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Perturbation theory for thermodynamic properties of a ν-dimensional square-well fluid

J P SINHA and S K SINHA
Department of Physics, L S College, Bihar University, Muzaffarpur 842001, India

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Abstract. The Barker-Henderson perturbation theory is used for a ν-dimensional fluid with square-well potential. Analytic expressions are given for the equation of state, excess free energy per particle and internal energy. The numerical results are discussed. A significant feature is the increase of the thermodynamic properties with increasing dimensionality.

Keywords. Perturbation theory; equation of state; excess free energy; internal energy; dimensionality.

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1. Introduction

In recent years theoretical and experimental efforts have been made to understand the structural and thermodynamic properties of ν-dimensional fluids (Baus and Colot 1986, 1987; Colot and Baus 1986). However these efforts are confined to the fluid of hard ν-spheres as they are widely used as the hard-core reference system in ν-dimensional fluids. For a real fluid, an interparticle attraction works as a perturbation over a reference-system potential. The square-well (SW) potential is the simplest model which takes into account both the attractive and repulsive features of the intermolecular interaction. However no attempt has been made to study the ν-dimensional fluid with a potential model having attracting interaction.

In this paper we study the thermodynamic properties of ν-dimensional classical fluid of molecules interacting via the SW potential. The SW potential with $\zeta = 1{\cdot}5$ is a reasonable model for real simple fluid (Henderson *et al* 1976). Moreover, the complicating effects due to a softness of the repulsive part of potential are not present for this model.

For classical SW fluid considerable progress has been made (Hansen and McDonald 1976; Van Kampen *et al* 1967; Barker and Henderson 1967, 1976; Tago 1974; Smith *et al* 1974; Henderson and Chen 1975; Handerson *et al* 1976; Ponce and Renon 1976). But almost all these studies have been confined to the three-dimensional fluid. Mishra and Sinha (1984) have calculated the thermodynamic properties of the two-dimensional SW fluid. However, no work is available for general ν-dimensional fluid.

One of the most successful approaches for dealing with fluids is the Barker-Henderson (BH) perturbation theory (Barker and Henderson 1967). For the SW fluid, the BH perturbation theory can be solved analytically. It has been used to obtain analytic expressions for thermodynamic properties such as the equation of state and