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New Insight into an Under-doped Regime of High Tc Superconductivity - NMR Studies of Multi-layered Cuprates[1]

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High-temperature superconductivity (HTSC) has not been fully understood yet despite 20 year's intensive research. In particular, a possible interplay between antiferromagnetism (AFM) and HTSC remains as a most interesting problem. It is believed that they all fit into a universal phase diagram which suggests a competition between AFM and HTSC. Recently, however, through the systematic Cu-NMR studies on the Hg-, Tl- and Cu-based five-layered HTSC, we propose a novel phase diagram [1-3], which differs from the generic phase diagram of the HTSC reported so far, for instance, such as LSCO. The multi-layered HTSC compounds include two types of CuO_2 planes, an outer CuO_2 plane (OP) in a pyramidal coordination and an inner CuO_2 plane (IP) in a square one with no apical oxygen. Remarkable feature of the multi-layered HTSC is the presence of ideally flat CuO_2 planes that are homogeneously doped, which is ensured by the narrowest NMR spectral width among the various HTSC compounds with very high quality to date. It should be noted that the nearly non-doped AFM in the IP and the IP* takes place, whereas inhomogeneous magnetic phases such as spin-glass phase or stripe phase are not observed at both the IP's and the OP's. Instead, the existence of the doped AFM metallic (AFMM) phase at the IP and the IP* is remarkable at the boundary between AFM insulating (AFMI) phase and SC. This differs from the case of LSCO where the disorder-driven magnetic phases exist between the AFMI phase in $N_h < 0.02$ and the SC phase in $N_h > 0.05$. In an underlying phase diagram, the AFMM is extended to a higher hole density due to the flatness of CuO_2 plane with no apical oxygen and the homogeneous distribution of carrier density. By contrast, the prototype phase diagrams reported thus far are under the inevitable disorder effect associated with the chemical substitution introduced into the CuO_2 out-of-planes as corroborated by the observation of a disorder-driven transition from AFMM phase to AFMI phase found in theCu-based multi-layered system [3]. Through the discovery of the uniform mixing of AFM and HTSC in a single CuO_2layer (OP) at Hg-1245(UD) with M_{AFM}=0.1μ_B and T_c=72 K., we will shed new light on the generic phase diagram of HTSC in the under-doped regimes. Namely, both phases may be mediated by the same magnetic interaction. It is this global phase diagram presented here to make one convince the presence of *the AFM+SC uniformly coexisting phase*. From the results presented in this talk, we may raise a question; *Do we need a bosonic glue to pair electrons in the uniformly coexisting state of AFM and SC ?* References: [1]. H. Mukuda et al.Phys. Rev. Lett. **96**, 087001 (2006); [2] N. Shimizu et al., submitted to PRL (2006). [3] H. Mukuda et al.,J. Phys. Soc. Jpn. **75**, No.12 (2006).

[1]These works have been done in collaboration with H. Mukuda, M.Abe, S Shmizu.