Targeted simulation-based inference of dark matter substructures in strong gravitational lenses

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Galaxy-galaxy strong gravitational lenses are a unique laboratory for probing dark matter substructure and testing the ΛCDM paradigm. However, performing precise statistical analysis of such observations is extremely challenging, since it requires disentangling the source galaxy's light from the lens' mass distribution and marginalizing over different substructure configurations. In this talk I will present a new multi-stage method that combines parametric lensing models and a likelihood-free neural simulation-based inference method called truncated marginal neural ratio estimation (TMNRE). I will explain how TMNRE enables measuring both the properties of individual subhalos and directly the parameters of the subhalo mass function, overcoming limitations of likelihood-based analyses. I will finally show the first application of machine learning to a real strongly lensed observation by reanalyzing JVASB1938+666 system, one of the few examples so far of substructure detection using traditional gravitational imaging technique. These first results demonstrate that this method is imminently applicable to existing lensing data and to the large sample of very high-quality observational data that will be delivered by near-future telescopes.