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Nonequilibrium electron dynamics–photovoltaic Hall effect, ac-induced repulsion-attraction conversion

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Nonequilibrium can give rise to a variety of intriguing phenomena that are unimaginable in equilibrium. Here I shall focus on two such phenomena, both generated by intense laser light in electron systems and/or cold atom systems:

(i) Can we look for the abilities of strong laser light beyond just high-energy excitations? We propose here to evoke a topological system for controlling topological properties by dynamical (i.e., photoinduced) nonequilibrium. Namely, we predict a "photovoltaic Hall effect" in zero uniform magnetic field should occur in graphene when a circularly polarised light is applied[1]. While the spin Hall effect is known to occur when a spin-orbit interaction opens a gap in the Dirac cone, the circularly polarised light opens a dynamical gap when the k-points encircling the Dirac point acquire an Aharonov-Anandan phase. The effect is genuinely nonlinear as well as dynamical, since the photovoltaic Hall current is carried by the Floquet states drastically modified by strong laser light, and is quadratic in the laser intensity. The required intensity of the laser field is within experimental feasibility. We can also propose an all-optical detection of the photovoltaic Hall effect, where the Faraday rotation is used to measure the optical Hall conductivity[2]. The effect is rather universal extending to multi-layer graphene and other multi-band systems[2].

(ii) A completely different, but again a genuinely nonequilibrium effect, is predicted as a "repulsion-attraction conversion" in the inter-fermion interaction[3]. For cold atom systems in optical lattices it has been known and verified that an ac modulation of the optical lattice potential renormalised the hopping energy (J) between lattice sites by Bessel's function which oscillates with the (amplitude/frequency) of the modulation[4]. We have shown, from a time-dependent DMFT simulation, that (a) an originally repulsive inter-fermion interaction (Hubbard U) effectively changes sign to become attractive (as directly detected from the enhanced double occupancy) when we suddenly switch on (i.e., quench) the ac modulation into a region where the hopping is negative. (b) Physically, this comes from the ac-quench causing a population inversion (a negative T) on the flipped band dispersion, as confirmed from the energy and momentum distributions. This opens up a novel possibility of a dynamically induced superconductivity, since an attraction (for which Tc ˜ 0.1 J) is obviously favourable for realising superconductivity, for which we discuss how to ramp up the ac, or how to choose appropriate electron systems.

The works described here are collaborations with Takashi Oka, Naoto Tsuji and Philipp Werner.

[1] T. Oka and H. Aoki, Phys. Rev. B 79, 081406 (R) (2009), 79, 169901(E) (2009).

[2] T. Oka and H. Aoki, arXiv:1007.5399.

[3] N. Tsuji, T. Oka, P. Werner and H. Aoki, arXiv:1008.2594.

[4] N. Tsuji, T. Oka and H. Aoki, Phys. Rev. B 78, 235124 (2008); Phys. Rev. Lett. 103, 047403 (2009).

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