Excitations of distorted magnetosonic lump waves by orbital charged space debris objects in ionospheric plasma

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Abstract. We consider the forced Kadomtsev-Petviashvili I (KPI) equation derived in a recent work on magnetosonic waves excited by space debris objects of Acharya et al. [Adv. Space Res. 69, 4045-4057 (2022)] for further analysis in this work. For first time, we have derived a special exact distorted lump wave solution of the forced KPI equation for a specific localized form of the forcing function. The reason for choosing such a typical forcing function has been discussed in detail in the context of orbital motions of charged space debris objects in ionospheric plasma. Such exotic magnetosonic lump wave structures showing characteristic distortions resulted by orbital charged space debris objects can have potential implications in their indirect detection methods.

Introduction

The excitations of nonlinear magnetosonic waves by orbital motions of charged space debris objects have been recently investigated in inertial magnetohydrodynamics (MHD) framework by Acharya et al. [1]. These magnetosonic waves are found to be governed by a forced Kadomtsev-Petviashvili (KP) equation where the forcing function interprets effects of charged space debris objects functioning as current density sources. In particular, nonlinear evolution of slow magnetosonic waves in entire parameter space and fast magnetosonic waves in a large region of parameter space has been shown to be governed by a forced KPI equation. Similarly, forced KPII equation governs dynamics in the remaining small region of parameter space for fast magnetosonic waves [1]. One important point in this context is that lump wave solutions showing bending features or distortions for the forced KPI equation have not been analysed in [1, 2, 3]. But such exotic magnetosonic wave structures can be of potential importance in designing indirect detection systems for space debris objects. Inspired by this fact, we have derived a special exact pinned distorted lump wave solution of the forced KPI equation in this work for a specific localized form of the forcing function for first time. The reason for choosing such a peculiar forcing function has been discussed in context of orbital space debris objects using [4, 5].

Results and discussions

The most important result of the special exact pinned distorted magnetosonic lump wave solution is that its characteristic distortions have been modelled in our work with an arbitrary function satisfying a set of appropriate localization conditions. The effects of orbital charged space debris objects are incorporated in our model using these localization conditions which specify the forcing function in the forced KPI equation. One significant advantage of our work is that different types of distortions in lump waves consistent with practical observations can be formulated with appropriate values of the arbitrary function. A typical distorted lump wave solution for an appropriate value of the arbitrary function has been shown in Figure 1.

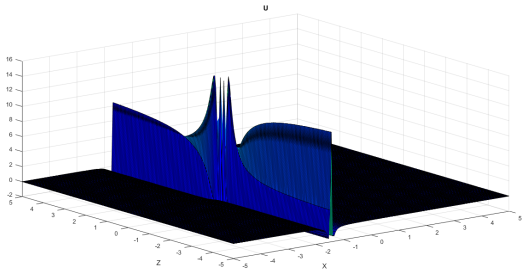

Figure 1: Distorted magnetosonic lump wave excited by a space debris object.

References

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