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# CosmicRIM : Reconstructing Early Universe by Combining Differentiable Simulations with Recurrent Inference Machines

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## Abstract

Reconstructing the Gaussian initial conditions at the beginning of the Universe from the survey data in a forward modeling framework is a major challenge in cosmology. This requires solving a high dimensional inverse problem with an expensive, non-linear forward model: a cosmological N-body simulation. While intractable until recently, we propose to solve this inference problem using an automatically differentiable N-body solver, combined with a recurrent networks to learn the inference scheme and obtain the maximum-a-posteriori (MAP) estimate of the initial conditions of the Universe. We demonstrate using realistic cosmological observables that learnt inference is 40 times faster than traditional algorithms such as ADAM and LBFGS, which require specialized annealing schemes, and obtains solution of higher quality.

**Keywords:** Reconstruction, optimization, recurrent neural networks

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