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Interpretable order parameters from persistent homology in non-Abelian lattice gauge theory

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Finding interpretable order parameters for the detection of critical phenomena and self-similar behavior in and out of equilibrium is a challenging endeavour in non-Abelian gauge theories. Tailored to detect and quantify topological structures in noisy data, persistent homology allows for the construction of sensitive observables. Based on hybrid Monte Carlo simulations of SU(2) lattice gauge theory I will show how the persistent homology of filtrations by chromoelectric and -magnetic fields, topological densities and Polyakov loops can be used to gauge-invariantly and partly without cooling algorithms uncover a multifaceted picture of the confinement-deconfinement phase transition. In classical-statistical simulations far from equilibrium the topological observables reveal self-similar scaling related to a non-thermal fixed point. The results showcase the extensive versatility of persistent homology in non-Abelian gauge theories, with promising perspectives in relation to topological machine learning for lattice field theories.

This talk is based on joint works with Jürgen Berges, Kirill Boguslavski, Jan Pawlowski and Julian Urban.

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