Precision results from improved Borel summation of critical exponents and amplitude ratios of the $d = 3, n = 2$ universality class

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Highly accurate experimental results obtained from space experiments near the lambda transition of ^{4}He [1] constitute a challenge to analytical renormalization-group (RG) calculations. Theoretical RG predictions with comparatively large error bars have been obtained from previous Borel summations [2]. We perform improved Borel summations for the critical exponents α and γ of the $d = 3, n = 2$ universality class on the basis of seven-loop perturbation series of the ϕ^4 field theory [3] with an n component order parameter in d dimensions. A new extremum criterion is introduced that significantly reduces the error bars compared to the earlier Borel summations [2]. Our result for $\alpha = -0.010 \pm 0.002$ is close to the experimental result $\alpha_{exp} = -0.0127 \pm 0.0003$ [1] but is outside the error bars of numerical data for XY type lattice models [4]. Furthermore, Borel resummed results on the basis of four-loop perturbation series [5] are presented for the universal amplitude ratios $P = (1 - A^+/A^-)/\alpha$ related to the specific heat and for R_ξ^T related to the superfluid density. While our result for R_ξ^T is in good agreement with experiments [6] our result for $P = 4.433 \pm 0.077$ is outside the error bars of both experimental [1] and numerical results [7]. Further theoretical and experimental investigations are required to resolve these discrepancies.

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