Nonlinear Modulated Envelope Electrostatic Wavepacket Propagation in Plasmas [1, †]

Ioannis Kourakis [2]

Institut für Theoretische Physik IV, Fakultät für Physik und Astronomie
Ruhr–Universität Bochum, D–44780 Bochum, Germany
Email: ioannis@tp4.rub.de

Wave *amplitude modulation* is a generic nonlinear mechanism, known to dominate (finite amplitude) wave propagation in dispersive media. Its relevance to *energy localization*, localized *pulse formation* and wave *harmonic generation* phenomena is now long established in fields as diverse as Condensed Matter Physics, Nonlinear Optics and Biophysics. In Plasma Physics, the occurrence of such phenomena has been confirmed by experiments related to the nonlinear propagation of electrostatic (e.g. ion-acoustic) as well as electromagnetic (e.g. whistler) waves. In the context of Space Physics, localized modulated wave packets are encountered in abundance in the Earth's magnetosphere, for instance, where they are associated with localized field and/or density variations observed during recent satellite missions. Furthermore, recent studies have supplied evidence for the relevance of such effects in dust-contaminated (*complex*) plasmas, where a strong presence of mesoscopic, massive, charged dust grains strongly affects the plasma characteristics.

This presentation is dedicated to a brief review of the occurrence of amplitude modulated structures in plasmas, followed by a theoretical analysis of the mechanism of carrier wave (self-) interaction with respect to electrostatic plasma modes. A generic collisionless fluid model is applied. Both cold– (zero-temperature) and warm–fluid descriptions are discussed and compared. The weakly nonlinear oscillation regime is investigated by applying a multiple scale technique and a Nonlinear Schrödinger Equation (NLSE) is obtained, describing the evolution of the slowly varying wave amplitude in time and space. The amplitude's stability profile reveals the possibility of *modulational instability* to occur under the influence of external perturbations. This NLSE admits exact localized envelope (solitary wave) solutions of bright (*pulses*) or dark (*holes, voids*) type, whose characteristics depend on intrinsic plasma parameters. The role of perturbation obliqueness, finite temperature and defect (dust) concentration is explicitly considered. The relevance of this description, as regards known *e-i* [1, 2] (and *complex* [3 - 5]) plasma modes, is briefly discussed.

References

[1] I. Kourakis and P. K. Shukla, *J. Phys. A: Math. Gen.*, **36** (47), 11901 (2003).
[2] *Idem*, *Phys. Rev. E*, **69** (3), 036411 (2004).
[3] *Idem*, *Phys. Plasmas*, **10** (9), 3459 (2003).
[4] *Idem*, *Eur. Phys. J. D*, **28**, 109 (2004).
[5] *Idem*, *Phys. Scripta*, **69**, 316 (2004).

[1] *22nd Summer School and International Symposium on the Physics of Ionized Gases (SPIG 2004)*, 23 - 27 August, 2004, National Park "Tara", Serbia and Montenegro.
† Collaboration with Padma Kant Shukla.
[2] On leave from: U.L.B. - Université Libre de Bruxelles, Faculté des Sciences Appliquées, C.P. 165/81 Physique Générale, Ave. F. D. Roosevelt, B-1050 Brussels, Belgium (ikouraki@ulb.ac.be).