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Bose-Einstein Condensation with Attractive Boundary Conditions

Derek W. Robinson

Département de Physique, Université d'Aix-Marseille II, Luminy, and Centre de Physique Théorique, CNRS, F-13274 Marseille Cedex 2*, France

Abstract. The phenomena of Bose-Einstein condensation is discussed for particles in a box with attractive walls. Variation of the elasticity has the following effects, a) the critical temperature, fugacity, etc. vary, b) separation of phases occurs, c) condensation in one and two dimensions is possible.

1. Introduction

Theoretical understanding of phase transitions has been greatly enhanced by the study of simple soluble models such as the Ising model or the ideal Bose gas. The spontaneous magnetization exhibited by the former model has been examined by variation of boundary conditions (for a review see [1]). In two dimensions this model appears to have the simple feature that its basic thermodynamic structure is not affected by such variation. The boundary conditions only affect the relative proportions of the phases. This simplification is probably not shared by the three-dimensional model and is certainly not valid for the ideal Bose gas.

Condensation of the Bose gas has been exhaustively studied with periodic boundary conditions or Neumann conditions, $\partial\psi=0$ (see, for example, [2–4]). We consider a family of conditions, $\partial\psi=\sigma\psi$, which correspond to varying the elasticity of the walls containing the system and examine the influence of these conditions on the condensation phenomena[1]. The effects are threefold if the walls are attractive;

1. The thermodynamic region, the critical temperature, etc. vary with the elasticity and, in particular, condensation occurs at values of the fugacity, z, strictly less than one.
2. Phase separation occurs.
3. Condensation occurs in one and two dimensions.

Each of these effects is illustrated by examination of the density of the system.

* Postal address

1 In [4] the conditions $\partial\psi=a\psi$ are considered for a system of dimension L but with $a\sim L^{-1}$ and hence for macroscopic systems this is effectively $\partial\psi=0$