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Study of propagation of linear and non-linear Alfvén-gravity waves in rotating medium

L.N. Achala [a,*], M. Venkatachalappa [b]

[a] P. G. Department of Mathematics and Research Centre in Applied Mathematics, MES College, Bangalore 560003, India
[b] Department of Mathematics, Central College, Bangalore University, Bangalore 560 001, India

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ABSTRACT

Travelling waves in an incompressible, infinitely conducting, inviscid fluid of variable density are investigated under the influence of a horizontal magnetic field and Coriolis force. Periodic solutions are found in the limit of infinite vertical wave length. Phase diagrams are drawn to show the solution.

1. Introduction

It has been established that disturbances in uniformly rotating incompressible liquids can propagate as wave motions. Many aspects of upper atmospheric dynamics and ionospheric irregularities may be explained in terms of internal gravity waves which are responsible for transfer of momentum and energy from one region to another. The effect of Coriolis force due to Earth's rotation plays an important role in the understanding this mechanism. Venkatachalappa et al. [1] have studied the propagation of linear and non-linear travelling waves in a compressible rotating atmosphere. Venkatachalappa et al. [2] investigated the propagation of linear and non-linear travelling waves in an exponentially stratified incompressible rotating fluids. Venkatachalappa et al. [3] have studied the propagation of linear and non-linear hydromagnetic waves in an exponentially stratified non-rotating incompressible medium. In the present paper we analyse the effect of rotation and magnetic field on linear and non-linear internal gravity waves propagating in an exponentially stratified incompressible and infinitely conducting fluid. The waves under study are governed by a system of nine non-linear inhomogeneous PDEs. We seek travelling wave solutions of this system. The resulting ODE system is reduced via some first integrals to one of third order and analysed in phase-space.

The scheme of the present paper is as follows. Section 2 contains basic equations and travelling wave formulation. Phase-plane analysis for both linear and non-linear waves is given in Section 3 and the conclusion of the present study in Section 4.

2. Basic quations

We consider Cartesian coordinate system with x and y axes in the horizontal plane and the z-axis along the vertical direction. We study quasi-simple waves in an incompressible, infinitely conducting stratified fluid rotating with a uniform angular velocity Ω about vertical axis in the presence of an applied horizontal magnetic field. The equations governing the unsteady system are

$$\rho\left[\frac{D\vec{q}}{Dt}+2\vec{\Omega}X\vec{q}\right]+\nabla P-\rho\vec{g}-\mu(\vec{H}\cdot\nabla)\vec{H}=0, \tag{1}$$

$$\frac{D\rho}{Dt}=0, \tag{2}$$

$$\nabla\cdot\vec{q}=0, \tag{3}$$

$$\frac{D\vec{H}}{Dt}-(\vec{H}\cdot\nabla)\vec{q}=0, \tag{4}$$

$$\nabla\cdot\vec{H}=0, \tag{5}$$

* Corresponding author.
E-mail address: anargund@hotmail.com (L.N. Achala).

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