## Combined Temperature and Density Series for Fluid-Phase Properties II. Lennard-Jones Chains

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Cluster integrals are evaluated for the coefficients of the combined temperature- and density expansion of pressure:  $Z = 1 + B_2(\beta)\eta + B_3(\beta)\eta^2 + B_4(\beta)\eta^3 + \cdots$ , where Z is the compressibility factor,  $\eta$  is the packing fraction, and the  $B_i(\beta)$ coefficients are expanded as a power series in reciprocal temperature,  $\beta$ , about  $\beta = 0$ . The methodology is demonstrated for Lennard-Jones Chains with  $N_c = [1-20]$ , where  $N_c$  is the number of carbons in the TraPPE-UA model of n-alkanes. Expanding the Bicoefficients in  $\beta$  provides a correspondence between the power series in density (typically called the virial series) and the power series in  $\beta$  (typically called thermodynamic perturbation theory, TPT). The coefficients of the  $\beta$  series result in expressions for the Helmholtz energy that can be compared to recent computations of TPT coefficients to fourth order in  $\beta$ . These comparisons show good agreement at first order in  $\beta$ , suggesting that the virial series depends on the order in  $\beta$ . The treatment of Helmholtz energy that is second order in $\beta$  appears to be stable and convergent at least to the critical density. Higher-order coefficients can be inferred through treatment of the  $\beta$  expansion of the second virial coefficient in the context of the Gaussian extrapolation approximation of Ghobadi and Elliott.