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# Machine Learning for Next-Generation Gravitational Wave Observatories: The MANGO Project

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The next generation of gravitational wave observatories—the Einstein Telescope (ET), Cosmic Explorer (CE), and LISA—will revolutionize astrophysics but present unprecedented data analysis challenges. LISA will detect tens of thousands of overlapping signals requiring simultaneous inference in high-dimensional Bayesian settings, while ground-based detectors will face thousands of overlapping compact binary coalescences annually. Traditional MCMC methods suffer from poor scalability and slow convergence, making them impractical for the expected detection rates and computational demands of third-generation facilities.

The MANGO project addresses these challenges through a comprehensive ML framework. Central to our approach is GWINESS (Gravitational Wave Inference using NEural Source Separation), which uses encoder-decoder architectures inspired by music source separation to disentangle overlapping gravitational wave signals and accelerate classical inference pipelines. MANGO extends this across five objectives: reproducible ML pipelines aligned with Data Challenges; automated detector characterization with denoising diffusion models; source separation in confusion regimes; neural surrogates and normalizing flows for rapid parameter estimation; and scalable population inference with anomaly detection. Recent progress encourages this approach—CNNs achieve matched-filtering sensitivity with orders-of-magnitude faster latency, while normalizing flows produce posteriors in seconds rather than hours.

This talk will present the GWINESS framework for LISA's Global Fit problem, demonstrate how hybridizing physics-based inference with deep learning dramatically reduces computational costs, and discuss MANGO's broader strategy to prepare the community for the transformative science of next-generation gravitational wave astronomy.

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