Granulation Formation and Turbulent Trapping in Wave Kinetics

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Plasma physics has contributed two notable problems to nonlinear science, namely the problem of Vlasov turbulence and the nonlinear modulation instability or "collapse" problem, typified by the Langmuir turbulence problem. Here, we combine the ideas and methods of these two problems to describe turbulent trapping in nonlinear modulational dynamics.

We argue that it is convenient to classify approaches to the well-known modulation dynamics problems according to their location in a 2D space parametrized by the eikonal ray Chirikov parameters (which exceeds unity when group-phase resonances overlap) and the ray Kubo number K (which exceeds unity when a trapped ray bounces several times in a single structure). The regime where $s > 1$ and $K \gtrsim 1$ is the regime of *turbulent trapping*. We show that both the 1D Langmuir and 2D drift wave-zonal flow interaction problems in this regime may be mapped to the 1D Vlasov turbulence problem in the regime of turbulent trapping. We then apply the theory of phase space density granulation, developed for turbulent trapping in Vlasov systems, to describe the turbulent trapping of waves in modulation structures. We focus on three specific issues, namely:

i.) the modification of the dynamics of relaxation of the wave population $\langle N \rangle$ induced by granulations. In particular, the diffusive quasi-linear wave-kinetic equation is replaced by a Lenard-Balescu type equation, with a drag, induced by incoherent fluctuations in N (i.e. granulations).
ii.) the appearance of novel modulational instability mechanisms related to granulations.
iii.) the role and significance of caustics in the theory. These are interesting as they have *no* counterpart in the Vlasov turbulence problem.

Special attention will be given to turbulent trapping in drift wave-zonal flow turbulence.