Higher-order Gap Ratios of Singular Values in Open Quantum Systems

Contributed Talk

S. Harshini Tekur[1], M. S. Santhanam[1] and Bijay Kumar Agarwalla[2]

[1]*Department of Physics, Indian Institute of Science Education and Research, Pune, India*
[2]*International Centre for Theoretical Sciences, Tata Institute of Fundamental Research, Bangalore, India*

Understanding open quantum systems from information encoded in its complex eigenvalues using the tools of Random Matrix Theory has been a subject of growing interest. A recent study [1] has shown that the singular values (eigenvalues of $\sqrt{M\,\dagger\,M}$ with M being a generic non-Hermitian matrix) of underlying non-Hermitian matrices can markedly distinguish different non-Hermitian symmetry classes for both the level spacing and the gap ratios. However, these quantities encode information of only short-range correlations. In this work, we study higher-order gap ratios of the singular values of generic open quantum systems [2]. We show that the k-th order gap ratio of the singular values of an open quantum system can be connected to the nearest-neighbor spacing ratio of positions of classical particles of a harmonically confined log gas with inverse temperature $\beta'(k)$, where $\beta'(k)$ is an analytical function that depends on k and the Dyson's index$\beta = 1, 2$, and 4 that characterizes the properties of the associated Hermitized matrix. Our findings are crucial not only for understanding long-range correlations between the eigenvalues but also provide an excellent way of distinguishing different symmetry classes in an open quantum system. To highlight the universality of our findings, we demonstrate the higher-order gap ratios using different platforms such as non-Hermitian random matrices, random dissipative Liouvillians, Hamiltonians coupled to a Markovian bath, and Hamiltonians with built-in non-Hermiticity.

References

[1] K. Kawabata, Z. Xiao, T. Ohtsuki, and R. Shindou, Singular-value statistics of non-hermitian random matrices and open quantum systems, PRX Quantum **4**, 040312 (2023).

[2] S. Harshini Tekur, M. S. Santhanam, Bijay Kumar Agarwalla, and Manas Kulkarni, Higher-order gap ratios of singular values in open quantum systems, Phys. Rev. B **110**, L241410 (2024).