Superfluid density vs. layer spacing in high-T_c cuprates

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Separating the two-dimensional and three-dimensional physics of high-T_c superconductors is complicated by the narrow range of layer spacings, 6 ± 1 Å, available in most cuprate compounds [1]. We have overcome this using chemical intercalation – placing carbon chain compounds between the superconducting blocks – increasing the spacing $\bar{c}$ between the CuO_2 layers by a factor of up to three [2]. Using μSR, we have studied intercalated Bi2212 and Bi2201 systems where the average spacing between layers increases from 7.72 to 23 Å (see Fig. 1).

The superfluid density of these samples is found to be proportional to $1/\bar{c}$, but T_c remains approximately constant. This strongly suggests that the superfluid density in the Uemura scaling relation $n_s/m^* \propto T_c$ [1] should be interpreted as the two dimensional density in the superconducting layers [3], which is constant for each system investigated. In the samples with the largest layer spacings, thermal fluctuations break up the vortex lattice for $T \ll T_c$, consistent with a solely electromagnetically coupled vortex lattice.

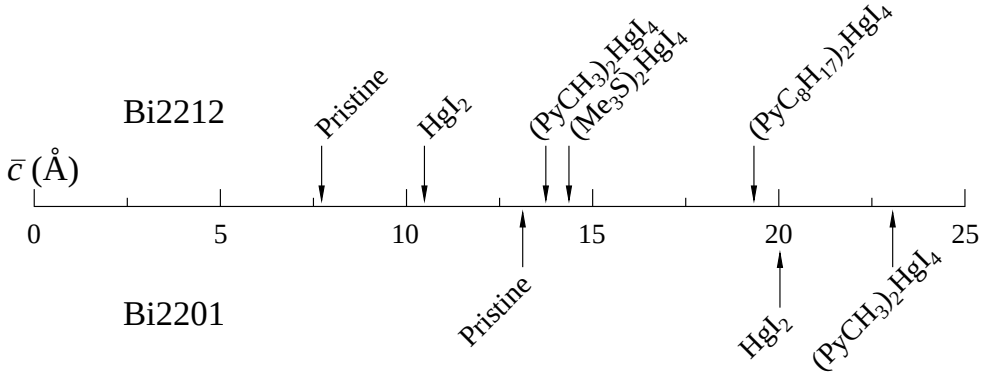

Fig. 1: The average CuO_2 layer spacings, $\bar{c}$, of the samples investigated.

[1] Y. J. Uemura *et al.*, Phys. Rev. Lett. 62 (1989) 2317.
[2] J. H. Choy *et al.*, Science 280 (1998) 1589.
[3] Y. J. Uemura *et al.*, Phys. Rev. Lett. 66 (1991) 2665.