Journal Club on 2nd June 2015 (Kouki Nakata)

``Thermal vector potential theory of transport induced by temperature gradient"

Gen Tatara

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A microscopic formalism to calculate thermal transport coefficients is presented based on a thermal vector potential, whose time-derivative is related to a thermal force. The formalism is free from unphysical divergences reported to arise when Luttinger's formalism is applied naively, because the equilibrium ('diamagnetic') currents are treated consistently. The mathematical structure for thermal transport coefficients are shown to be identical with the electric ones if the electric charge is replaced by energy. The results indicate that the thermal vector potential couples to energy current via the minimal coupling.

``Comparison of the magneto-Peltier and magneto-Seebeck effects in magnetic tunnel junctions"

J. Shan, F. K. Dejene, J. C. Leutenantsmeyer, J. Flipse, M. Münzenberg, B. J. van Wees

arXiv:1505.07718

Understanding heat generation and transport processes in a magnetic tunnel junction (MTJ) is a significant step towards improving its application in current memory devices. Recent work has experimentally demonstrated the magneto-Seebeck effect in MTJs, where the Seebeck coefficient of the junction varies as the magnetic configuration changes from a parallel (P) to an anti-parallel (AP) configuration. Here we report the study on its as-yet-unexplored reciprocal effect, the magneto-Peltier effect, where the heat flow carried by the tunneling electrons is altered by changing the magnetic configuration of the MTJ. The magneto-Peltier signal that reflects the change in the temperature difference across the junction between the P and AP configurations scales linearly with the applied current in the small bias but is greatly enhanced in the large bias regime, due to higher-order Joule heating mechanisms. By carefully extracting the linear response which reflects the magneto-Peltier effect, and comparing it with the magneto-Seebeck measurements performed on the same device, we observe results consistent with Onsager reciprocity. We estimate a magneto-Peltier coefficient of 13.4 mV in the linear regime using a three-dimensional thermoelectric model. Our result opens up the possibility of programmable thermoelectric devices based on the Peltier effect in MTJs.

``Long distance transport of magnon spin information in a magnetic insulator at room temperature”

L.J. Cornelissen, J. Liu, R.A. Duine, J. Ben Youssef, B.J. Van Wees

arXiv:1505.06325

The transport of spin information has been studied in various materials, such as metals, semiconductors and graphene. In these materials, spin is transported by diffusion of conduction electrons. Here we study the diffusion and relaxation of spin in a magnetic insulator, where the large bandgap prohibits the motion of electrons. Spin can still be transported, however, through the diffusion of non-equilibrium magnons, the quanta of spin wave excitations in magnetically ordered materials. Here we show experimentally that these magnons can be excited and detected fully electrically in linear response, and can transport spin angular momentum through the magnetic insulator yttrium iron garnet (YIG) over distances as large as 40 micrometer. We identify two transport regimes: the diffusion limited regime for distances shorter than the magnon relaxation length, and the relaxation limited regime for larger distances. With a model similar to the diffusion-relaxation model for electron spin transport in (semi)conducting materials, we extract the magnon relaxation length lambda = 9.4 micrometer in a 200 nm thin YIG film at room temperature.

``Anderson localization and the topology of classifying spaces”

Takahiro Morimoto, Akira Furusaki, Christopher Mudry

arXiv:1503.00119

We construct the generic phase diagrams encoding the topologically distinct localized and delocalized phases of noninteracting fermionic quasiparticles for any symmetry class from the tenfold way in one, two, and three dimensions. To this end, we start from a massive Dirac Hamiltonian perturbed by a generic disorder for any dimension of space and for any one of the ten symmetry classes from the tenfold way. The physics of Anderson localization is then encoded by a two-dimensional phase diagram that we deduce from the topology of the space of normalized Dirac masses. This approach agrees with previously known results and gives an alternative explanation for the even-odd effect in the one-dimensional chiral symmetry classes. We also give a qualitative explanation for the Gade singularity and Griffiths effects in the density of states using the first homotopy group of the normalized Dirac masses in two dimensions. Finally, this approach is used to analyze the stability of massless Dirac fermions on the surface of three-dimensional topological crystalline insulators.