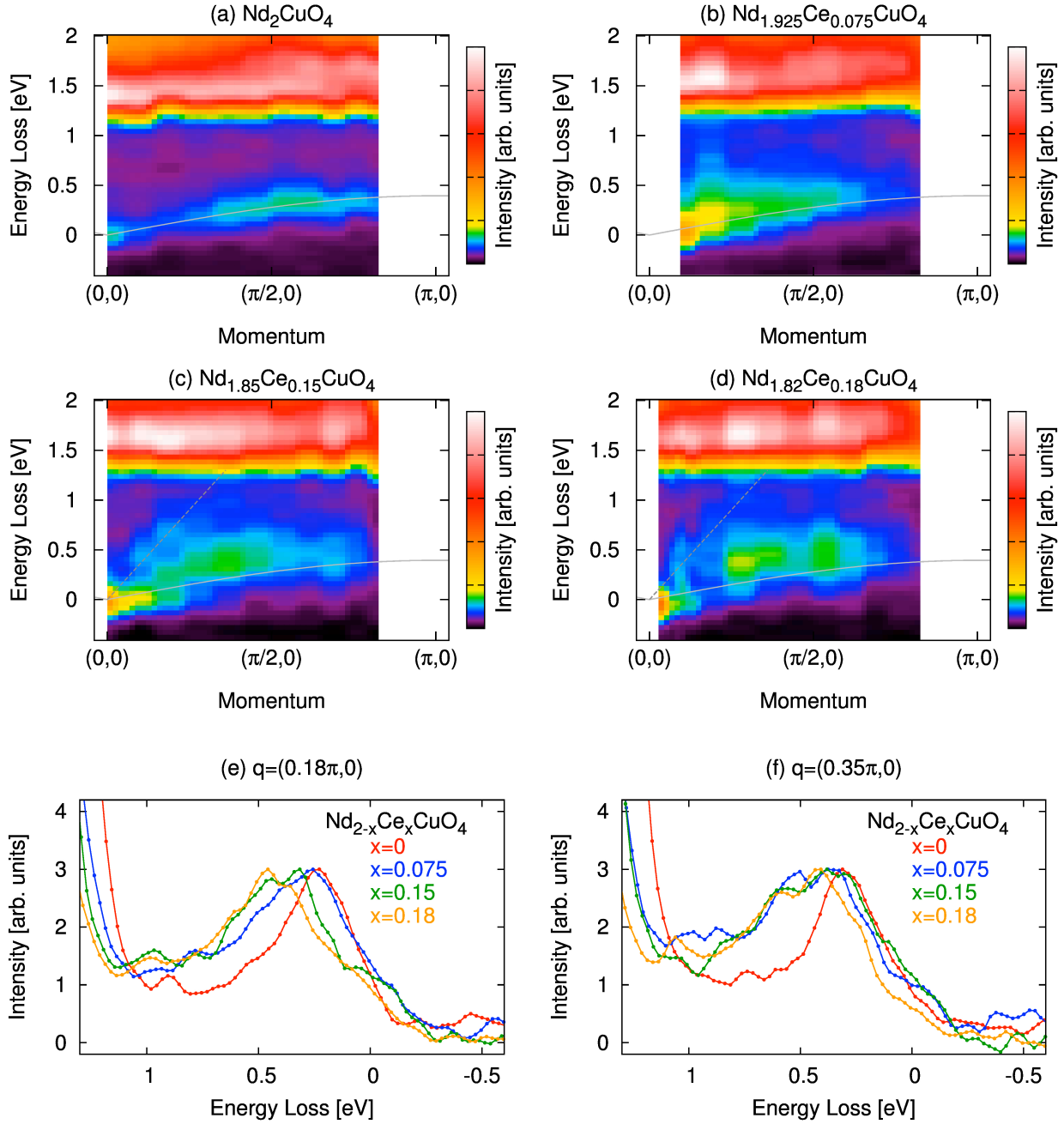


FIG 1: (a)-(d) RIXS intensity map of $Nd_{2-x}Ce_xCuO_4$. The intensity is normalized so that the maximum of the *dd* excitations is unity in each map. Solid and dashed lines are guide to eyes for magnetic and charge excitations, respectively. (e),(f) Raw spectra at two representative momenta nomalized by the maximum of the magnetic peak.

Figures 1(a)-(d) show RIXS intensity map of four samples along the [pi,0] direction. Incident polarization is horizontal and parallel to the scattering plane. Strong intensity above 1 eV in the spectra is attributed to *dd* excitations. Below that, magnetic excitations are observed. In undoped $Nd_2CuO_4$ [Fig. 1(a)], magnetic excitation is sharp and its dispersion follows a sinusoidal shown as the solid line. Upon electron doping, the magnetic excitation becomes broader, but the excitation survives clearly even in the overdoped sample. The persistence of the broad magnetic excitation is proven to be common to hole and electron doped superconductors. By duplicating the dispersion curve of x = 0 on the intensity maps of doped samples in Fig. 1(b)-(d), it is found that the magnetic excitation broadens to higher energy significantly while lower edge of the peak is less changed. Such doping evolution of

the RIXS spectra can be confirmed in raw spectra in Fig. 1(e),(f). In contrast, the broadening by hole-doping occurs symmetrically at both lower- and higher-energy sides [2,3].

In x = 0.15, 0.18, and possibly 0.075, an additional dispersive mode, which is located at higher energy that the magnetic excitation, is identified as indicated by the dashed line in Fig. 1(c),(d). Because this mode is connected smoothly to a dispersive excitation which was observed by the Cu K-edge RIXS [4], the same assignment is likely, that is, an intraband charge excitation of doped electrons in the upper Hubbard band is a possible origin. Alternatively, it may come from an acoustic plasmon which is theoretically proposed the possibility of observation by the Cu K-edge RIXS [5].

In summary, we have succeeded to observe the magnetic excitations in electron-doped NCCO using RIXS at the Cu $L_3$-edge. Quantitative analysis is not complete yet, but even the raw data and intensity maps demonstrate that the damped and dispersive magnetic excitation persists clearly even in the overdoped superconductor.

References:

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