Fluctuating high temperature superconductivity in monolayer FeSe / $SrTiO_3$

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The nature and origin of the enhanced superconductivity in monolayer FeSe / $SrTiO_3$ has been attracted tremendous interest due to its unique character as an interfacially enhanced high-T_c superconductor. FeSe / $SrTiO_3$ exhibits a spectroscopic gap opening temperature (T_{gap}) between 60 to 70 K, nearly one order of magnitude higher than that of bulk FeSe (T_c = 8K), and in excess of related electron-doped FeSe-based bulk compounds. This dramatic enhancement remains the largest amongst known superconductors, positioning monolayer FeSe / $SrTiO_3$ as an ideal platform for investigating fundamental questions about interfacial superconductivity. In particular, the combination of its high-T_c and inherently two-dimensional (2D) nature makes FeSe / $SrTiO_3$ suited for exploring the interplay between 2D phase fluctuations and the interfacial enhancement of superconductivity, a better understanding of which could enable the future design and engineering of artificial higher-T_c superconductors. In this work, we employ a combination of *in situ* electrical resistivity and angle-resolved photoemission spectroscopy (ARPES) measurements of monolayer FeSe / $SrTiO_3$ to reveal an unprecedentedly large pseudogap regime between the initial formation of incoherent Cooper pairs (T_{gap} ~ 70K) and the onset of a zero resistance state (T_0 ~ 30 K). Through measurements of the V(I) characteristics, we identify this large pseudogap regime as originating from two-dimensional superconducting fluctuations, establishing the critical role that reduced dimensionality plays in the superconductivity of monolayer FeSe / $SrTiO_3$.

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