Colloquium

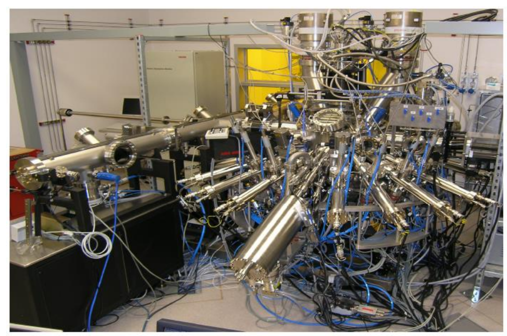
Department of Physics, Temple University

Why is Tc in cuprates so high?

Ivan Božović

Brookhaven National Laboratory and Applied Physics Department, Yale University

Abstract



Superconductivity in cuprates has many mysterious facets, but the most important question is why the critical temperature (T_c) is so high. Our experiments target this question. We use atomic-layer-by-layer molecular beam epitaxy to synthesize atomically perfect thin films and multilayers of cuprates and other complex oxides. By atomic-layer engineering, we optimize the samples for a particular experiment. Using a continuous spread in composition we tune the doping level in steps of 0.01%. We have used high-throughput magneto-transport measurements on combinatorial libraries to measure accurately the coherence length ξ. We measure the absolute value of penetration depth λ to accuracy better than 1%.

We have shown that HTS films can be quite homogeneous, having a very uniform SC gap. Superfluid can be confined to a single CuO2 layer, with T_c equal to that in bulk samples. Phase fluctuations are seen up to 15-20 K above T_c. Pairs exist on both sides of the superconducting transition, be it induced thermally or by doping. I will present the results of a comprehensive study that took ten years and thousands of cuprate samples, perhaps without precedence in Condensed Matter Physics. The large statistics is essential when dealing with complex materials such as cuprates. We have measured the key physical parameters (T_c, λ, and ξ) of the superconducting state and established their precise dependence on doping, temperature, and external fields. The findings bring in some great surprises, challenge the commonly held beliefs, rule out many models, and answer our initial question.

References: Nature 536, 309 (2016), 472, 458 (2011); 455, 782 (2008); 422, 873 (2003); Science 326, 699 (2009); 316, 425 (2007); 297, 581 (2002); Nature Materials 12, 877 (2013); 12, 387 (2013); 12, 1019 (2013); 12, 47 (2013); 11, 850 (2012); Nature Physics 10, 256 (2014); 7, 298 (2011); Nature Nanotechnology 9, 443 (2014); 5, 516 (2010); Nature Communications 2, 272 (2011); Phys. Rev. Letters 106, 237003 (2011); 102, 107004 (2009); 101, 247004 (2008); 93, 157002 (2004); 89, 107001 (2002); Proc. Nat. Acad. Sci. 113 (2016), 107, 8103 (2010).

Monday, October 24, 2016 at 3:00pm
SERC, Room 116
Refreshments served at 2:45pm