JGSP 30 (2013) 49–61

JOURNAL OF
Geometry and Symmetry in Physics
ISSN 1312-5192

A MODEL SUITABLE FOR NUMERICAL INVESTIGATION OF BEAM-SOLITON INTERACTION IN ELECTROSTATIC PLASMAS

EVSTATI G. EVSTATIEV

Communicated by Jean-Francois Ganghoffer

Abstract. We derive a model suitable for computer simulations of a weak ion beam with solitons of the Korteweg-de Vries (KdV) equation. This type of interactions arise in experiments on soliton generation in double plasma devices and include soliton growth, damping, or decay. Our simplified model aims at capturing only the essential physics of these interactions. The model is formulated in the context of plasma physics in the electrostatic approximation. The bulk plasma is described by cold fluid ions and warm, massless electrons. The ion beam is included as a separate plasma species and is coupled to the bulk plasma through Poisson's equation. The derivation uses the Lagrangian of the system of plasma and beam and an expansion in small amplitude perturbations around an equilibrium. The Korteweg-de Vries equation arises from this expansion naturally. The model is thus applicable to general weakly non-linear ion-acoustic plasma waves, of which solitons are a particular case. A novel feature of our method is that it includes both the evolution of the wave and the perturbation while in previous analyses the perturbation is kept fixed. The computational advantages of such description other approaches, such as fluid description of both plasma and beam or all kinetic description, are that in the former case particle trapping cannot be fully simulated while in the latter case the computational time is much longer and the numerical noise is higher than in our hybrid approach.

1. Introduction

The Korteweg-de Vries (KdV) equation has been derived in multiple areas of physics [19], including plasma physics [4, 9, 23] (see also the review article [20], and references therein). Ion-acoustic solitons were first observed by Ikezi *et al.* [13] and subsequently confirmed by other experimental groups [2, 18]. In plasma physics experiments it is rare that when plasmas are excited only the phenomenon under investigation develops. As a rule, a variety of phenomena occur simultaneously and often their interaction affects, or even obscures, the targeted physics. For example, in double plasma experiment machines [2, 13, 18], the excitation of

doi: 10.7546/jgsp-30-2013-49-61