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Emergence of excitonic superfluid at topological-insulator surfaces

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Excitons are spin integer particles that are predicted to condense into a coherent quantum state at sufficiently low temperature, and exciton condensates can be realized at much higher temperature than condensates of atoms because of strong Coulomb binding and small mass. Signatures of exciton condensation have been reported in double quantum wells, microcavities, graphene, and transition metal dichalcogenides. Nonetheless, transport of exciton condensates is not yet understood and it is unclear whether an exciton condensate is a superfluid or an insulating electronic crystal. Topological insulators (TIs) with massless particles and unique spin textures have been theoretically predicted as a promising platform for achieving exciton condensation. Here we report experimental evidence of excitonic superfluid phase on the surface of three-dimensional (3D) TIs. We unambiguously confirmed that electrons and holes are paired into charge neutral bound states by the electric field independent photocurrent distributions. And we observed a millimetre-long transport distance of these excitons up to 40 K, which strongly suggests dissipationless propagation. The robust macroscopic quantum states achieved with simple device architecture and broadband photoexcitation at relatively high temperature are expected to find novel applications in quantum computations and spintronics.

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