Chapter 4
Molecular Dynamics Study of Diffusion Coefficient for Low-Temperature Dusty Plasmas in the Presence of External Electric Fields

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ABSTRACT

The effects of external electric field (E) on the diffusion coefficient of dust particles in low-temperature dusty plasmas (LT-DPs) have been computed through nonequilibrium molecular dynamics (NEMD) simulations. The new simulation result was obtained by employing the integral formula of velocity autocorrelation functions (VACF) using the Green-Kubo relation. The normalized self-diffusion coefficient (D) is investigated for different combinations of plasma coupling (Γ) and Debye screening*

DOI: 10.4018/978-1-7998-8398-2.ch004

(κ) parameters. The simulation outcome shows that the decreasing position of D shifts toward Γ and also increased with the increase of κ. The D* linearly decreased with Γ and increased when applied external E increases. It is observed that the increasing trend of D* depends on the E strength. These investigations show that the present algorithm provides precise data with fast convergence and effects of κ, Γ, E. It is shown that the current NEMD techniques with applied external E can be employed to understand the microscopic mechanism of dusty plasmas.*

INTRODUCTION

During the last few decades, the science of low-temperature plasma physics becomes a prominent research field. Plasma science and technology are serving every field of life, ranging from agriculture to nuclear fusion energy. The Irving Langmuir is the first scientist who discovered the fourth state of matter called "Plasma." From that date, plasma rapidly grows and becomes the core of numerous industries and technologies. Plasma is the fourth state of matter that contained 99% of the physical matter in the universe; and is defined as "Plasma is fully or partially ionized gas that contained neutral atoms, electrons, and ions." These particles show a collective behavior in the plasmas. Plasmas are classified based on many characteristics such as temperature, density, degree of ionization, etc. (Shahzad et al., 2018); here, we only discuss few types related to our topic.

Types of Plasma

Hot Plasma

In this type of plasma, the gas is fully ionized at high-pressure, high-temperature and acquires a local thermal equilibrium state. The temperature of the electron is equal to the ion and must satisfy the conditions ($T_e \equiv T_i$); here, T_e and T_i denote the temperature of electron and ion, respectively. The collisions between the particles are frequent. It is thermal, and equilibrium plasma associated with astrophysics, spark, flame, atmospheric, solar wind, sun, and nuclear fusion plasma cores are examples of hot plasma. It has a high density of nearly one trillion electrons per cubic centimeter and a degree of ionization near equal to 1 (100% ionized gas).

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