Preface

Ever since the experimental realization of single layer graphene in 2004, it has opened a door for the exploration of the fundamental physics and also fabrication of nanoelectronic devices. It has spawned tremendous interest and activity in studying the properties of this unique system of two dimensional (2D) electron gases. Graphene holds distinct advantage over conventional 2D systems due to its unique properties. Its high electrical conductivity, high optical transparency and mechanical strength make it a potential candidate for transparent conducting electrodes required for applications such as touchscreens, liquid crystal displays, organic photovoltaic cells and organic light-emitting diodes, solar cells. There is a need to provide theoretical interpretation and feedback to experimental measurements, to predict device characteristics, and to provide a basis for the functional progress of new devices. All these devices need to have a better understanding of physical properties and quantities before they can be well modified and engineered so as to have better devices.

Electron-electron interaction plays an important role in determining various ground state properties of the system. The Many particle interaction gives rise to screening which influences major properties of the system. Hence it gets necessary to understand and carry out studies on screening effect to gain knowledge about properties such as structure factor, pair correlation function, screening charge density, self-energy, compressibility, energy loss, wake effects. Collective excitations arise due to interaction of many bodies. It helps to simplify the many-body phenomenon in terms of plasmons, phonons, magnons, Plasmon-phonon modes etc. to have a better understanding of the system. EELS (Electron energy loss

Spectroscopy) and Light scattering experiments are the most useful tools to probe collective excitations.

One of the most widely accepted approaches has been the random-phase approximation (RPA). In this approximation it is assumed that only the single particle excitations of the same wave vector as the Coulomb interaction plays an effective role in the screening process while the effects of others having different wave vectors cancels out. Use of RPA is justified when the electron-electron interactions are strong enough so that the quantum coherence doesn't dominate.

Chapter 1 consists of Origin and formation of Graphene, followed by explanation of properties and peculiarities of Graphene. Description of Graphene-related systems i.e. gapped graphene and graphene superlattice, is reported. It includes basic description of 2D electron gas and its comparison with Graphene. Essential theoretical models and associated experimental results are reported. This is followed by reviewing of many body aspects of Graphene which includes basic properties like Structure Factor, Pair Distribution Function, Screening, Self Energy, Compressibility and energy loss. Light is thrown on Plasmon-Phonon modes of various Superlattice models. A literature Survey of Previously reported work is also made.

Chapter 2 consists of many body aspects and the phenomenon of screening in Single layer Graphene (SLG). The chapter starts with a brief introduction followed by essential formalism and results and discussion. Topics covered in this chapter are the structure factor and pair distribution function, screening charge density, self energy and compressibility of graphene.

Chapter 3 consists of studies on structure factor, energy loss and wake effects of gapped graphene, which is introduced at the beginning of chapter. Essential formalism to study these effects has been described followed by results and discussions stating its importance.

Chapter 4 includes study on Graphene superlattice. It reports discussion on Plasmon-Phonon couple modes, coupling strength, damping and energy loss by stating essential formalism, results and discussions.

Chapter 5 presents summary and conclusions of work done. Requisite references are quoted at the end of each chapter.