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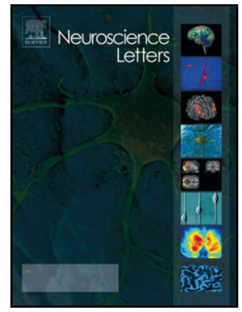

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TOWARDS PLASMA-LIKE COLLISIONLESS TRAJECTORIES IN THE BRAIN

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HIGHLIGHTS

- Plasma collective movements are similar to brain dynamics.
- We build a plasma-like model for brain activity.
- We elucidate the possible role of collisionless activities in cortical phase transitions.

ABSTRACT

Plasma studies depictcollisionless, collective movements of charged particles. In touch with these concepts, originally developed by the far-flung branch of high energy physics, here we evaluate the role of collective behaviors and long-range functional couplingsof charged particlesin brain dynamics. We build a novel, empirically testable, brain model which takes into account collisionless movements of charged particles in a system, the brain, equipped with oscillations. The model is cast in a mathematical fashionwith the potential of being operationalized, because it can be assessed in terms of McKean-Vlasov equations, derived from the classical Vlasov equations for plasma. A plasma-like brain also elucidates cortical phase transitions in the context of a brain at the edge of chaos, describing the required order parameters.In sum, showing how the brain might exhibit plasma-like features,we go through the concept of holistic behavior of nervous functions.

KEYWORDS

Extracellular space; current; spike; collisionless; collective dynamics; high energies

In the true plasma, i.e., the fourth state of matter displayed at high energies, the particles' collective behavior is governed by: a) the reciprocal influences among the nearby charged particles embedded in a so called "Debye sphere", and b) by a plasma parameter, e.g., the average number of particles in the sphere (Sturrock, 1994; Goldston and Rutherford, 1995). In plasma, the spontaneous formation of spatial features takes place on a wide range of length scales on the boundary of a metastable state, giving rise to collisionless particles' collective movements (Cheng and Gamba 2012). A slight change in just one or two parameters is able to give rise to completely different particle trajectories and collisionless patterns.
We would not call brain function with the term *plasma*, but we will use instead the term *plasma-like*. The reason of our terminological choice is that, in true plasma, long-range correlations are preserved in order to avoid the large, disruptive electromagnetic fields which develop in presence of net charge. Furthermore, large systems of interacting particles