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Quantum geometry of a bosonic system exhibiting a quantum phase transition in terms of frame bundle structure

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We study the quantum geometry of a bosonic system with a quantum phase transition from the perspective of the frame bundle structure. The phase boundary appears in the form of a light cone in the parameter space which is regarded as the exceptional surface. We have obtained the complex eigenmodes which diagonalize the Hamiltonian all over the parameter space, enabling us to study analytical continuation across the entire parameter space. The quantum geometric tensor in terms of the operator algebra space is obtained based on the principal bundle theory. While the symmetric part of the tensor, known as the quantum metric, is a positive-definite Riemannian metric in the stable region, in the unstable region, we found that part of it becomes negative, turning into a pseudo-Riemannian metric. The antisymmetric part representing the Berry curvature experiences the transition from the real phase to the complex phase at the phase boundary. We have found that the operator space holds the Kähler structure in the stable domain as in the Hilbert space, but it transitions to a pseudo-Kähler structure in the unstable domain.

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