Recent example of SBI: (2310.12209)

pulsar timing arrays $\leftarrow$ radio astronomy

Nanograv
12.5 yr dataset
obs ~ 2 weeks
irregularly

~100 pulsars $\times$ 500 residuals each

ms pulsar

t_i ToA $\rightarrow$ δt_i residuals

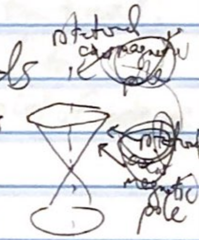
rotating $\lesssim 10$ ms $\longrightarrow$ very stable periods

old rapidly spinning neutron stars

maybe X-ray binary

radio pulses from rotating magnetic field

ie rotational axis, magnetic pole



rotational axis, magnetic pole

companion star

neutron

accretion disk

transferring ang. mom.

pulsar
stretch/squeeze
affect residuals
GW
ms

array of ms pulsars $\rightarrow$ very sensitive to passing gravitational waves

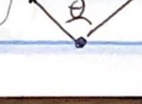
$\rightarrow$ "stochastic gravitational wave background"

SGWB

incoherent superposition supermassive BH binaries

$$\langle a_I(f)\, a_J(f') \rangle \sim A_{GW}^2 (f)^{-\gamma_{GW}} \chi_{IJ}\, \delta(f-f')$$

$$\boxed{\delta_I(t) = \int_{-\infty}^{\infty} df\, a_I(f) \cos 2\pi f t + (\sin)}$$



I, J, θ

$\gamma_{GW} = 13/3$ predicted

χ_{IJ} = "Hellings Downs curve" fn of θ

$$S_0\left(\delta_I(t_i)\,\delta_J(t_j')\right) \sim C_{IJ}(t_i - t_j')$$

$\downarrow$

"Gaussian process"

Giant gaussian cov

size $N_{pulsar} \times N_{residuals}$ $\sim$ 5000×5000

$$t_{iI}\left[C_{IJ}(t_i - t_j)\right]^{-1} t_{jJ}$$

$\rightarrow$ takes long time to invert!

$\sim$ 1 week for one plot of posterior

$\rightarrow$ neural posterior inference

$\rightarrow$ $\sim$ seconds!

Example 2: "optimal cosmological analysis"
2202.05282 Dai & Seljak

Generalizing cosmological inference beyond simple Gaussian CMB

- large scale structure — not Gaussian
- 3d maps (weak lensing, 21cm, ...) — too high dimensional

and beyond summary statistics

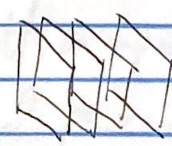
Goal: learn likelihood

$p(x|y)$

data

cosmo pars

Their example: 4 2D maps of matter overdensities 128^2 pixels each



$\leftarrow$ N body sim FastPM

vary Ω_m, σ_8 uniform prior

other ΛCDM pars fixed to Planck 2015

total dim:

$4 \times 128^2 = 65536$

$\rightarrow$ too large for ordinary flow!

→ Impose translation & rotation symmetries
reduce model parameters
want $f : X \to Z$ to be
rot & transl equivariant
then latent space has same symmetries as data

$\vec{x} = \begin{pmatrix} x_1 \\ \vdots \\ x_i \\ \vdots \end{pmatrix}$ pixel intensities

translation $i \to i+1$ these should have same PDF
$\vec{x}_i' = \vec{x}_{i-1}$ f map should preserve that automatically

$e^{-\vec{z}^2/2}$ is translation inv't

$\sum z_i^2 \quad \sum z_{i-1}^2$

Build f out of pixelwise nonlinearities $\Psi(\vec{x})$
Fourier transform convolution

$$\int d\vec{r}^{3\prime}\, \underbrace{T(\vec{r}-\vec{r}\,')}\, x(\vec{r}\,')$$

$$= \int d^3k\, e^{ik|\vec{r}|}\, T(k)$$ ← rot'l inv'ce

Ψ & T param
by NNs

→ "TRENF"

Impressive results on improving sensitivity to Ω_m, σ_8 vs conventional power-spectrum approach!