Abstract Submitted
for the MAR14 Meeting of
The American Physical Society

Probing superfluid rigidity in ultrathin 2D superconductor at microscopic, mesoscopic, and macroscopic length scales H.D. NAM, J.S. KIM, C.D. ZHANG, Department of Physics, University of Texas at Austin, Austin, Texas 78712, USA, J. YONG, T.R. LEMBERGER, Department of Physics, The Ohio State University, Columbus, Ohio 43210, USA, P.A. KRATZ, J.R. KIRTLEY, K.A. MOLER, Departments of Physics and Applied Physics, Stanford University, Stanford, California 94305, USA, C.K. SHIH, Department of Physics, University of Texas at Austin, Austin, Texas 78712, USA — Within the conventional picture, two-dimensional (2D) superconductivity is fragile because phase fluctuations disrupt the long-range order of Cooper pairs. Investigations on epitaxially grown conventional superconductors in the ultra-thin regime, however, revealed rather surprisingly robust superconductivity. Since the robust T_C at this extreme limit was observed primarily using scanning tunneling spectroscopy (STS), it has been suggested that while Cooper pairing remains robust, phase fluctuations can still destroy long range coherence, leading to a much more fragile superconductivity. This work is aimed at addressing this issue by probing superfluid rigidity in ultra-thin Pb films at microscopic, mesoscopic, and macroscopic length scales, using STS, scanning SQUID (SSM), and double coil mutual inductance method, respectively. All three methods yield very similar Tc, attesting the robustness of the supercurrent at macroscopic scale. We further discuss the underlying mechanism for the strong phase rigidity for ultra-thin Pb films at microscopic and macroscopic length scales.

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Date submitted: 15 Nov 2013 Electronic form version 1.4