Deep Science Publishing, 2025
https://doi.org/10.70593/978-93-7185-898-4_5

DeepScience
Open Access Books

Chapter 5: Stability Analysis of Turbulent Astrocloud in the Presence of Tidal force

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Abstract: A systematic linear stability analysis in a spherically symmetric dense dust cloud is performed in the presence of nonthermal (kappa-distributed) electrons. A new dispersion relation is derived by employing the fluid equations and Poisson equations in a close integrated form. The effects of dust polarization force coming from the charged dust particles, tidal force due to nearby stars and viscosity due to strong correlation among dust-particles are also concurrently considered. A standard technique of linear perturbation analysis (spherical Fourier analysis) is applied over the basic governing equations. The frequency spectra (real as well as imaginary) are numerically analyzed to see the effects of the key structuring factors in stability behaviour of the considered cloud.

Keywords: kappa-distribution, tidal force, viscosity, polarization force, Fourier analysis.

1. Introduction

Complex plasma or dusty plasma shows remarkable features in different scales; from laboratory to astrophysical. The main constituents of such plasmas are electrons, protons (ions) and charged (both polarities) micro-particles maintain a charge-neutrality condition [1-6]. The plasma has wide range applications in laboratory such as semi-conductor devices, earth's atmosphere, controlled thermonuclear fusion, liquid radioactive waste, cancer treatment and so on [7-9]. Moreover; they are ubiquitous in varied astrophysical situations, such as interstellar clouds, the Saturn rings, comet tails [3-6] etc. It has significant influences in the formation of stars, clusters and other large-scale astrophysical objects. The dust grains are important ingredients in space and astrophysical environments. These are mainly silicates, graphite grains and polycyclic aromatic hydrocarbons (PAHs). Their maximum size is of the order of 1 micron [10-12]. It has also been observed that in astrophysical environment the typical dust-to-gas ratio is 1:100 [13]. The dust grains have both the polarities (positive and negative) depending upon the electron concentration. The space dust grains can be charged by number of charging processes such as secondary electron emission, plasma particle sticking mechanism and photoionization [1]. Due to the interaction between thermal plasma ions and dust grains in a plasma system, the dust polarization force arises [14]. The polarization force tries to decrease the screening length (Debye length) irrespective of the polarity of the plasma species. If the polarization force is taken into account then the total force on the small charged dust grains will become $F_{total} = Q_d E - \frac{Q_d^2 \nabla \lambda_D}{\lambda_D^2}$, where, $\lambda_d$is known as plasma Debye length, E is the electric field and Q_d is the dust charge (~1000 times the electron charge) [15]. Several researchers have already investigated about the dust polarization force and calculated the value of dust polarization parameter [14-15]. The polarization force plays an important