Levels and widths statistics of the quantum many-body systems

Shoujirou Mizutori[1], Hirokazu Aiba[2]
Kansai University of Welfare Sciences[1], *Kyoto Koka Women's College*[2]
mizutori@tamateyama.ac.jp[1], h_aiba@mail.koka.ac.jp[2]

Recently, it is claimed that the widths of the low-lying neutron resonances do not follow the Porter-Thomas(PT) distribution, thus indicate the failure of the random matrix theory[1]. Against this claim, a possibility is pointed out that the super-radiant phenomena, namely the width collectivization due to the strong coupling to the contituum, lead to the modification of the statistics[2]. Another possibility is proposed that the correlation between the target nuclei and the compound one (the target nuclei plus a neutron) causes the deviation of the statistics of the width distribution[3]. While these considerations focus on the widths only, it is also interesting to examine the statistics of the levels as well to judge whether these explanations hold.

We adopt the two-body random ensemble as the intrinsic Hamiltonian, and construct non-Hermite effective Hamiltonian with the imaginary part due to the coupling to the continuum evaluated consistently with the intrinsic Hamiltonian. With this model, we analyze the nearest neighbor level spacings(NNLS), fitting with the Brody distribution, and the width statistics fitting with the χ^2 function. Changing the strength κ of the couplings to the continuum, we try to clarify the condition in which the width distribution deviates from the PT distribution(for which the degree of freedom ν of the χ^2 function is 1.0) , and how the parameter β of the Brody distribution deviates from 1.0 (the value for the Wigner distribution) when irregularity is observed in the width distribution.

It turns out that the couplings between the intrinsic states and the continuum depend strongly on the energy. Therefore, we do not analyze whole spectrum but concentrate on a narrow region in which the energy dependence of the couplings can be neglected. We choose the region around the expectation value of the Hamiltonian with target + one particle state. Then, if the κ is very small, the widths follows the PT distribution while the NNLS follows the Wigner distribution. With increasing κ, the widths deviate from the PT distribution and the NNLS deviate from the Wigner distribution, simultaneously. Further increase of the coupling restore the PT distribution of the widths and the Wigner distribution of the NNLS, respectively.

The shifts of the positions of the poles in the energy-width plane indicate that these simultaneous deviations are inevitable. Namely, if the deviation of the distribution of the neutron width from the PT one would be because of the width collectivization due to the strong coupling to the continuum, one would also observe the deviation of the NNLS distribution.

[1] P.E. Koehler et al., Fortschr. Phys. **61**, 80-94 (2013)
[2] G.L. Celardo, N. Auerbach, F.M. Izrailev, and V.G. Zelevinsky, Phys. Rev. Lett. **106**, 042501(2011)
[3] A. Volya, Phys. Rev. C **83**, 044312 (2011)