Floquet chiral magnetic effect

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We show that a single Weyl fermion can be realized in a periodically driven three-dimensional lattice system (left figure in Fig. 1) [1], even though it is prohibited in static systems by the Nielsen-Ninomiya theorem [2,3]. A spin-polarized wave packet in this drive is transported in its spin direction due to the spin-momentum locking of Weyl fermions. If a synthetic magnetic field is applied, a wave packet moves parallel to the field (right figure in Fig. 2), leading to a Floquet realization of the chiral magnetic effect [4].

Generalizing the idea behind these, we give a topological classification of Floquet unitary operators in Altland-Zirnbauer symmetry classes, and use it to predict that all gapless surface states of topological insulators and superconductors can emerge in bulk quasi-energy spectra in Floquet systems.

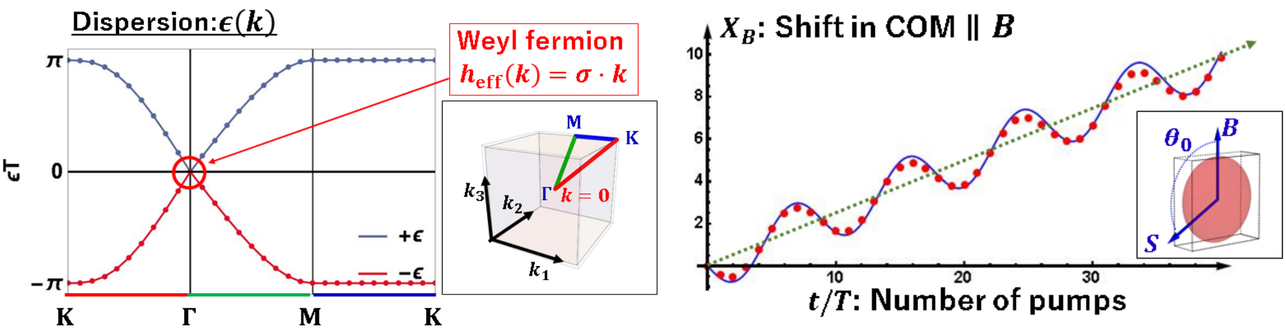

Figure 1 : (left) Quasienergy spectra $\pm\epsilon(\boldsymbol{k})T$ (T is the period of driving) of the Floquet-Bloch operator $U(\boldsymbol{k})$ of our driving protocol along the loop connecting the points $\mathrm{K} = (\pi,\pi,\pi)$, $\mathrm{M} = (0,\pi,\pi)$, and $\Gamma = (\pi,\pi,\pi)$, where the inset shows the Brillouin zone $\mathbb{T}^3 = \{(k_1,k_2,k_3) | -\pi \le k_i \le \pi\}$ of the cubic lattice.

(right): Time evolution of the center of mass X_B along the direction of an applied magnetic field $\boldsymbol{B}$, where the initial state is taken as the spin-polarized pancake-shaped Gaussian wave packet (inset). The numerical result (red points) well agrees with the theoretical curve (blue line).

[1] S. Higashikawa, M. Nakagawa, and M. Ueda, in preparation.

[2] H. Nielsen and M. Ninomiya, Nuclear Physics B 185, 20 (1981).

[3] H. Nielsen and M. Ninomiya, Nuclear Physics B 193, 173 (1981).

[4] K. Fukushima, D. E. Kharzeev, and H. J. Warringa, Phys. Rev. D 78, 074033 (2008).