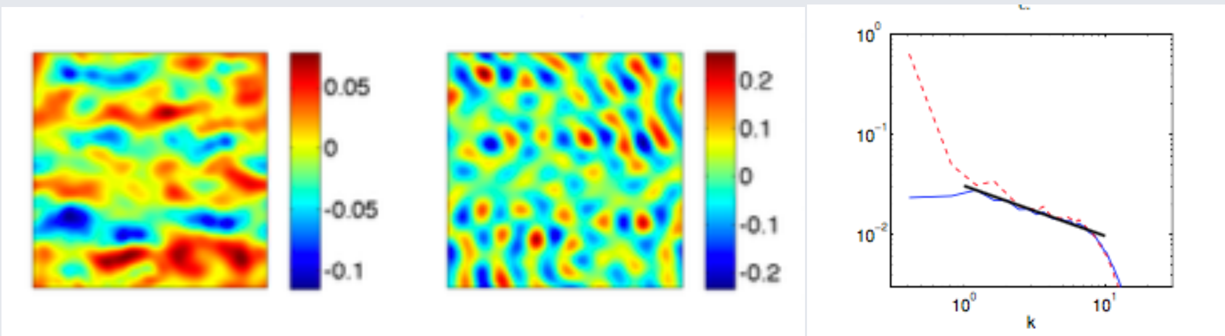
Wave turbulence of gluons

B. gallet, S. Nazarenko and B. Dubrulle (SPEC, CEA).

In field theory, particles are waves or excitations that propagate on the fundamental state. In experiments or cosmological models one typically wants to compute the out-of-equilibrium evolu- tion of a given initial distribution of such waves. Wave Turbulence deals with out-of-equilibrium ensembles of weakly nonlinear waves, and is therefore well-suited to address this problem. As an example, we consider the complex Klein-Gordon equation with a Mexican-hat potential. This simple equation displays two kinds of excitations around the fundamental state: massive particles and massless Goldstone bosons. The former are waves with a nonzero frequency for vanishing wavenum- ber, whereas the latter obey an acoustic dispersion relation. Using wave turbulence theory, we derive wave kinetic equations that govern the coupled evolution of the spectra of massive and mass- less waves.



They admit a two-parameter family of thermodynamic equi- librium spectra of the Rayleigh-Jeans type. When the initial condition corresponds to little energy per particle, the thermodynamic state reached in the long-time limit displays massless-wave condensation, the classical analogue of Bose-Einstein condensation. The out- of-equilibrium dynamics is dominated by nonlocal interactions in scale-space. We have highlighted two cases of such nonlocal evolution. The first one is when a massive mode spontaneously decays into massless waves, and the second one is when small-scale fields evolve in presence of an intense large-scale condensate. In the latter regime some particles are rapidly transferred to the condensate, and the small-scale remaining waves follow a single reduced kinetic equation which admits a Kolmogorov-Zakharov solution corresponding to an energy cascade with a $k^{-1/2}$ power-law. This state corresponds to a case where nonlocal transfers of particles with the condensate coexist with a local energy cascade. This state is therefore the intermediate asymptotics that describes the evolution between the initial distribution of waves and the thermodynamic equilibrium attained in the long-time limit.

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