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Imaginarity in Neutrino Systems: A Resource-Theoretic Perspective

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We present the first analysis of the quantification of imaginarity in neutrino flavor and spin-flavor oscillations by framing neutrino systems as coherent quantum superpositions within the emerging resource theory of imaginarity. Employing measures such as the $\ell 1$-norm and the relative entropy of imaginarity, we show that imaginarity is nonzero in two-flavor neutrino mixing and peaks when quantum probabilistic features are most pronounced, specifically when survival and transition probabilities approach 1/2. Extending it to the three-flavor framework, we explore the role of a complex CP-violating phase in this quantification. We find that imaginarity, as a resource, can be harnessed not solely from the presence of a complex phase but also from the intrinsic quantum dynamics of flavor mixing. Our findings underscore the fundamental significance of complex numbers in quantum mechanics and position neutrino systems as a rich platform for studying imaginarity through a resource-theoretic lens.

Collaboration you are representing

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