Scattering via separable potential with higher angular momenta: Application to statistical mechanics

Ali Maghari
Department of Physical Chemistry, University of Tehran, Tehran, Iran

In two our recent works, the scattering properties of a system with zero angular momentum (s-wave) via a separable potential of rank two was calculated and then applied to obtain the equilibrium statistical mechanical properties of fluids. A generalized formulation for partial wave scattering wave function and its properties, such as phase shift and time delay, subjected to the potential scattering in a given partial wave form factor with any angular momentum has recently been developed. This paper presents a new formulation of the equilibrium and non-equilibrium statistical mechanical properties of a gas consisting of free particles and independent correlated pairs with any angular momentum, interacting via nonlocal separable potential, in terms of partial wave scattering amplitude. At low density and moderate temperature, the effect of exchange symmetry plays a minor role and the system obeys the Boltzmann statistics. For an N-particle system, the evaluation of thermodynamic functions necessitates the evaluation of the partition function

$$Z_N = Tr[exp(-H/kT)]. \tag{1}$$

We show that the thermal trace, appeared in Eq. (1), can be expressed in terms of the transition matrix. Define the Green operators $G_0(E_0, \epsilon)$ and $G(E, \epsilon)$ corresponding to H_0 and H, respectively, as follow:

$$G_0(E_0, \varepsilon) = \frac{1}{E + i\epsilon - H_0} \tag{2}$$

$$G(E, \varepsilon) = \frac{1}{E + i\epsilon - H} \tag{3}$$

Using the Lippman-Shcwinger equation, we have

$$G(E, \epsilon) - G_0(E_0, \varepsilon) = G_0(E_0)T(E)G(E) \tag{4}$$

Inserting Eq. (4) and its corresponding adjoint operator in to the Eq. (1) leads to the difference between the interacting partition function and free-particle partition functions in terms of transition matrix elements. Furtheremore, Transport properties such as diffusion, viscosity and heat conductivity are described by the corresponding transport coefficients or, equivalently, by the effective transport cross sections. These cross sections are related to the so-called transport collision integrals, which are integrals of transport cross section. The transport cross sections for each orientation are determined from the partial-wave phase shifts.

[1] A. Maghari, N. Tahmasbi, J. Phys. A: Math. Gen. **38**, 4469 (2005).
[2] N. Tahmasbi and A. Maghari, Physica A **382**, 537 (2007).