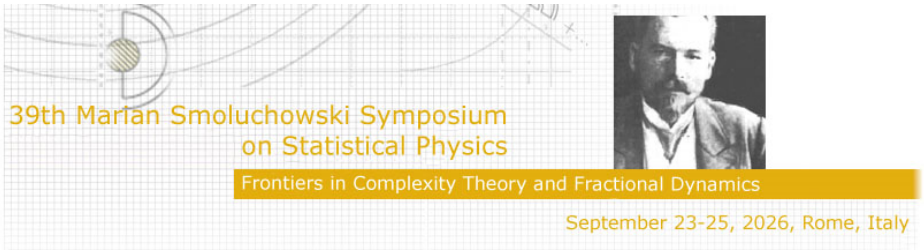

Contribution ID: **29** Type: **Invited talk**

The Cost of Ignorance: Sparse Corruption and BBP-Type Transitions in Low-Rank Matrix Inference

Wednesday, 23 September 2026 14:30 (30 minutes)

Low-rank matrix inference is a central problem in high-dimensional statistics, machine learning, and statistical physics. In the classical spiked random matrix setting, a rank-one signal is corrupted by dense random noise, and the celebrated BBP transition marks the point at which the signal becomes detectable by principal component analysis. In many applications, however, the corrupting noise is not dense but sparse, structured, and graph-like. What is the cost of ignoring this sparsity and applying 'vanilla' PCA to recover the signal buried under a sparse noise?

In this talk, I will discuss a rank-one spiked matrix model in which the noise is the weighted adjacency matrix of a sparse random graph with finite average connectivity. Using the replica method, we compute the typical top eigenvalue, the distribution of the top eigenvector components, and the overlap between the top eigenvector and the planted signal. The solution is expressed through recursive distributional equations (integral equations for auxiliary probability density functions) that can be solved efficiently by a population dynamics algorithm.

The resulting phase diagram reveals a sparse analogue of the BBP transition, whose threshold depends explicitly on the graph degree distribution and average connectivity. In our setting, the detachment of a signal-related eigenvalue from the spectral bulk does not necessarily coincide with successful recovery by the leading eigenvector. A structural outlier generated by the sparse noise can dominate the spectrum, creating an intermediate regime in which the signal is spectrally visible but not recoverable by the top principal component. In the large-connectivity limit, the standard dense-noise BBP results are recovered.

These results illustrate how tools from disordered systems and random graphs can sharpen our understanding of spectral inference beyond the classical dense-noise paradigm.

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