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Particle-vortex duality of 2d Dirac fermion from electric-magnetic duality of 3d topological insulators MAX METLITSKI, Perimeter Institute for Theoretical Physics, ASHVIN VISHWANATH, University of California, Berkeley — Particle-vortex duality is a powerful theoretical tool that has been used to study systems of bosons. In arXiv:1505.05142, we propose an analogous duality for Dirac fermions in 2+1 dimensions. The physics of a single Dirac cone is proposed to be described by a dual theory, QED3 with a dual Dirac fermion coupled to a u(1) gauge field. This duality is established by considering two alternate descriptions of the 3d topological insulator (TI) surface. The first description is the usual Dirac cone surface state. The second description is accessed via an electric-magnetic duality of the bulk TI coupled to a gauge field, which maps it to a gauged topological superconductor. This alternate description ultimately leads to a new surface theory - dual QED3. The dual theory provides an explicit derivation of the T-Pfaffian state, a proposed surface topological order of the TI, which is simply the paired superfluid state of the dual fermions. The roles of time reversal and particle-hole symmetry are exchanged by the duality, which connects some of our results to a recent conjecture by Son on particle-hole symmetric quantum Hall states at $\nu = 1/2$.

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