PHYSICS
COLORADO STATE UNIVERSITY

CSU Condensed Matter Physics Seminar

"Odd and Even Linear Magnetoresistances at Low Field"

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Abstract

Onsager's relationship governs the galvanomagnetic behavior as $\sigma_{ij}(H) = \sigma_{ji}(-H)$, which in the low field limit, typically leads to quadratic field dependence. Here I discuss two scenarios where linear magnetoresistance (MR) of either odd or even parity, becomes dominant in the low field limit. In ferromagnets [1], the Onsager relationship is modified as $\sigma_{ij}(H, M) = \sigma_{ji}(-H, -M)$. Thus in the presence of a magnetization M that is independent to the external field H, Onsager's relation does not hold for a system under reversing field, but instead for two systems of opposite initial magnetization condition. Nevertheless, there exist at least two different microscopic mechanisms to induce odd-parity MR behavior as either a Zeeman energy split Fermi surface or anomalous electron velocity that also serves as the origin of Anomalous Hall Effect. Experimental proof and separation of these two mechanisms necessarily goes beyond the transverse MR channel and involves both longitudinal MR and planar Hall effect. For even-parity linear MR rho(H)~abs(H) [2], Onsager's relationship is only mathematically violated at H=0, where the magnetoresistance becomes non-analytical. Nevertheless, in several spin- and charge-density wave materials at the zero temperature limit, linear MR behavior could be experimentally traced down to delta_ rho/rho ~ $1x10^{-3}$ under a field of tens of Oersted. Here the magnetoresistance is no longer due to incoherent disorder scattering, but instead is generated by coherent movement of carriers around extremely sharp corners at the Fermi surface, which are the direct consequence of Fermi surface gapping by the density wave order. This coherent mechanism of large positive MR satisfactorily explains a zero-temperature magnetoresistance anomaly that is widely observed in many density wave materials and semimetals such as Bi, graphite, and WTe_2.

[1] Yishu Wang, Patrick A. Lee, D. M. Silevitch, F. Gomez, S.E. Cooper, Y. Ren, J.-Q. Yan, D. Mandrus, T. F. Rosenbaum, Yejun Feng, arxiv:1904.00330.

2] Yejun Feng, Yishu Wang, D.M. Silevitch, J.-Q. Yan, Riki Kobayashi, Masato Hedo, Takao Nakama, Yoshichika Ōnuki, A. V. Suslov, B. Mihaila, P. B. Littlewood, T. F. Rosenbaum, arXiv:1811.02758. Published at Proc. Natl. Acad. Sci. USA (2019).

Biography

Yejun Feng got his Bachelor's degree in Physics at Fudan University, China. He then came to the US and got a Master of Science degree at the City College of New York, and a PhD degree in Physics from the University of Washington in Seattle. After a postdoc stay at the University of Chicago, he was a Physicist at the Argonne National Laboratory for over 9 years. He became an Associate Professor at the Okinawa Institute of Science and Technology in Japan in 2017.