Z$_2$ and Chiral Anomalies in Topological Dirac Semimetals

We demonstrate that topological Dirac semimetals, which possess two Dirac nodes, separated in momentum space along a rotation axis and protected by rotational symmetry, exhibit an additional quantum anomaly, distinct from the chiral anomaly. This anomaly, which we call the Z$_2$ anomaly, is a consequence of the fact that the Dirac nodes in topological Dirac semimetals carry a Z$_2$ topological charge. The Z$_2$ anomaly refers to nonconservation of this charge in the presence of external fields due to quantum effects and has observable consequences due to its interplay with the chiral anomaly.
We discuss possible implications of this for the interpretation of magnetotransport experiments on topological Dirac semimetals. We also provide a possible explanation for the magnetic field dependent angular narrowing of the negative longitudinal magnetoresistance, observed in a recent experiment on Na$_3$Bi