Research Interests

Random Matrix Theory and applications in statistical mechanics and field theory

The applications of random matrices are manyfold. Their analytical predictions for spectral statistics can be seen to hold in many physical systems, notably in the context of quantum chaos, in the Riemann ζ-function in mathematics, as well as in stock market prices in economics or spacial correlations in biology. See the reference below for more examples. In many of such instances the findings are ad hoc, and the energy window, in which such a random matrix approximation holds, is not easy to derive from the underlying theory.

There are several exceptions however. The complex eigenvalues of non-Hermitian random matrices directly describe the distribution of point charges in a two-dimensional static Coulomb gas in a confining potential, at specific values of the inverse temperature of the Gibbs measure. Second, the ground state wave function of trapped, noninteracting Fermions can be directly mapped to the joint density of eigenvalues of Hermitian or non-Hermitian random matrices in one or two dimensions, in various setups (rotation, magnetic field). Third, in quantum field theory in the phase with broken chiral symmetry, notably in Quantum Chromodynamics, the effective theory of Goldstone bosons reduces to leading order in a certain finite volume limit to a random matrix ensemble.

These direct relations and the universal appearance of random matrix statistics motivates more mathematical investigations of their properties. It is fascinating to see, how many features of physical or other systems can be incorporated in simple random matrix ensembles, while keeping their integrability. Tools from various areas of mathematics can be applied, including analysis, discrete mathematics or probability theory. One of my favourites is the theory of orthogonal polynomials and their asymptotic analysis. Despite being a classical topic, many interesting open questions prevail.

Keywords: non-Hermitian random matrices, eigenvalue and eigenvector statistics, unitary group integrals, determinantal and Pfaffian point processes, planar orthogonal polynomials, universality

Literature: *The Oxford Handbook of Random Matrix Theory*,
Gernot Akemann, Jinho Baik, and Philippe Di Francesco (Editors),
Oxford University Press, Oxford 2011, xxxii+919 pages,
`https://doi.org/10.1093/oxfordhb/9780198744191.001.0001`