First-Principles Calculation of the Third Virial Coefficient of Helium

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Knowledge of the pair and three-body potential-energy surfaces of helium is now sufficient to allow calculation of the third density virial coefficient, $C(T)$, with significantly smaller uncertainty than that of existing experimental data. In this work, we employ the best available pair and three-body potentials for helium and calculate $C(T)$ with path-integral Monte Carlo (PIMC) calculations supplemented by semiclassical calculations. The values of $C(T)$ presented extend to temperatures below 100 K. In the important metrological range of temperatures near 273.16 K, our uncertainties are several times smaller than the best experimental results.