

# Nonlinear modulated electrostatic wave packets in e-p-i plasmas or in pair-ion plasmas doped with a stationary charged component

I. Kourakis<sup>1,†</sup>, A. Esfandyari-Kalejahi<sup>2</sup>, P. K. Shukla<sup>1</sup>

<sup>1</sup> Ruhr-Universität Bochum, Institut für Theoretische Physik IV, D-44780 Bochum, Germany

<sup>2</sup> Azarbaijan University of Tarbiat Moallem, Faculty of Science, 51745-406, Tabriz, Iran

† Email: ioannis@tp4.rub.de

The nonlinear amplitude modulation of electrostatic wave packets propagating in a three-component plasma is investigated, by employing a two-fluid plasma description. Focus is made on *electron-positron-ion* (e-p-i) plasmas [1]; alternatively, the model describes pair-ion [2] (eg. fullerene [3]) plasmas contaminated by a uniform and stationary minority charged particle species (e.g. defects, or dust particulates). Wave propagation parallel to the external magnetic field is considered. Two distinct electrostatic modes are obtained, namely an acoustic lower mode and a Langmuir-like optic-type upper one, in agreement with previous studies of pair plasmas [2, 4]. Considering a weakly nonlinear deviation from equilibrium, a nonlinear Schrödinger equation for the slowly varying electric potential perturbation amplitude.

The modulational stability analysis shows that both modes are sensitive to variations of the positive-to-negative-ion (or positron-to-electron) density and temperature ratio(s). It is shown that the lower (acoustic) mode is stable for large wavelengths, and may propagate as a dark-type envelope soliton (a potential dip, or a void). On the other hand, the upper (optic) one is modulationally unstable, and favors the formation of bright-type envelope solitons (pulses).

These results may be of relevance in experimental [3] and astrophysical [1] contexts. In specific, one may anticipate that the existence of a third minority species in pair plasmas (e.g. defects, or dust) may be used to “tune” the stability profile of electrostatic modes.

## References

- [1] F. C. Michel, *Rev. Mod. Phys.*, **54**, 1 (1982).
- [2] R.G. Greaves and C. M. Surko, *Phys. Rev. Lett.* **75**, 3847 (1995).
- [3] W. Oohara and R. Hatakeyama, *Phys. Rev. Lett.* **95**, 175003 (2005); W. Oohara, D. Date and R. Hatakeyama, *Phys. Rev. Lett.* **95**, 175003 (2005).
- [4] I. Kourakis, A. Esfandyari-Kalejahi, M. Mehdipoor and P.K. Shukla, *Modulated electrostatic modes in pair plasmas*, submitted to *Physics of Plasmas*.