Nonlinear Phase Synchronization and Intermittency Enhancement: the role of spacing in shell models

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Résumé

A shell model can be considered as a self-similar chain of interacting triads, where each triad can be interpreted as a nonlinear oscillator that can be mapped to a spinning top. Investigating the relation between phase dynamics and intermittency in such a chain of nonlinear oscillators, it is found that synchronization is linked to increased energy transfer. In particular, our results indicate that the observed systematic increase of intermittency, as the shell spacing is decreased, is associated with strong phase alignment among consecutive triadic phases, facilitating the energy cascade. It is shown that while the overall level of synchronization can be quantified using a Kuramoto order parameter for the global phase coherence in the inertial range, a local, weighted Kuramoto parameter can be used for the detection of burstlike events propagating across shells in the inertial range. This analysis reveals how locally phase-locked states are associated with the passage of extreme events of energy flux. Applying this method to helical shell models (i.e., for a class of helical interactions that couple the two helicities in a nonseparable topology) reveals that a reduction in phase coherence correlates with suppression of intermittency. When inverse cascade scenarios are considered using two different shell models including a nonlocal helical shell model, and a local standard shell model with a modified conservation law, it was shown that a particular phase organization is needed in order to sustain the inverse energy cascade. It was also observed that the PDFs of the triadic phases were peaked in accordance with the basic considerations of the form of the flux, which suggests that a triadic phase of

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