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The effects of higher order truncations in the 2PI description of phase transitions

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We thoroughly investigated the applicability of the two-particle irreducible
(2PI) formalism in the description of phase transitions occurring at finite temperature in scalar field theories. We studied the importance of truncation effects on the order of the phase transition and indeed found that the long known problem of the Hartree-Fock truncation is cured by improving the approximation to the next level. during the investigation of Bose-Einstein condensation at finite density we found infrared problems one might face in the self-consistent treatment of the propagators. We studied this problem in more detail developing various semi-analytical localized approximations. We have shown within a truncation at two-loop level that the so-called symmetry improved 2PI, recently proposed in the literature to enforce the Goldstone theorem on the variational propagator, results in a loss of solution to the self-consistent propagator equations because the resummation cannot cope with the deep IR modes. We think that the most likely way out for this rather general problem is to employ vertex resummations e.g. using 1/N expansion to next to leading order in the 2PI effective action.

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