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Geometrical View of Quantum Phase Transition: From Kähler to Pseudo-Kähler Structure Transition

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We study the quantum geometry of the quantum phase transition system consisting of a single-mode bosonic quadratic coupling Hamiltonian with the SU(1,1) symmetry, where the system parameters corresponding to the three generators forms a three-dimensional parameter space.
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 phase boundary.
We have defined the quantum geometric tensor of the complex eigenmodes based on the principal bundle theory.
The symmetric part of the tensor, known as the quantum metric, is a positive-definite Riemannian metric in the stable region.
However, in the unstable region, we found that part of it becomes negative, turning into a pseudo-Riemannian metric.
The antisymmetric part represents the Berry curvature, which shows the transition from the real phase to the complex phase on the QPT.
It is found that the present system possesses the K{\"a}hler structure in the stable domain which shows a topological change to a pseudo-K{\"a}ler structure in the unstable domain.
Our method reveals the analytic continuation on the QPT from the stable region to the unstable region.

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