CHAPTER I

INTRODUCTION

Preliminary

In the past two decades, remarkable progress has been made in the study of two-dimensional (2D) electron systems. During this period, clear recognition of the two-dimensional character of interface electrons, development of different types of two-dimensional electron systems, and disclosure of very important and unusual properties have taken place. The recent discovery of the quantum Hall effect (QHE) has brought the study of these electrons to a new stage in which solid state physics is linked with quantum electrodynamics. In this thesis, we consider the density of states (DOS) of a two-dimensional electron gas with disorder in a magnetic field. By definition, two-dimensional electron systems are formed when electrons can be trapped on a surface such as that of liquid helium below 4.2 K. Other two-dimensional electron systems have been realized in the interface between two semiconductors. From a microscopic point of view, they are formed when the surface of liquid helium presents a barrier V_0 of more than 1 eV to electron transmission into the liquid, while the image potential attracts the electron to the interface. As a result, the wave function is localized, as is illustrated in Fig. 1.

Examples of two-dimensional electron systems are electrons confined to metal-oxide-semiconductor(MOS) space charge layers and at semiconductor heterojunctions. Earliest interest was in electron transport properties, the integer quantum Hall effect [1, 2, 3, 6] and fractional quantum Hall effect, [2, 4, 5] and in distinguishing localized from delocalized states. However, transport measurements do not readily observe the total density of states available to the electrons. Recently, many experiments [7-15] with two-dimensional electron systems show that the disorder, due to impurities [16, 17] or to inhomogeneities [18, 19], broadens the Landau levels (LL's) significantly. They confirm that there is a large density of states between LL's.

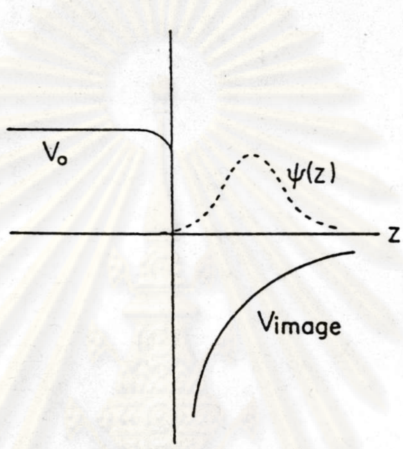

Fig. 1 Schematic potential diagram on the surface of liquid helium. ψ (z) representing a charge distribution.

The density of states of an electron confined in two dimensions in the presence of a transverse magnetic field and a disorder potential may be evaluated using several techniques developed for disordered systems. In the Born approximation [2, 11, 14, 16, 17, 20], a perturbative approach, the density of states is elliptical around each Landau level (LL) and zero between LL's. More exact methods [21-25] yield a Gaussian density of states for the lowest LL, as do path-integral methods [26, 27]. Broderix et al. [28] discuss all these methods and the approximations in them carefully.

In the last few years, Sa-yakanit et al. [27] have used the Feynman path integration method and shown that a substantial density of states between LL's could be obtained using non-perturbative methods for electrons interacting with disorder having a finite correlation length L. Last year, Sa-yakanit et al. [33] calculated, without the large-time approximation, the density of states exactly within the first cumulant approximation using numerical integration and showed that the first cumulant approximation is sufficient to obtain an appropriate density of states, which compares very well with experiments [15]. However, the density of states can take on negative values in some situations at higher energies, which is unphysical. To overcome this, we could go beyond the first- order cumulant approximation.

Outline of Thesis

The purpose of this thesis is to evaluate the density of states of a two-dimensional electron gas with a random potential in a transverse magnetic field. The basic idea of our calculation comes from the works of Gerhardts [26], and Sa-yakanit et al. [27, 33]. The outline of our work is as follows:

In the next chapter, we review some basic theory for two-dimensional electron systems. This review not only gives the basic ideas of constructing the Feynman path integral but also on how to formulate it from Schrödinger's equation. An example, the harmonic oscillator, will be presented in chapter III. In chapter IV, we calculate the averaged propagator using a Gaussian potential. In Chapter V, using the result of Chapter IV, we obtain the density of states with the second cumulant approximation averaged propagator. Discussion and conclusions, including suggestions, will be given in the last chapter.