Antiferromagnetic spin fluctuations in the heavily overdoped regime of the Bi-2201 cuprates

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It has formerly been proposed that ferromagnetic order/fluctuations develop and compete with the high-T_c superconductivity in the non-superconducting heavily overdoped (HOD) regime of the hole-doped cuprates [1]. To clarify the magnetic states in the HOD regime, we formerly performed neutron-scattering experiments in 5% Fe-substituted Bi-2201 cuprates at the Oak Ridge National Lab. (ORNL) in USA and JRR-3 in Japan and found incommensurate magnetic peaks at low temperatures, suggesting the formation of an Fe-induced incommensurate antiferromagnetic (AF) order [2]. On the other hand, whether ferromagnetic fluctuations exist was unclear yet. To clarify the details of the magnetic states and their hole-doping dependence, we performed neutron-scattering experiments using 9% Fe-substituted Bi-2201 cuprate $Bi_{1.74}Pb_{0.38}Sr_{1.88}Cu_{1-y}Fe_yO_{6+\delta}$ with $y = 0.09$ in the overdoped and HOD regimes at TOPAN and HER in JRR-3. First, we conducted experiments in June and July using the reduced overdoped samples. After the experiments, we oxidized these samples and performed subsequent experiments in October to thoroughly investigate the changes in incommensurability and peak width with hole doping.

In both the overdoped and HOD samples, incommensurate magnetic peaks resulting from the formation of incommensurate AF order were observed at low temperatures. Figure 1 shows the hole-concentration dependence of the incommensurability δ, along with the data obtained using CTAX at ORNL and the results from previous studies [2,3]. The δ value for the overdoped sample is identical to that of the previous study [3], and δ increases slightly with increasing hole concentration. This behavior is similar to that of La-based cuprates substituted with Nd or Fe, but the values of δ are considerably larger. On the other hand, the peak width showed no significant dependence on the hole concentration. These findings suggest that the incommensurate AF orders observed in the overdoped and HOD regimes highly likely have the same origin. Furthermore, because δ values deviate from the linear relationship between δ and hole concentration in the underdoped and optimally doped regimes, derived from the stripe order, the origin of the incommensurate AF order in overdoped and HOD Bi-2201 is most likely a spin density wave induced by Fermi surface nesting, as has been proposed for the overdoped regime of Fe-substituted La-based cuprates.

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[2] Y. Komiyama *et al.*, J. Phys. Soc. Jpn. **95**, 073701 (2026).
[3] H. Hiraka *et al.*, Phys. Rev. B **81**, 144501 (2010).

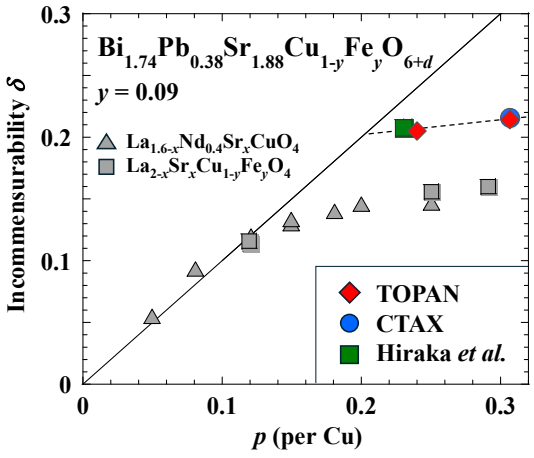

Fig. 1. Hole-concentration dependence of the incommensurability of $Bi_{1.74}Pb_{0.38}Sr_{1.88}Cu_{1-y}Fe_yO_{6+d}$ with $y = 0.09$, together with the preceding results [2,3].