unimpeded: A universal parameter estimation, model comparison and tension quantification distributed over every dataset

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DiRAC

Simple and straightforward pip installable package gives you access across models and datasets!
Your choice of samplers! MCMC or Nested Sampling

```
pip install unimpeded

samples = unimpeded.get(data='planck_2018_CamSpec', model='lcdm',
method='ns')
```

Cosmological datasets

- CMB:(Plik, Camspec, NPIPE, BICEP) $\pm$ CMB lensing
- BAO:SDSS, BOSS, eBOSS, Lyα
- SNe: Pantheon, SH0ES
- WL: DESY1

Cosmological models

- ΛCDM : $H_0, \tau_{\mathrm{reio}}, \Omega_b h^2, \Omega_c h^2, A_s, n_s$
- $K\Lambda$CDM : ΛCDM $+ \Omega_K$ (varying curvature)
- $N\Lambda$CDM : Varying N_{eff} and total mass of 3 degenerate ν's
- $n\Lambda$CDM : Varying total mass of 3 degenerate ν's with N_{eff}=3.044
- $m\Lambda$CDM : Varying N_{eff} with two massless ν and one with m=0.06
- $n_{\mathrm{run}}\Lambda$CDM : ΛCDM $+ n_{\mathrm{run}}$ (running of spectral index $dn_s/d \ln k$)
- wCDM : ΛCDM $+ w$ (constant cosmological equation of state)
- $w_0 w_a \Lambda$CDM : ΛCDM $+ w_0 + w_a$ (varying dark energy equation of state, CLP)
- $r\Lambda$CDM : ΛCDM $+ r$ (varying scalar-to-tensor ratio)

Metropolis–Hastings MCMC

- Single "walker"
- Explores posterior
- Fast, if proposal matrix is tuned
- Parameter estimation, suspiciousness calculation
- Channel capacity optimised for generating posterior samples
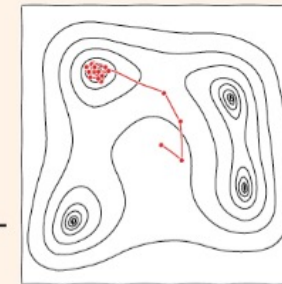
Nested Sampling

- Ensemble of "live points"
- Scans from prior to peak of likelihood
- Slower, no tuning required
- Parameter estimation, model comparison, tension quantification
- Channel capacity optimised for computing partition function
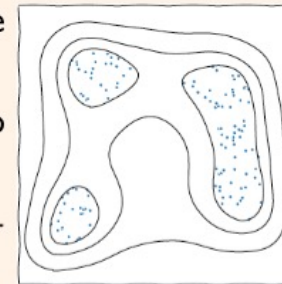
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DiRAC

➢ A re-usable library of machine learning emulators, implemented with piecewise normalising flows

➢ Rapid tension statistics comparisons across models and datasets

DES year 1
Emulated by `margarine`

Parameters: $\log(10^{10} A_s)$, n_s, Ω_k, H_0, $\Omega_b h^2$, $\Omega_c h^2$, τ_{reio}

	BAO vs BICEP	BAO vs DES	BAO vs Pantheon	BICEP vs DES	BICEP vs Pantheon	DES vs Pantheon	BAO vs Planck	BICEP vs Planck	DES vs Planck	Planck vs Pantheon
NΛCDM	-0.29	5.3	3.6	0.42	-0.19	2.2	7.3	2.8	1.9	3.9
rΛCDM	0.021	5.8	3.9	-0.5	0.4	1.9	6.7	2.9	0.52	3.5
$w_0 w_a \Lambda$CDM	1.3	5.9	3.8	0	-0.59	2.6	8.5	3.2	5	4.8
nrunΛCDM	0.013	5.3	3.5	0.55	-0.11	2.5	8	4.9	3.3	4
wΛCDM	0.62	5.5	3.6	0.2	-0.046	2.1	7.5	2.8	2.8	3.3
mΛCDM	-0.011	5.7	3.7	-0.51	-0.46	2.2	7.9	6.9	2.9	4.1
nΛCDM	1.3	7.4	3.1	1	0.23	3.3	4.7	4.2	6.2	0.19
KΛCDM	1.3	5.9	3.8	0	-0.59	2.6	8.5	3.2	5	4.8
ΛCDM	1.2	6.9	3.4	0.99	-0.045	2.6	4.9	2.5	5.6	0.52

$\log R$ mean