

Accelerated Bayesian inference of multimessenger astronomy with jax and machine learning

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Nuclear Multi-Messenger Astrophysics

- NMMA: Nuclear Multi-Messenger Astrophysics (Peter T.H. Pang)
- A Pythonic library for probing nuclear physics and cosmology with multimessenger analysis
- Used for overview of EOS constraints, with “precomputed” EOS set (arXiv:2402.04172)
 - Metamodel
 - Speed-of-sound extension scheme

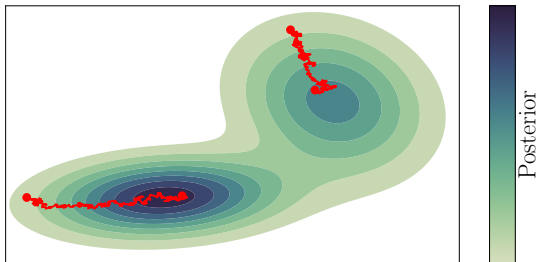
Next step: Infer EOS parameters directly from multimessenger data

Bayesian inference

Bayesian inference: get **posterior** of parameters θ from data d

$$p(\theta|d) = \frac{p(d|\theta)p(\theta)}{p(d)}$$

Problem: Prohibitively expensive with multimessenger data



JAX = NUMPY + composable transformations:

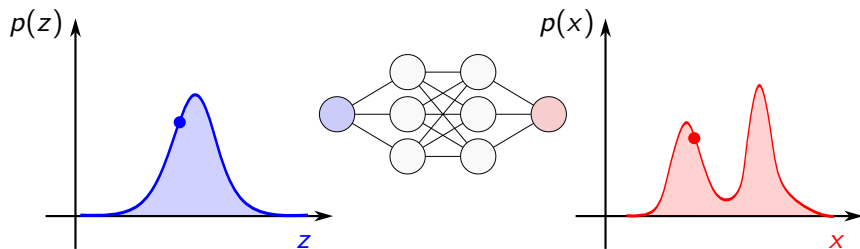
- ① Automatic differentiation
- ② Just-in-time (JIT) compilation
- ③ GPU acceleration
- ④ Parallelization




Potential for acceleration in various science areas!

Normalizing flows



- Generative machine learning model
- Learn mapping between **latent** and **parameter** space
- Enable approximate sampling from complicated distributions






Accelerating Bayesian inference for MMA: progress

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 - Analyze binary neutron stars in **15 – 30 minutes** rather than $\mathcal{O}(\text{hours})$ (arXiv:2404.11397)
 -  kazewong/jim




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- Future work:
 - Next-generation gravitational wave detectors
 - Combine into one multimessenger analysis pipeline