The Nonlinear Meissner Effect in Superconductors

Steven M. Anlage, University of Maryland, DMR-0201261

Superconductors are intrinsically nonlinear, meaning that there properties depend on how much current or magnetic field is applied to them. These nonlinearities have practical implications for devices, but are also of intense fundamental interest because they reveal the basic physics of the superconducting state. We have found that the nonlinearities are strongly doping dependent in the high-temperature superconductors, and there is evidence of a broken-time-reversal state below the transition temperature. This suggests that new physics may be at play in the high-T_c superconductors.

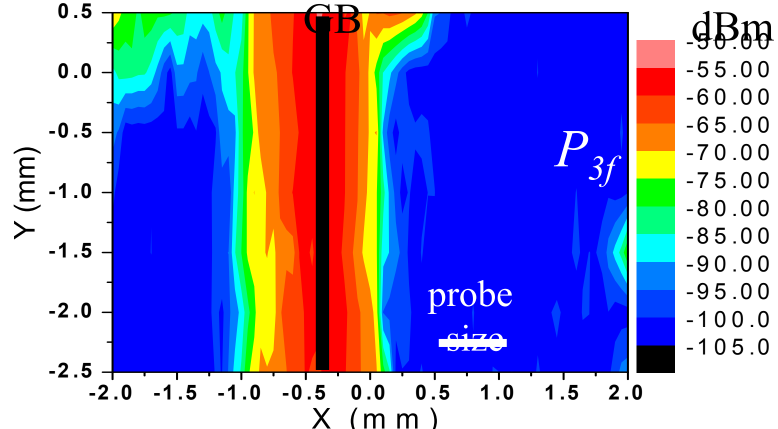
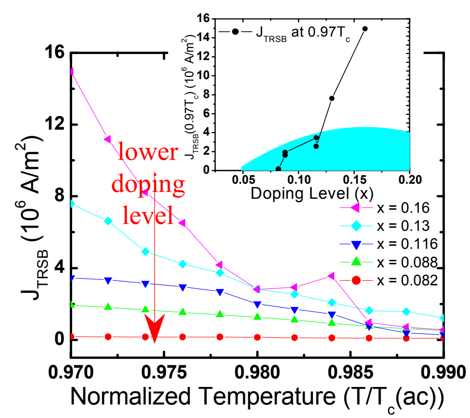


Image of microwave nonlinear third harmonic response (P_{3f}) in the vicinity of a bi-crystal grain boundary (GB) in a high-T_c film measured at 6.5 GHz and 60 K. The GB is a source of intense nonlinear response.



Broken-time-reversal characteristic current density versus T/T_c for high-T_c films with variable doping levels.

Appl. Phys. Lett. **82**, 1893 (2003); Physical Review B, in press (2004); cond-mat/0405595.

Superconductors are intrinsically nonlinear, meaning that there properties depend on how much current or magnetic field is applied to them. These nonlinearities have practical implications for devices because they can distort electromagnetic signals that are sent through them. The nonlinearities are also of intense fundamental interest because they reveal the basic physics of the superconducting state. We have found that the nonlinearities are strongly doping dependent in the high-temperature superconductors. As the materials are more under-doped, the nonlinearities become intrinsically stronger. We have also found evidence of a broken-time-reversal state below the transition temperature. It appears that a spontaneous current flows on the surface, or in the bulk, of the superconductor below its transition temperature. This suggests that new physics may be at play in the high-Tc superconductors.

Appl. Phys. Lett. **82**, 1893 (2003); Physical Review B, in press (2004); cond-mat/0405595.

The Nonlinear Meissner Effect in Superconductors

Steven M. Anlage, University of Maryland, DMR-0201261

Education:

Two undergraduates (Gregory Ruchti and Akshat Prasad) and three graduate students (Sheng-Chiang Lee, Young-noh Yoon, and Dragos Mircea) contributed to this work. Gregory won a prize at graduation for his senior thesis, and is a graduate student in physics at Hopkins. Akshat is a junior physics major at UMD. Sheng-Chiang Lee received his Ph.D. in 2004 and is presently a postdoc with Steven Hill at the University of Florida. Young-noh and Dragos are still members of the PI's group and are performing related experiments.

Industrial Impact:

Our results are of direct relevance to industry. We have had extensive Industrial Liaisons with Steve Remillard (Illinois Superconductor and Agile Devices), Andrew Schwartz (Neocera) and with Superconductor Technology Inc.

Societal Impact:

Our results shed light on the fundamental and applied aspects of superconductivity. Improved superconducting microwave devices will result from this research.