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Von Neumann information entropy, second quantization, and spectral action

We show that by incorporating chemical potentials one can extend the formalism of spectral action principle to Bosonic second quantization. In fact we show that the von Neumann information entropy, the average energy, and the negative free energy of the state defined by the Bosonic, or Fermionic, grand partition function can be expressed as spectral actions, and all spectral action coefficients can be given in terms of the modified Bessel functions.In the Fermionic case, we show that the spectral coefficients for the von Neumann entropy, in the limit when the chemical potential μ approaches to 0, can be expressed in terms of the Riemann zeta function. This recovers a recent result of Chamseddine-Connes-van Suijlekom (joint work with Rui Dong, arXiv:1903.09624).