Quantum critical behavior of the quantum Ising model on fractal lattices

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In this research work, I study the properties of the quantum critical point of the transverse-field quantum Ising model on various fractal lattices such as the Sierpinski carpet, Sierpinski gasket, and Sierpinski tetrahedron. When a magnetic field is applied perpendicular to the Ising spin direction, quantum fluctuations affect the transition between the ferromagnetic and the paramagnetic phases. Using a recently developed continuous-time quantum Monte Carlo simulation method and finite-size scaling analysis, I investigated the interplay between the quantum fluctuations and the exotic dimensionality of the fractal structure and its effect on the critical behavior. As a result, I could identify the quantum critical point and investigate its scaling properties. Among others, I calculated the dynamic critical exponent and found that it is greater than one for all three structures studied in this work. The fact that it deviates from one is a direct consequence of the fact that the spatial dimensions have a fundamentally different structure that the time dimension because fractal lattices are not integer-dimensional regular lattices. Other critical exponents were also calculated. All evaluated exponents are different from those of the classical critical point and satisfy the quantum scaling relation, thus confirming that I have indeed found the quantum critical point. I found that the Sierpinski tetrahedron, of which the dimension is exactly 2, belongs to a different universality class than that of the two-dimensional square lattice. I therefore confirm that the critical exponents depend on more details of the structure than just the dimension and the symmetry.

[l] H. Yi, Phys. Rev. E **91**, 012118 (2015).
[2] H. Yi, Phys. Rev. E **88**, 014105 (2013).