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Chiral Magnetic Effect in Condensed Matters

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The chiral magnetic effect is the generation of electrical current induced by chirality imbalance in the presence of magnetic field. It is a macroscopic manifestation of the quantum chiral anomaly in systems possessing charged chiral fermions. In quark-gluon plasma containing nearly massless quarks, the chirality imbalance is sourced by the topological transitions. In condensed matter systems, the chiral quasiparticles emerge in the 3D Dirac and Weyl semimetals having a linear dispersion relation. Recently, the chiral magnetic effect was discovered in a 3D Dirac semimetal - zirconium pentatelluride, $ZrTe_5$, in which a large negative magnetoresistance is observed when magnetic field is parallel with the current [Li et al - arXiv:1412.6543, Nature Physics - doi:10.1038/nphys3648)]. It is now reported in more than a dozen Dirac and Weyl semimetals. Broadly speaking, the chiral magnetic effect can exist in a variety of condensed matters. In some cases, a material may be transformed into a Weyl semimetal by magnetic field, exhibiting the chiral magnetic effect. In other cases, the chiral magnetic current may be generated in magnetic Dirac semimetals without external magnetic field, or in asymmetric Weyl semimetals without electric field where only a magnetic field and the source of chiral quasipartiles would be necessary. In the limit of conserved quasiparticle chirality, charge transport by the chiral magnetic current is non-dissipative. The powerful notion of chirality, originally discovered in high-energy and nuclear physics, holds promise in new ways of transmitting and processing information and energy. At the same time, chiral materials have opened a fascinating possibility to study the quantum dynamics of relativistic field theory in condensed matter experiments.