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High Resolution Polar Kerr Effect Measurements of Sr_2RuO_4: Evidence for Broken Time Reversal Symmetry in the Superconducting State[1]

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Strontium ruthenate (Sr_2RuO_4) is an odd-parity superconductor, which has odd orbital angular momentum and symmetric spin-triplet (p-wave) pairing. Some of the possible p- wave states can further break time-reversal symmetry (TRS), since the condensate has an overall magnetic moment because of either the spin or orbital (or both) parts of the pair wave function. However, this TRS-breaking moment will be screened by the Meissner effect. Previously, tests for broken time-reversal symmetry in Sr_2RuO_4 relied on surfaces and defects where the Meissner screening is not perfect. However, for an unambigous determination of this effect, a bulk measurement, such as measuring magneto-optic like effects, on high quality crystals, is needed. To this end we developed a new technique of measuring Polar Kerr Effect (PKE) at temperatures much below the transition temperature of Sr_2RuO_4 of 1.5 K. The technique is based on a fiber Sagnac interferometer with a zero-area Sagnac loop. This new technique allowed us to measure PKE with an accuracy of 10 nano-radian at 400 mK, while rejecting other artifacts like linear birefringence of the sample. The incident optical power was set to be below 2 micro-Watts in order not to heat up the sample locally at such low temperatures. We have observed non-zero Kerr rotations as big as 65 nanorad appearing below T_c in domains comparable in size with the 25-micron-diameter optical beam. Our results imply a broken time reversal symmetry state in the superconducting state of Sr_2RuO_4, similar to ^{3}He-A. More recent results on other oxide superconductors will also be described. This work was supported by Center for Probing the Nanoscale, NSF NSEC Grant 0425897 and by the Department of Energy grant DEFG03-01ER45925.

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