Perturbative Results Without Diagrams

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Higher-order perturbative calculations in zero-temperature Quantum (Field) Theory suffer from the factorial increase of the number of individual diagrams. Here I describe an approach which evaluates the total contribution numerically for finite temperature from the cumulant expansion of the corresponding observable followed by an extrapolation to zero temperature. The method is applied to the calculation of higher-order terms for the ground-state energy of the polaron in the path integral formulation where an exponential convergence is demonstrated. Using state-of-the-art multidimensional integration techniques I easily confirm the $3^{\rm rd}$ order analytical result obtained by Smondyrev in 1986 with a precision of less than 0.05%. For the first time the $4^{\rm th}$ order coefficient is obtained with an accuracy of 0.5% and the $5^{\rm th}$ order with an accuracy of (presently) 5% .