NITheP cordially invites you to a seminar by:

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Date: Tuesday, 12th November 2013
Time: 14h14 – 15h15
Venue: NITheP Seminar Room, H-Block, 3rd Floor

TITLE: Fundamentals of electrostatic solitary structures in multispecies plasmas

Abstract:

Large solitary electrostatic structures in multispecies plasmas cannot be described by weakly nonlinear methods like reductive perturbation theory, but require a Sagdeev pseudopotential or equivalent analysis, which assumes that structures propagate with constant shape, and far from this disturbance the plasma is at rest. This approach reduces the fluid equations, together with Poisson’s equation, to a pseudomechanical energy-balance equation, involving a pseudopotential \( S(\varphi, M) \), where \( \varphi \) is the electrostatic potential, and leads to hump or dip soliton, or double layer/kink profiles for \( \varphi \). Here \( S(\varphi, M) \), is a function of \( \varphi \) and of the compositional parameters fixing the plasma model, but also of the a priori unknown solitary structure velocity \( M \). The problem then consists in determining the appropriate parameter ranges for solitary structures to be possible, which usually involves some numerics to evaluate the analytical expressions.

We have recently succeeded in proving a number of new results, which constrain the traditional numerical trial-and-error methods that one finds commonly in the relevant literature. First, an important analytical tool in structuring the discussion is the generic property that \( \partial S / \partial M < 0 \), which involves only the inertial fluid species. Hence, for a fixed plasma composition and a chosen \( \varphi \), we can obtain neighbouring pseudopotentials by varying \( M \), but these can never cross one another. This has an immediate bearing on the location of the roots, which correspond to the amplitudes of the solitary structures, and enables us to focus on regions in parameter space where such solutions can be encountered.

Second, and equally important, there is a systematic way in which one can determine the sign of the KdV-like solitary structures, which have amplitudes which become arbitrarily small as \( M \to M_s \), as do solutions of Korteweg-deVries equations, but can become quite large if \( M \) can be increased sufficiently above the acoustic speed \( M_s \). On the other hand, there might be solutions of the opposite polarity, which are then additional to the KdV-like solitons, but have a minimum amplitude and are therefore called “nonKdV-like”. When solutions of both polarities are possible for the same plasma model one speaks of “coexistence”. Third, I will address the novel concept of “supersolitons”, which are distinguished from ordinary solitons by their electric field signatures (a quantity seldom investigated in soliton studies), having additional “wiggles” on the typical bipolar structures prominent in space observations.