# Strange Attractors in Drift Wave Turbulence

(oral presentation)

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There are growing experimental, numerical and theoretical evidences that the anomalous transport observed in tokamaks and stellarators is caused by slow, drift-type modes (such as trapped electron modes and ion-temperature gradient-driven modes). Although typical collision frequencies in hot, magnetized fusion plasmas can be quiet low in absolute values, collisional effects are nevertheless important since they act as dissipative sinks.

As it is well known, dissipative systems with many (strictly speaking more than two) degrees of freedom are often chaotic and may evolve towards a so-called attractor. Each attractor can be conveniently characterized, in particular, through its Hausdorff dimension; some attractors have noninteger (fractal) dimensions and are called strange attractors.

We study the possible existence of strange attractors in particle-in-cell (PIC) model of electrostatic drift waves with kinetic electrons in the presence of collisional effects. In order to study the system on long time scales, and noting the stringent (numerical) condition of $\sim \sqrt{m_i/m_e} \gg 1$, we introduce the splitting scheme, which is based on an exact separation between adiabatic and nonadiabatic electron responses. The linear and nonlinear elliptic problems that arise in the splitting scheme are solved using a multigrid solver.

The motivation behind the multigrid particle-in-cell method is that this scheme yields more accurate linear growth rates, as compared to the standard $\delta f$ scheme [1], and has better momentum and energy conservation properties, as compared to other electron schemes.

The computation of the attractor dimension using conventional box-counting algorithms are very difficult when the number of degrees of freedom ($\equiv N_f$) is larger than two [2]. In this talk, we use the method of Grassberger and Procaccia [3] to determine a lower bound, known as the correlation exponent, to the attractor dimension. It is shown that a low-dimensional attractor does exist for our specific model and that its dimension is sensitive to the electron-ion collision frequency. The existence of a low-dimension attractor in a system with a large number of degrees of freedom has also been observed in a very different context: the evolution of the Earth's climate. The implications of such attractors will be discussed.

## References

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[3] P. Grassberger and I. Procaccia, Phys. Rev. Lett., **50**, 346 (1983).