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Landscape of 4D spinfoam quantum geomoetry: Results from next-to-leading order spinfoam large-j asymptotics of 1-5 Pachner move

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To study the large-j asymptotics of Lorentzian spinfoam EPRL models on complex four dimensional geometries with internal points, it is crucial to first understand the underlying impact of geometrical structures on the spinfoam amplitudes, due to the existence of continuous critical points and their non-trivial contribution in the covariant path integral formalism. In this paper we propose several criteria to probe the non-trivialities of four dimensional 1-5 Pachner move geometry impacting spinfoam amplitude, including the standard deviation of 4-volumes of constituting 4-simplices, the smallest 4-simplex volume, and also whether the directions of tetrahedron 4-normals are close to the null direction. By computing numerically and analyzing in detail the spinfoam amplitudes up to next-to-leading order of large amounts of 1-5 move samples sharing the same boundary 4-simplex, the connection between non-trivial quantum geometry and spinfoam amplitudes is revealed as large standard deviation of 4-simplex volumes can result in both leading order and next-to-leading order amplitudes being large, while the close to null tetrahedron 4-normals impact on the increase of next-to-leading order amplitude much greater than it impact the leading order amplitude, making it mostly a quantum effect. After comparing all of the samples we computed, we are able to further confirm that the factors we investigate in our work are the major impacting factors on spinfoam amplitude of samples with the same boundary, since the randomness of each sample can be fully explained by taking into account of these factors. The results we obtain in this work can be naturally generalized to the large-j analysis of other graphs as well.

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