# Likelihood-free inference techniques † for cosmology

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## Bayesian forward modelling: the ideal scenario





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# Likelihood-based solution: BORG at work

www.aquila-consortium.org/



Initial conditions

### **Final conditions**

### Observations

### All data products are publicly available:

https://github.com/florent-leclercq/borg\_sdss\_data\_release, doi: 10.5281/zenodo.1455729

Jasche, FL & Wandelt 2015, arXiv:1409.6308

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## Likelihood-free inference: two scenarios

• Specific cosmological models ( $d \lesssim 10$ ), general exploration of parameter space

 Bayesian Optimisation for Likelihood-Free Inference (BOLFI)

Gutmann & Corander 2016, arXiv:1501.03291 FL 2018, arXiv:1805.07152

- Model-independent theoretical parametrisation (d ≥ 100), strong existing constraints in parameter space
- Simulator Expansion for Likelihood-Free Inference (SELFI)

FL, Enzi, Jasche & Heavens 2019, arXiv:1902.10149

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### **BOLFI**: Data acquisition



### **Bayesian Optimization in Action**

F. Nogueira, https://github.com/fmfn/BayesianOptimization

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FL 2018, arXiv:1805.07152

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# BOLFI: Re-analysis of the JLA supernova sample



- The number of required simulations is reduced by:
  - 2 orders of magnitude with respect to likelihood-free rejection sampling (for a much better approximation of the posterior)
  - 3 orders of magnitude with respect to exact Markov Chain Monte Carlo sampling

#### FL 2018, arXiv:1805.07152

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## SELFI: Method



FL, Enzi, Jasche & Heavens 2019, arXiv:1902.10149

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### SELFI + Simbelmynë: Proof-of-concept



 $N_{
m modes} \propto k^3$ : 5 times more modes are used in the analysis

#### FL, Enzi, Jasche & Heavens 2019, arXiv:1902.10149

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