Contribution ID: **32** Type: **talk**

Minimal pole representation and controlled analytic continuation of Matsubara response functions

Monday 20 January 2025 16:00 (45 minutes)

Analytic continuation is a central step in the simulation of finite-temperature field theories in which numerically obtained Matsubara data are continued to the real frequency axis for a physical interpretation. Numerical analytic continuation is considered to be an ill-posed problem where uncertainties on the Matsubara axis are amplified exponentially. Here, we present a systematic and controlled procedure that approximates any Matsubara function by a minimal pole representation to within a predefined precision. We then show a systematic convergence to the exact spectral function on the real axis as a function of our control parameter for a range of physically relevant setups. Our methodology is robust to noise and paves the way towards reliable analytic continuation in many-body theory and, by providing access to the analytic structure of the functions, a direct theoretical interpretation of physical properties.

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Session Classification: Monday afternoon