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Spontaneous chiral symmetry breaking and chiral magnetic effect in Weyl semimetals

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We study interacting Dirac fermions with chiral imbalance (modelled by a chiral chemical potential) in the mean-field approximation and find that the chiral imbalance is strongly enhanced due to spontaneous chiral symmetry breaking. We then consider the Chiral Magnetic Effect (CME) in the linear response approximation and find that in a phase with broken chiral symmetry the CME current is saturated by vector mesons with different polarizations, which are mixed in chirally imbalanced matter. It turns out that strong screening of CME current in this phase is exactly compensated by enhancement of chiral imbalance, so that the chiral magnetic conductivity remains finite in the strong-coupling limit. We illustrate these conclusions for a Weyl semimetal which is modelled by a single flavour of Wilson-Dirac fermions with chiral chemical potential. We also argue that this model is free of the sign problem by virtue of time-reversal symmetry and can be efficiently simulated using the Rational Hybrid Monte-Carlo algorithm.

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