Ground-State Energy and Condensate Density of a Dilute Bose Gas Revisited

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The ground-state energy per particle E/N and condensate density n_0 of a dilute Bose gas are studied with a self-consistent perturbation expansion satisfying the Hugenholtz-Pines theorem and conservation laws simultaneously.[1)] A new class of Feynman diagrams for the self-energy, which has escaped consideration so far, is shown to add an extra constant $c_{\rm ip} \sim O(1)$ to the well-known expressions reported by Lee, Huang, and Yang[2)] as

$$\frac{E}{N} = \frac{2\pi\hbar^2 an}{m}\left[1+\frac{16}{5}\left(\frac{8}{3\sqrt{\pi}}+c_{\rm ip}\right)\sqrt{a^3n}\right], \qquad \frac{n_0}{n} = 1-\left(\frac{8}{3\sqrt{\pi}}+c_{\rm ip}\right)\sqrt{a^3n},$$

where a, n, and m are are the s-wave scattering length, particle density, and particle mass, respectively.[3)] We present a couple of estimates for $c_{\rm ip}$; the third-order perturbation expansion yields $c_{\rm ip} = 0.412$. The existence of such an additional contribution is also suggested by a previous diffusion Monte Carlo simulation.[4)]

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