Finite momentum pairing in an MoS_2 bilayer

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Abstract

2D materials with strong spin orbit interactions are an intriguing platform for the study of exotic superconductivity. This is particularly true, if the symmetry properties of the 2D material vary with the layer number. A transition metal dichalchogenide such as MoS2 serves as an excellent example. The behavior at high doping levels has been studied for the hexagonal phase in the monolayer regime. The monolayer possess in-plane mirror symmetry, but lacks inversion symmetry. As a result, a large non-zero in-plane crystal field exists that produces a strong out of plane spin orbit effective magnetic field. It splits the spin states due to spin orbit interaction in opposite directions for the two different valleys. As a result, spin singlet pairs with zero momentum of opposite spin from both valleys can form. This gives rise to Ising superconductivity with an exceptional resilience against pair breaking from an in-plane magnetic field [1,2], since the effective spin orbit field, as large as 100 T, needs to be overcome first. In a bilayer, each layer is non-centrosymmetric and possesses an in-plane crystal field in opposite directions, but globally inversion symmetry is restored. The spin, valley and layer degrees of freedom are all coupled. The layer degree of freedom enlarges significantly the number of possible superconducting channels and an unusual hitherto unobserved variant of finite momentum pairing may manifest according to theory [3]. A fascinating aspect of this non-uniform superconducting ground state is that the Fermi surface can be fully gapped and can entirely participate in pairing. This is in contrast to previous instances of finite momentum pairing where just segments of the Fermi surface as can contribute. Access to this superconducting state requires that both layers are doped in a balanced/symmetric fashion, while simultaneously retaining high sample quality to ensure that interlayer coherence is maintained down to the lowest temperature. The very potent electrolyte gating technique typically used to achieve the required doping levels is not capable of accomplishing this as only the layer closest to the electrolyte accumulates charges and a strong perpendicular electric field modifies the symmetry and generates an undesirable in-plane Rashba field. In addition, the strain fluctuations caused by an electrolyte drop on the active device area is detrimental for the material quality. Here we have overcome these shortcoming of electrolyte gating by using "remote" intercalation. Our observations are consistent with this new and unusual instance of finite momentum pairing in which the full Fermi surface can participate at small interlayer coupling.

References

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