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Quantum Critical Paraelectrics and the Casimir Effect in Time

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— We present a study of the quantum paraelectric-ferroelectric transition (QPFT) with special emphasis on temperature near a quantum critical point where it acts as a boundary condition in imaginary time. The effect of temperature on quantum critical fluctuations can be likened to the Casimir effect where critical electromagnetic fluctuations are probed through their sensitivity to boundary conditions in space. Exploiting this analogy, we use finite-size scaling methods to study the finite-temperature properties of a quantum paraelectic in the vicinity of a QPFT. Simple arguments are used to derive the $1/T^2$ divergence of the paraelectric susceptibility (χ) previously found with diagrammatic techniques. Self-consistent mean-field theory is used to probe the classical-quantum crossover in χ and the resulting temperature-pressure phase diagram is presented. Observable consequences of our scaling approach for high pressure measurements on strontium titanate and potassium tantalate at low temperatures will also be discussed.

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