第７７回トポロジカル物質科学セミナー
Topological Materials Science Seminar (77)

Z_4 parafermions in one-dimensional quantum systems

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Time: **16:30 -**

Abstract:

Parafermionic bound states are generalizations of Majorana bound states which can exist in strongly correlated topological systems. In recent years, interest in these quasi-particles has been mounting thanks to their proposed applications in topological quantum computation. In this talk, I will present approaches to engineer the simplest generalization of Majoranas, namely Z_4 parafermions, in one-dimensional systems.

One potential host system for parafermions are one-dimensional edge states of two-dimensional topological insulators. The interplay between spin-orbit coupling and electron-electron interactions produces backscattering in these helical edge states. If the chemical potential is at the Dirac point, this can open a gap in the edge state spectrum even if the system is time-reversal invariant. Zero-energy bound states then emerge at the interfaces between a section of the helical system which is gapped out by backscattering and another section gapped out by the superconducting proximity effect. I will show that these bound states, which are protected by time-reversal symmetry, have charges which are multiples of e=2, give rise to a Josephson current with 8_ periodicity, and can be described asZ_4 parafermions. I will discuss their braiding statistics and show how braiding can be implemented in topological insulator systems.

Moreover, symmetry-protected Z_4 parafermions can also emerge as the exact solutions of certain one-dimensional fermionic lattice models. Using the concept of Fock parafermions, I will present a mapping between lattice Z_4 parafermions and lattice spin-1/2 fermions which preserves the locality of operators with Z_4 symmetry. I will use this to construct a one-dimensional fermionic Hamiltonian which hosts exact parafermionic edge states. I will discuss their protection against various perturbations as well as their visibility in the fermionic spectral function. Such parafermions can thus potentially be realized in optical lattices or quantum dots arrays.

References

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[2] C. Pedder, T. Meng, R. P. Tiwari, and T. L. Schmidt, Missing Shapiro steps and the 8π-periodic Josephson effect in interacting helical electron systems, Phys. Rev.B 96, 165429 (2017).
[3] C. P. Orth, R. P. Tiwari, T. Meng, and T. L. Schmidt, Non-Abelian parafermions in time-reversal invariant interacting helical systems, Phys. Rev. B 91, 081406(R) (2015).

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