

## §6. Kinetic Self-Organization: Multiple Generation of Ion-Acoustic Double Layer

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It has been well established that the magnetohydrodynamic (MHD) plasma is a good medium in which self-organization takes place. The idea of "self-organization" which was shown in those previous works is: The parallel plasma current provides a free magnetic energy by which a current-driven kink instability (global instability) is excited to give rise to a global topological change in magnetic field configuration, whereby a non-linear rapid energy dissipation takes place. On top of the above conditions, if a superfluous entropy (thermal energy) produced during the process is swiftly removed from the system to an surrounding world, a new stable ordered structure is established.

In this work, we attempt to investigate a self-organization process in a kinetic plasma. As a candidate for such a process, an ion-acoustic double layer(IADL) is chosen. In 1979, Sato and Okuda[1] found the IADL in kinetic plasmas by using one-dimensional electrostatic particle simulation. They expressed typical size of IADL was approximately  $1000\lambda_D$ . Recently, we re-examined the IADL formation by using a million particles (100 times larger than Sato's simulation). In our simulation, we found several sizes of IADL, e.g., 250, 500,  $1000\lambda_D$ . By changing the drift speed of the shifted Maxwellian in the range from  $v_d = 0.2$  to  $0.9v_{th}$  and the system size in the range from 512 to  $2048\lambda_D$ , we have definitely confirmed so far that the self-breeding and intermittently excitation of the IADL is really a physical phenomenon.

The results are summarized as follows:

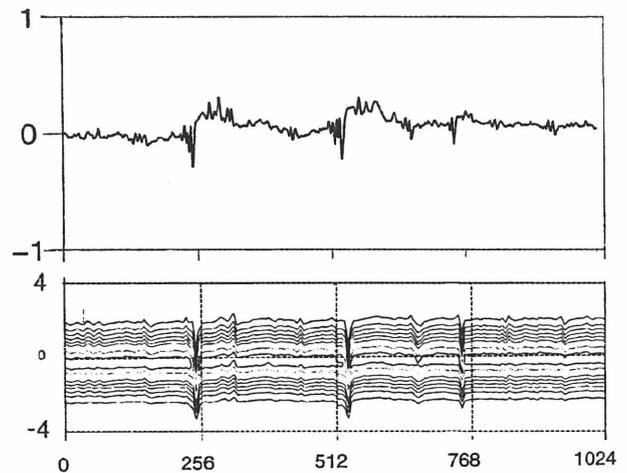
- 1) First, in the early phase of evolution, many V-type hole structures are formed in the ion phase space. The evolution is neither a monotone nor a single-shot.
- 2) A few of these V-hole structures are nonlinearly growing up, namely self-feeding or self-breeding condition is satisfied there, then IADLs with the primary size (typically  $250\lambda_D$ ) are simultaneously generated.
- 3) Secondly and most importantly, when the maximum potential difference reaches to the electron thermal energy during the evolution of IADLs, it happens that the behind side V-hole is struck out by high energy electrons which accelerated at the front side IADLs.

- 4) The size of new IADL structure is elongated toward double of the previous structure
- 5) Above process is repetitively generated.

So we call this intermittent and repetitive generation process as Shishiodoshi (a "scare-deer" stick in the Japanese fountain) type. Because, Shishiodoshi is that water flows into a short bamboo pipe which, when full, swings down, empties its water and swings back up.

To investigate the detail Shishiodoshi process for IADL formation, we performed particle simulations that several type of the hole structure are artificially put into the initial ion phase structure. These results are that (1) in the case of the "inverted-V" and "O" hole structure, all of IADLs are independently generated, (2) in the case of the "V" hole structure, the formation of IADLs are definitely introduced. These results indicate that the formation of ion hole structure is necessary process for generation of IADLs.

In this works, we found that multi-step Shishiodoshi process is important issue to generate IADL structure.



☒ 1: Spatial structure for the electrostatic Potential(top) and the ion phase space (bottom)

### Reference

- 1) Sato,T. and Okuda,H., *Phys.Rev.Lett.* **44**, 740 (1980); *J.Geophys.Res.* **86**, 3357(1981).
- 2) H.Takamaru et.al. *J.Phys.Socs.Jpn.* **66**, 3826-3830(1970)