In the last two decades, there has been substantial progress in the study of nonlinear dispersive PDE thanks to the influx of ideas and tools from nonlinear Fourier and harmonic analysis, geometry and analytic number theory, to the existing functional analytic methods. This body of work has primarily focused on deterministic aspects of wave phenomena and answered important questions related to existence and long time behavior of solutions in various regimes. Yet there remain important obstacles and open questions.

A natural approach to tackle some of them, and one which has recently seen a growing interest, is to consider certain evolution equations from a non-deterministic point of view (e.g. the random data Cauchy problem, invariant measures, etc) and incorporate to the deterministic toolbox, powerful but still classical tools from probability as well. Such approach goes back to seminal work by Bourgain in the mid 90's where global well-posedness of certain periodic Hamiltonian PDEs was studied in the almost sure sense via the existence and invariance of their associated Gibbs measures.

In this talk we will explain these ideas, describe some recent work and future directions, with an emphasis on the interplay of deterministic and probabilistic approaches.