Kundu, N. R.; **Masud, M. M.**; **Ashrafi, K. S.**; **Mamun, A. A.**

Dust-ion-acoustic solitary waves and their multi-dimensional instability in a magnetized nonthermal dusty electronegative plasma. (English) Zbl 1286.76056

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Summary: A rigorous theoretical investigation has been made on multi-dimensional instability of obliquely propagating electrostatic dust-ion-acoustic (DIA) solitary structures in a magnetized dusty electronegative plasma which consists of Boltzmann electrons, nonthermal negative ions, cold mobile positive ions, and arbitrarily charged stationary dust. The Zakharov-Kuznetsov (ZK) equation is derived by the reductive perturbation method, and its solitary wave solution is analyzed for the study of the DIA solitary structures, which are found to exist in such a dusty plasma. The multi-dimensional instability of these solitary structures is also studied by the small-k (long wave-length plane wave) perturbation expansion technique. The combined effects of the external magnetic field, obliqueness, and nonthermal distribution of negative ions, which are found to significantly modify the basic properties of small but finite-amplitude DIA solitary waves, are examined. The external magnetic field and the propagation directions of both the nonlinear waves and their perturbation modes are found to play a very important role in changing the instability criterion and the growth rate of the unstable DIA solitary waves. The basic features (viz. speed, amplitude, width, instability, etc.) and the underlying physics of the DIA solitary waves, which are relevant to many astrophysical situations (especially, auroral plasma, Saturn's E-ring and F-ring, Halley's comet, etc.) and laboratory dusty plasma situations, are briefly discussed.

MSC:

76E20 Stability and instability of geophysical and astrophysical flows
35Q35 PDEs in connection with fluid mechanics
82D10 Statistical mechanics of plasmas
35C08 Soliton solutions
85A30 Hydrodynamic and hydromagnetic problems in astronomy and astrophysics

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Keywords:

dust-ion-acoustic waves; nonthermal distribution; Zakharov-Kuznetsov equation; dusty electronegative plasma; instability; reductive perturbation method

Full Text: DOI

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