# Higher-order Time-Symmetry-Breaking Phase Transition due to meeting of an Exceptional Point and Fano Resonance

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We have theoretically investigated the time-symmetry breaking phase transition process for two discrete states coupled with a one-dimensional continuum by solving the nonlinear eigenvalue problem for the effective Hamiltonian associated with the discrete spectrum. We obtain the effective Hamiltonian with use of the Feshbach-Brillouin-Wigner projection method. Strong energy dependence of the self-energy appearing in the effective Hamiltonian plays a key role in the time-symmetry breaking phase transition: as a result of competition in the decay process between the Van Hove singularity and the Fano resonance, the phase transition becomes a higher-order transition when both the two discrete states are located near the continuum threshold.

In this talk, we also shed a new light on the nonlinear eigenvalue problem of the effective Hamiltonian in terms of the stability of the solutions. The time-symmetry breaking is regarded as a bifurcation in the complex plane of the solutions of the dispersion equation. According to the bifurcation theory, we define a *velocity field* toward the fixed point in the complex plane, and found out that a peculiar spiral flow appears around the resonance and anti-resonance states. We found out that the appearance of the spiral flow corresponds to the complex normalization factor of the eigenvector in the extended Hilbert space.