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Momentum dependence of the half-flux quantum effect in YBCO-Nb rings JOHN KIRTLEY, CHANG TSUEI, IBM Research, Watson Research Center, A. ARIANDO, HANS HILGENKAMP, University of Twente, the Netherlands — We have studied the half-flux quantum effect[1] in $YBa_2Cu_3O_{7-\delta}$(YBCO)-Nb rings with ramp-type junctions,[2] in a test for a time reversal symmetry breaking order parameter.[3] The angle of one junction normal relative to the YBCO a-axis was held fixed, while the other was varied in 5 degree intervals from ring to ring. The epitaxial YBCO thin film rings, with inside and outside diameters of 30μm and 130μm, were cooled in various fields and imaged at 4.2K with a SQUID microscope. The spontaneously generated flux Φ in the rings, when cooled in zero field, alternated systematically with the second junction angle from nearly zero flux ($N = 0$) to nearly $\Phi = \Phi_0/2 = h/4e$ ($N = 1/2$) in a manner consistent with a predominantly $d_{x^2-y^2}$ Cooper pairing symmetry. The transition between the $N = 0$ and $N = 1/2$ states occured at angles slightly different from multiples of 45^o, consistent with a small $a - b$ plane anisotropy in the gap. Deviations from $\Phi_0/2$ flux were small, indicating little, if any, imaginary component to the order parameter, independent of Cooper pair momentum.

[1]C.C. Tsuei *et al.* Phys. Rev. Lett. **73** 593(1994)
[2]H.J.H. Smilde *et al.* Appl. Phys. Lett. **80**, 4579(2002)
[3]T.K. Ng and C. Varma, cond-mat/0403379

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