Equation of state for degenerate electron gas: Analytical approximation and numerical simulation

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The equation of state for a degenerate electron gas is obtained explicitly using the Fermi–Dirac distribution through analytical expansions in the degeneracy parameter. A direct computer calculation is performed with the exact integral formulas of the Fermi–Dirac distribution so that to confirm the analytical approximations obtained. Practical formulas to the equation of state and chemical potential for degenerate electron gas are recommended:

$$\frac{p}{nT} = 1 + \frac{A}{11.3}, \qquad A \le 9.85, \tag{1}$$

$$\frac{p}{nT} = 0.305A^{2/3} + \frac{2.16}{A^{2/3}}, \qquad A \ge 9.85, \tag{2}$$

$$\frac{\mu}{T} = \ln(A/2) + \frac{A}{5.6}, \qquad A \le 7.15, \tag{3}$$

$$\frac{\mu}{T} = 0.762A^{2/3} - \frac{1.08}{A^{2/3}}, \qquad A \ge 7.15. \tag{4}$$

These approximations prove to be decent matching the strict numerical calculation over the whole range of the degeneracy parameter: $10^{-2} < A < 10^2$. Therefore, the equation of state for degenerate electron gas assumes a clear analytical representation over the whole range of electron densities and temperatures through the unique degeneracy parameter.

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