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Microscopic theory of soliton propagation in a mixture of two boson fluid films

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Abstract. A microscopic theory of soliton propagation in a mixture of two boson fluids at $T = 0°$K has been provided.

Keywords. Boson fluid; films; solitons.

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Introduction

In a recent paper Warke and the author gave a microscopic theory of soliton propagation in a film of liquid ^{4}He. In this paper we give a microscopic theory of soliton propagation in a film of a mixture of two boson fluids. Such a mixture can be visualized as a mixture of superfluid ^{3}He and liquid ^{4}He. We can also think of a mixture of liquid ^{6}He and liquid ^{4}He.

The Hamiltonian is

$$H=\sum\frac{P_i^2}{2M}+\sum\frac{P_i^2}{2m}+\sum u(r_i-r_j)+\sum V(r_i-r_j)+\sum_{i,j} W(r_i-r_j)$$
$$+\sum u_1(r_i)+\sum u_2(r_j), \tag{1}$$

where $u(r_i-r_j)$ is the interaction between the particles of system (1) and $V(r_i-r_j)$ is the interaction between particles of system (2), $W(r_i-r_j)$ is the interaction between particles of system (1) and system (2), $u_1(r_i)$ and $u_2(r_j)$ are the Van der Waal's interaction for the system (1) and system (2) particles respectively.

The action is

$$L=\int\left\langle\psi\left|i\hbar\frac{\partial}{\partial t}-H\right|\psi\right\rangle \mathrm{d}t. \tag{2}$$

We use the Hartree-Fock decomposition of the wave function and write

$$\psi=\prod_{i=1}^{N_1}\phi_1(r_i,t)\prod_{j=1}^{N_2}\phi_2(r'_j,t). \tag{3}$$

We put

$$\phi_1(r_j,t)=[\rho_{01}\,①\,(z_j-\eta)]^{1/2}\exp[i\theta(\eta_j,t)], \tag{4}$$

$$\phi_2(r'_j,t)=[\rho_{02}\,①\,(z_j-\eta)]^{1/2}\exp[i\theta(\eta_j,t)], \tag{5}$$