Dynamical Shiba states from precessing classical spins in *s*-wave superconductors

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Here we study theoretically the dynamics of the Shiba states forming around precessing classical spins in an *s*-wave superconductor. Utilizing a rotating wave description of the precessing magnetic impurities, we find the time-dependence of the Shiba states wave function, and their spatial extension. We also calculate the charge and spin currents probed by an STM tip above a precessing magnetic impurity and find a strong dependence of these quantities on the precession frequency and angle, as well as on the structure of the Shiba state through its superconducting coherence factors. We find that for precessions frequencies of the order of the gap and larger, the Shiba states, as expected, are not well defined anymore and merge with the continuum of quasiparticles [1].

It was realized recently that a chain of coupled Shiba states could host at its edges the so called Majorana fermions, particles that are their own antiparticles and which posses non-abelian statistics under braiding operations. Such a feature could be extremely useful for implementing a topological quantum computer with Majorana fermions. We extend our theory to a chain of dynamical Shiba states associated with chain of precessing magnetic impurities, and which couple to each other to give rise to a Shiba band. Utilizing a Floquet theory description of the time-dependent problem, we show that it is possible to change the topology of the resulting Shiba chain, and thus the number of Majorana edge modes emerging in the chain. Specifically, we calculate the effective Hamiltonian in the rotating frame, as well as the associated quasi-energies, and infer from those the resulting Chern number, which in turn count the number of edge modes. Finally, we also discuss briefly the possibility to analyze the combined dynamics of the two coupled systems, i.e. magnetic impurity and superconductor, by considering the impurities to be described by the Landau-Lifshitz-Gilbert equation. We also discuss the experimental implications of our proposal, that could be implemented simply by driving the impurities by a microwave field.

1. M. Trif, V. Kaladzhyan, P. Simon, (unpublished)