Chapter 6
Role of Electric Field on Diffusion Coefficients for Weakly Coupled Plasma

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ABSTRACT

Equilibrium molecular dynamics (EMD) has been used to investigate diffusion coefficient (D) of 3D weakly coupled complex dusty plasma (WCCDP) by varying applied electric field (E). Velocity auto correlation function technique has been used to compute diffusion coefficient of dust particles. Impact of varying electric field has been tested for complete series of plasma parameters (Γ, κ) in a canonical ensemble. EMD simulation have been used to compute D for fixed number of particles (N = 500) at different values of plasma parameters (0.1≤ Γ≤ 0.9 and (1≤ κ ≤ 3). Computed results showed that value of D decreases by increasing Γ and increases by increasing E and κ. Simulation results also exposed that result obtained through Green-Kubo has same drift as previous results. But this work has some advancement due to E.

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1. INTRODUCTION

Thermophysical properties of complex systems are dynamically investigated by simulation and in laboratories to study the complex system a microscopic level. It has played a fundamental role in the field of science and technology. Thermophysical is a combination of thermodynamic and transport properties. Thermodynamic defines the equilibrium condition of complex systems such as heat, temperature, enthalpy, entropy, pressure and density. Whereas, transport properties described the energy, mass and heat flow of complex systems. It includes diffusion, shear viscosity and thermal conductivity. In this chapter, our motivation is to explore the effect of electric field on diffusion coefficient in 3-D weakly coupled dusty plasma by using molecular dynamics (MD) simulations. First, it defines the basics of plasma and dusty plasmas (DPs) in physics. The existence of DPs in nature, laboratories and industries is explained in detail. The significance of DPs is discussed by their possible applications in industry, laboratory, space and tokomak. The general theory and mechanism of DPs, its main parameters and characteristics are discussed. Next is the introduction of computer simulation techniques used in this study, and a historical overview of molecular dynamics (MD) simulations and the model and method are explained in detail. The purpose and motivations of the presented work are to be obtained from simulation data of diffusive transport properties in the presence of varying electric field at numerous DPs' parameters, together with previous work that has been done to date. It provides necessary problems, justifying the current work performed with the contribution for this chapter.

1.1 Plasma

Plasma is the fourth state of matter it was firstly introduced by Sir William Crooks in 1879. In the universe, 99% of physical matter is in the plasma state and the rest part of the world is only about 1% (Chen, 1984). In space, the most visible matter is in the plasma state; the sun and stars are the main examples of plasma in our universe. Plasma is created artificially in a lab and used for a variety of technical applications, including fusion energy research, display, fluorescent lighting, and more. The Irving Langmuir, an American physicist, defines plasma first time as "plasma is a quasi-neutral gas of the charged particles that show collective behaviors." He received Noble prize in 1927 for introducing "plasma" first time. Here quasi neutrality means "the gas becomes electrically neutral when the number of positive charge density is equal to number of ions.($ni \approx ne$)" and Collective behavior means that charged particle collides with each other due to electric field and coulomb potential. . Plasma is used in over daily life fields such as laser, sterilizing of medical instruments, lightening, intense power beams, water purification planet and many more (Fortov & Morfill, 2009).

1.2 Dusty Plasma

Dusty plasmas are also known as complex plasmas that contain particulates of condensed matter. Lyman Spitzer along with Hannes Alfven described that dust in the universe was not just an interruption to optical observation, but that it was an essential component of the universe. One of the most interesting events in the field of dusty plasmas occurred in early 1980 during the Voyager 2 flyby of planet Saturn. In 2005, Cassini spacecraft took new and improved images of spokes with detail that would provide a better understanding of their origin. In 1992, the European spacecraft Ulysses flew by the planet Jupiter and detected the dust particles and measured their masses and impact speed. Dust particles sizes ranging

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