Empirical Inference

MPI-IS Retreat

Schluchsee, 2025

DINGO: Neural Posterior Estimation for Gravitational Waves

Collaboration including:

- **MPI-IS & ELLIS Institute & Uni Tübingen**
- Albert Einstein Institute
- University of Nottingham
- University of Rhode Island
- …


Maximilian Dax

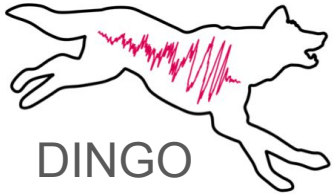

Annalena Kofler


Jonas Wildberger


Vincent Berenz


Jakob Macke

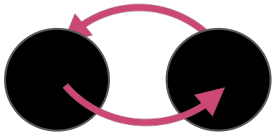

Bernhard Schölkopf



Talk by Annalena Kofler

Posterior Estimation for Gravitational Waves

Black holes merge → Emit gravitational wave



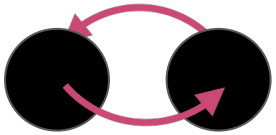
Described by physics parameters

$$\theta \in \mathbb{R}^{15}$$

Masses, spins, location, orientation

Posterior Estimation for Gravitational Waves

Black holes merge → Emit gravitational wave → Measured in detectors



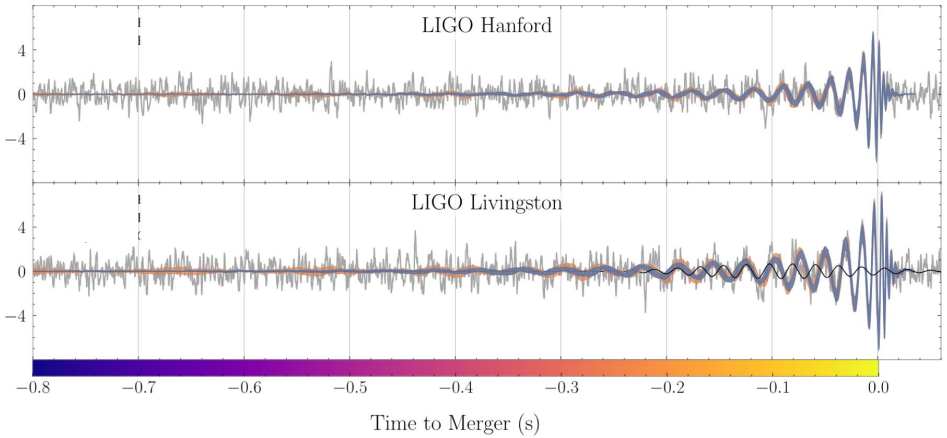
Described by physics parameters

$$\theta \in \mathbb{R}^{15}$$

Masses, spins, location, orientation

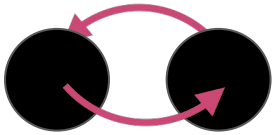
Universe

Measured data d



Posterior Estimation for Gravitational Waves

Black holes merge → Emit gravitational wave → Measured in detectors



Described by physics parameters

$\theta \in \mathbb{R}^{15}$

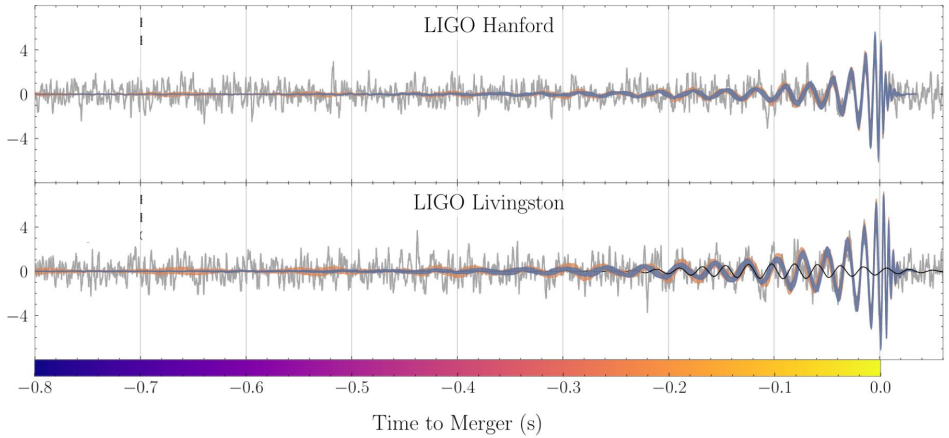
Masses, spins, location, orientation

Universe →

← Posterior Estimation

$p(\theta \mid d)$

Measured data d



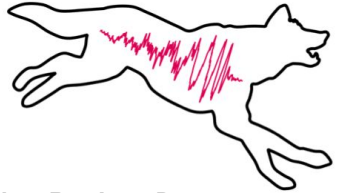
Goal: Extract information about parameters θ from data d

Why Machine Learning?

- **Fast** (real-time inference)
- **Computationally cheap** (~ 1 event per day in 2025)
- **Accurate** (Importance sampling)

Allows for …

- Searches for interesting physics (e.g., eccentricity[1])
- Pre-merger inference of binary neutron stars[2]
- Application to future detectors[3]
- Will be used within LIGO collaboration!



[1] **Gupte+ 2024**, “Evidence for eccentricity in the population of binary black holes observed by LIGO-Virgo-KAGRA”, *under review at* ***Phys.Rev.Lett. D***
[2] **Dax+ 2025**, “Real-time gravitational-wave inference for binary neutron stars using machine learning”, ***Nature***
[3] **Santoliquido+, 2025**, “Fast and accurate parameter estimation of high-redshift sources with the Einstein Telescope”, *under review at* ***Phys.Rev.Lett. D***

Come talk to us during the coffee break
if you have questions!