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An application of Hardy and Littlewood approximate functional equation: the vacuum energy with non-ideal boundary conditions

Nami Fux Svaiter
CBPF - Brazil

We present the vacuum energy of a quantized scalar field in the presence of classical surfaces, defining bounded domain where the field satisfy ideal or non-ideal boundary conditions. First, using an analytic regularization procedure, we obtain the vacuum energy of a massless scalar field at zero temperature in the presence a slab geometry with ideal Dirichlet boundary conditions. Next, we obtain the vacuum energy in the presence of such slab geometry with non-ideal boundary conditions. For the electromagnetic case, this situation describes the conductivity correction to the vacuum energy. Our approach is based in an asymptotic description with approximate functional equation for Riemann zeta-function, where finite sums outside the domain of convergence of the original function are defined. Finally, using an approximate functional equation of the Epstein zeta-function, we obtain the vacuum energy assuming a massless scalar field in the presence of a rectangular box with ideal or non-ideal boundary conditions.