

A hierarchical conditional generative model for planetary systems

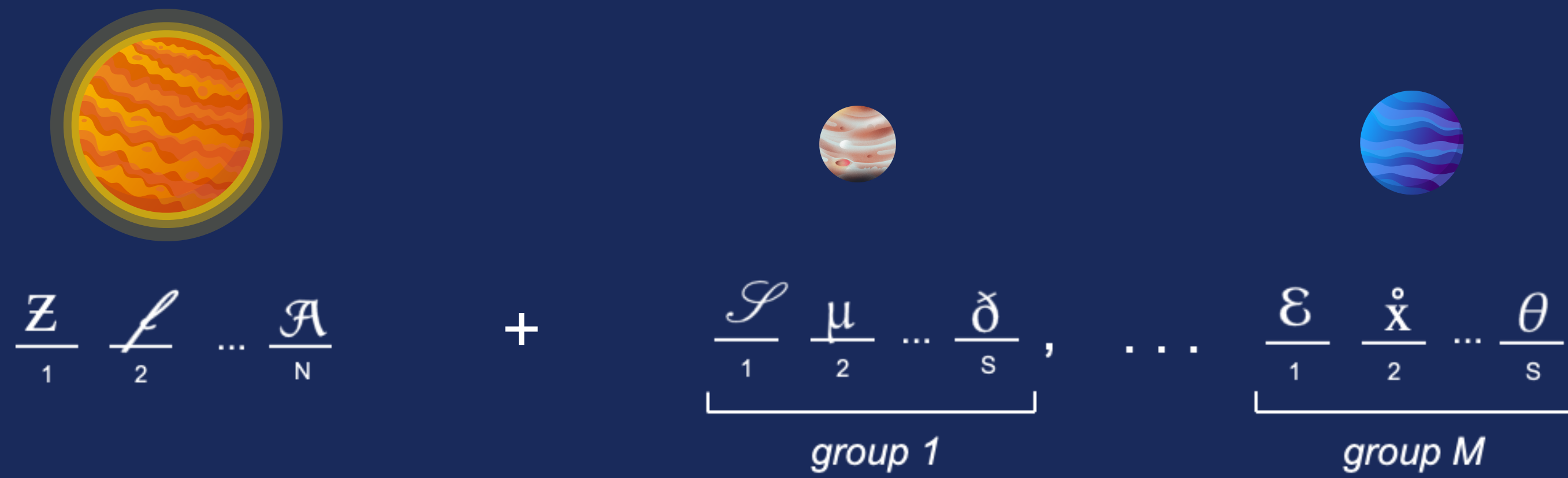
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1 Encode systems as sequences of tokens

We encode our data as a sequence of tokens. Each token encodes a property of the system or planet. In the end, we obtain a word characterising the system and planets within.



The data is encoded using an adaptive grid on the corresponding parameter space.

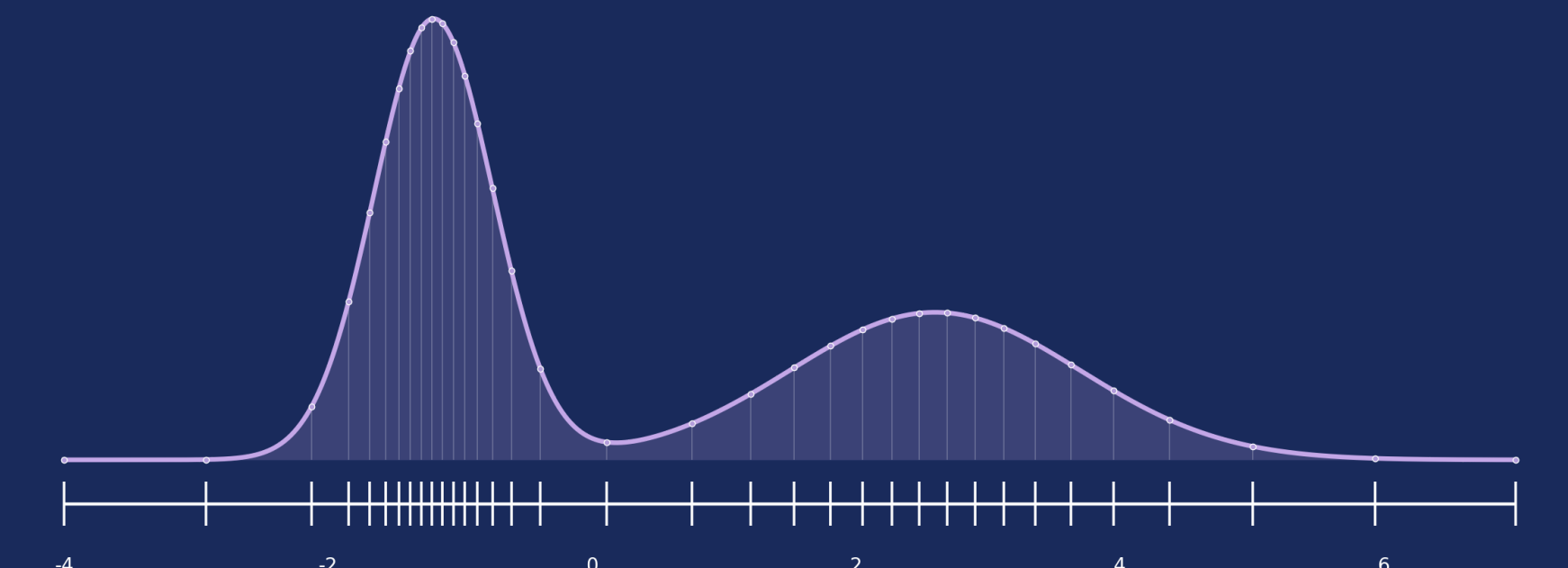


Fig 1. Example of a adaptive 1D grid containing 34 cells for a two Gaussian mixture distribution.

2 Train a Generative Model

We built a new generative model to generate new words, i.e. new complete systems of planets, conditioned on the global system properties, such as the stellar properties and/or protoplanetary disk properties. We use synthetic data from the Bern model (Emsenhuber et al. 2021) to train the model.

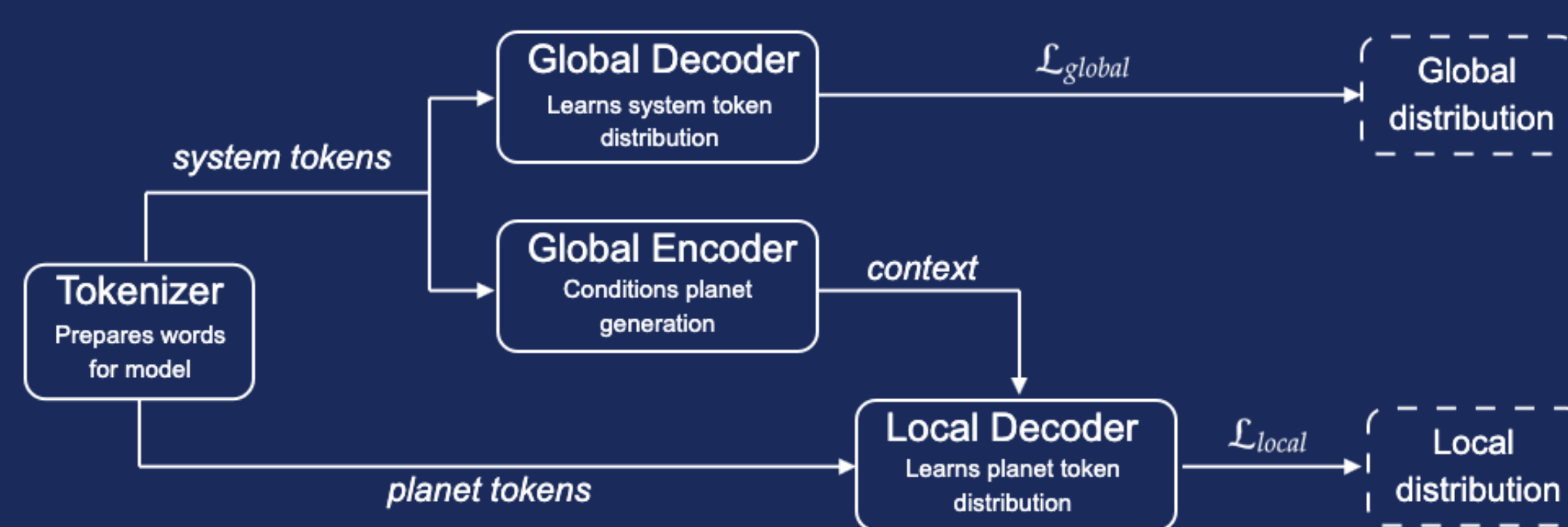


Fig 2. Overview of the architecture of the generative model

3 Evaluate generated systems

We verify that the newly generated systems contain the correlations and observational trends reproduced by the Bern model, that can be used to reproduce observational data.

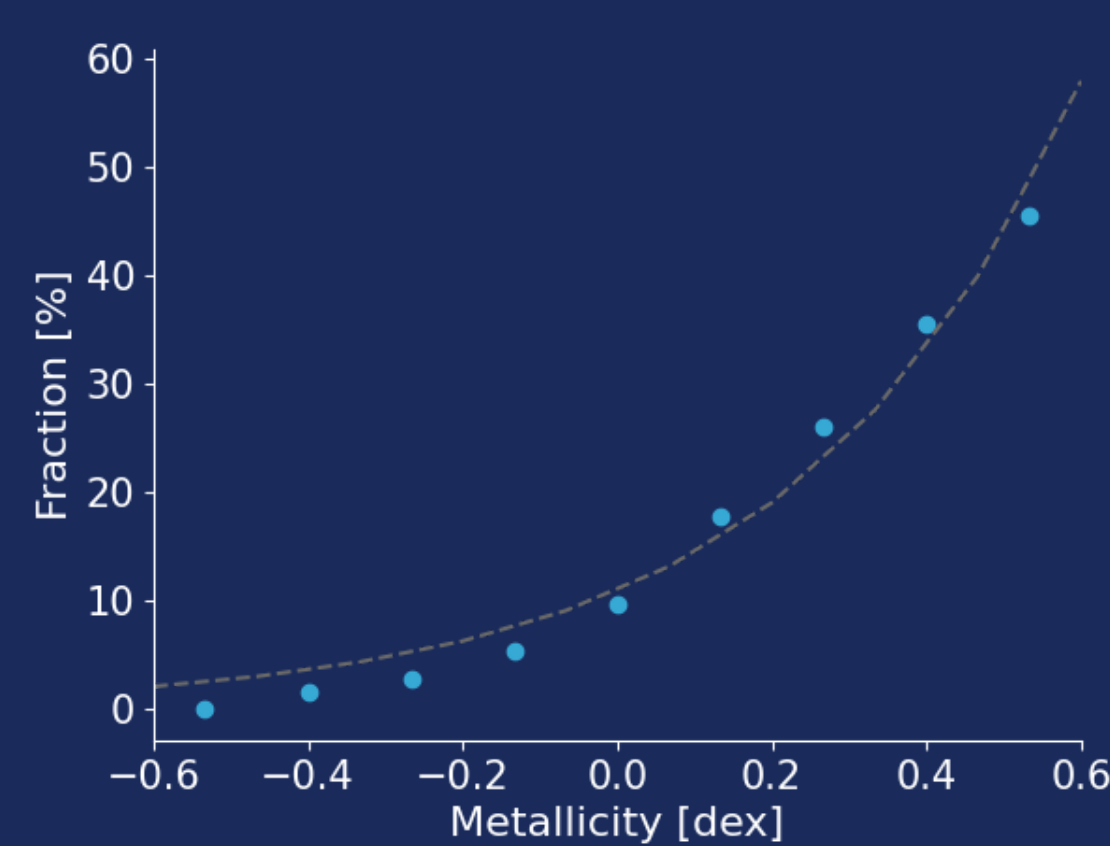


Fig 3. Giant-metallicity trend in generated systems.

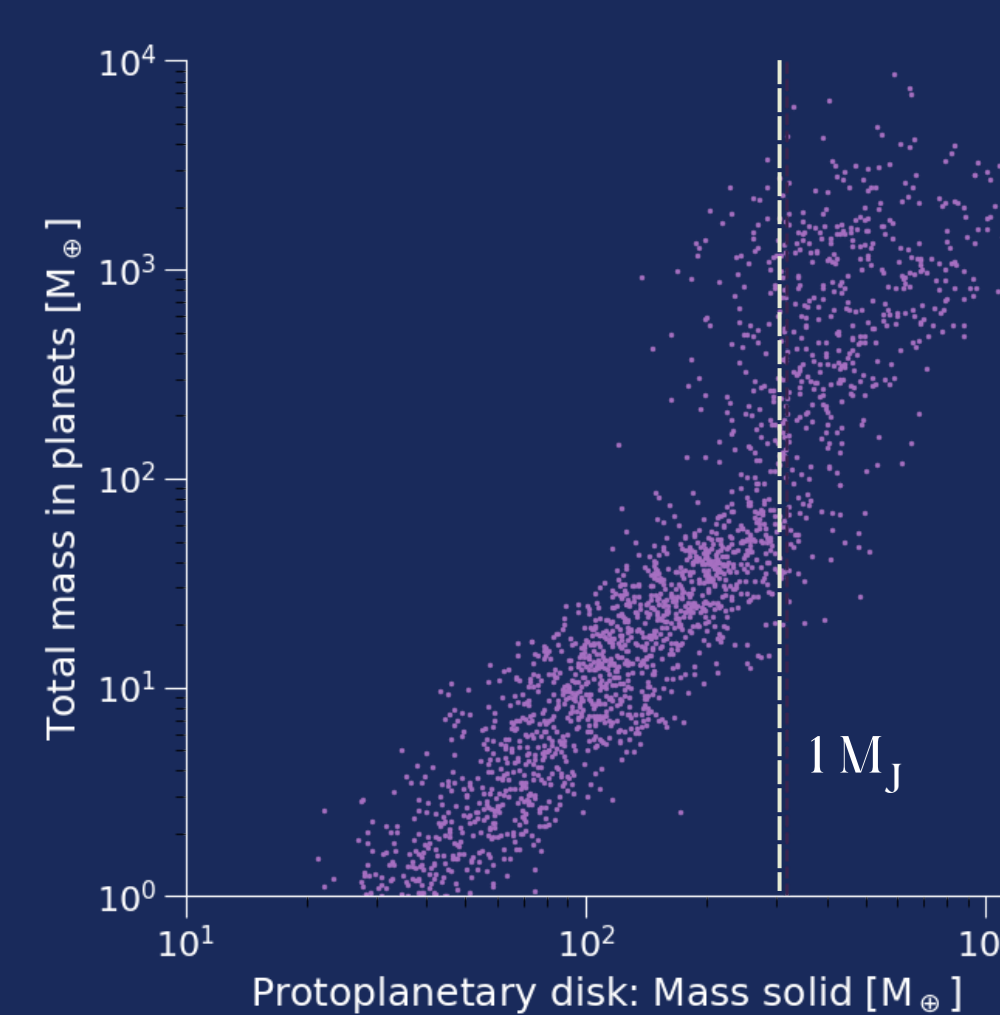


Fig 4. Mass of solids in protoplanetary disk converted to planets in a system.

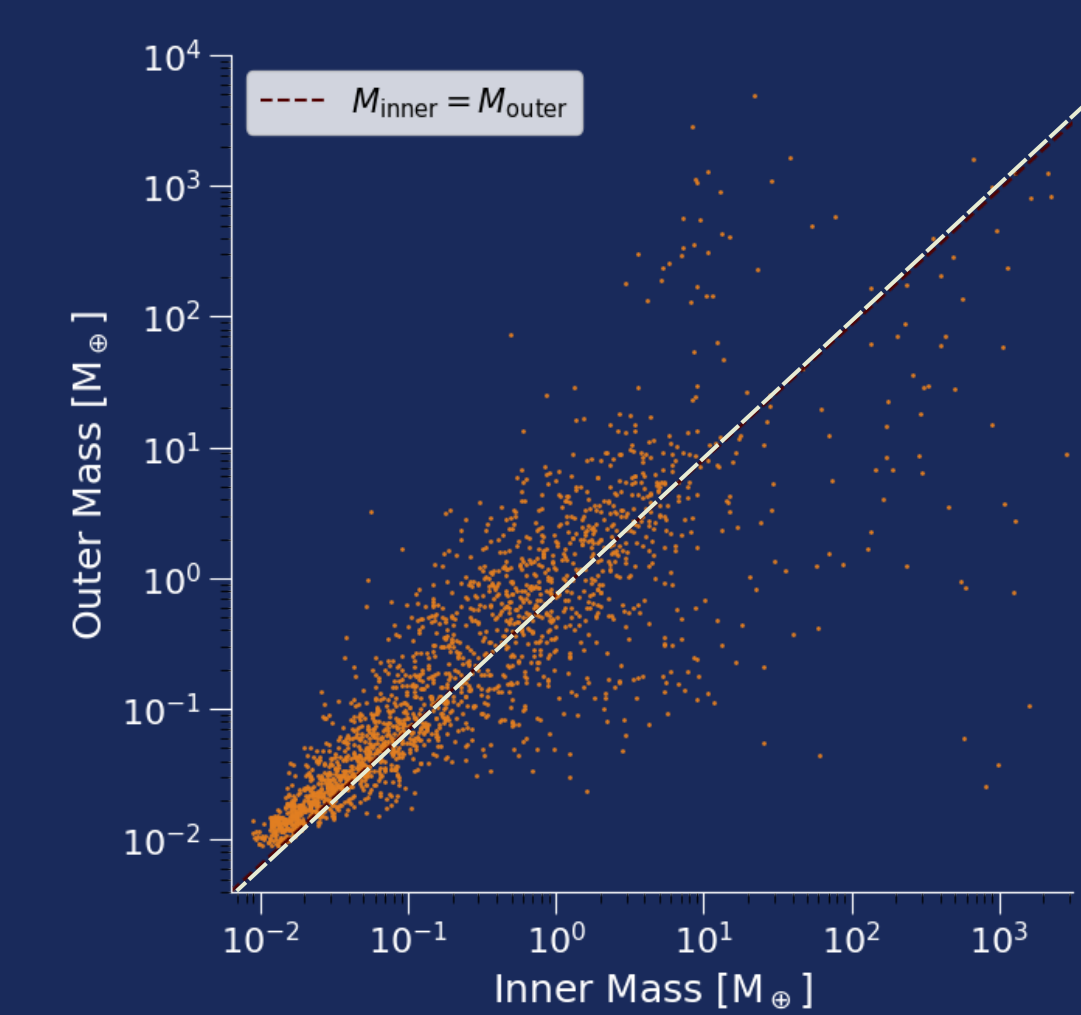


Fig 5. Similarity of mass for adjacent planets (peas-in-a pod).

4 Application to observed systems

The generated systems can be used to help predict the architecture of observed systems. As a demonstration, we hide planet b in system TOI-469 and predict the posterior distributions for the properties of planets c and d.

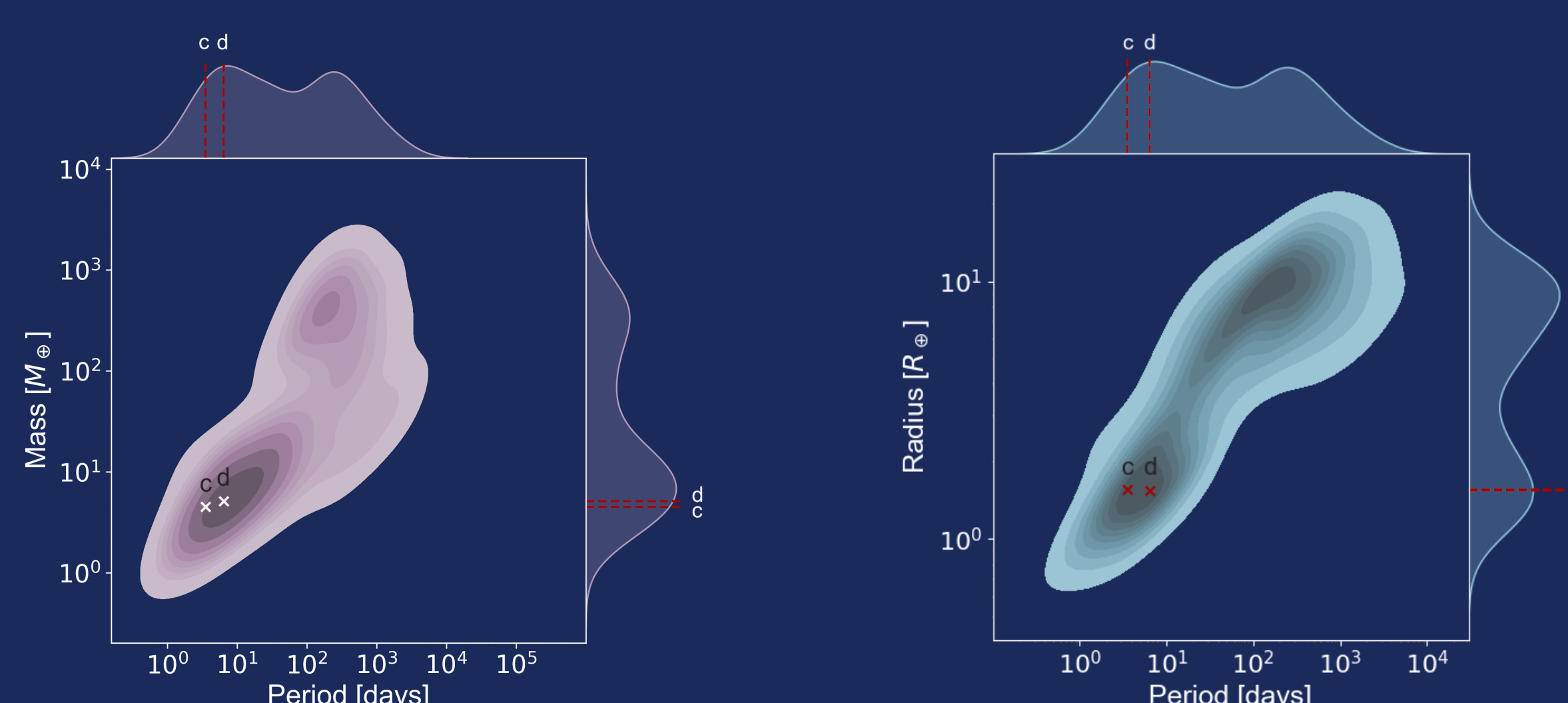


Fig 6. Posterior joint mass-period distribution for planets c and d for system TOI-469.

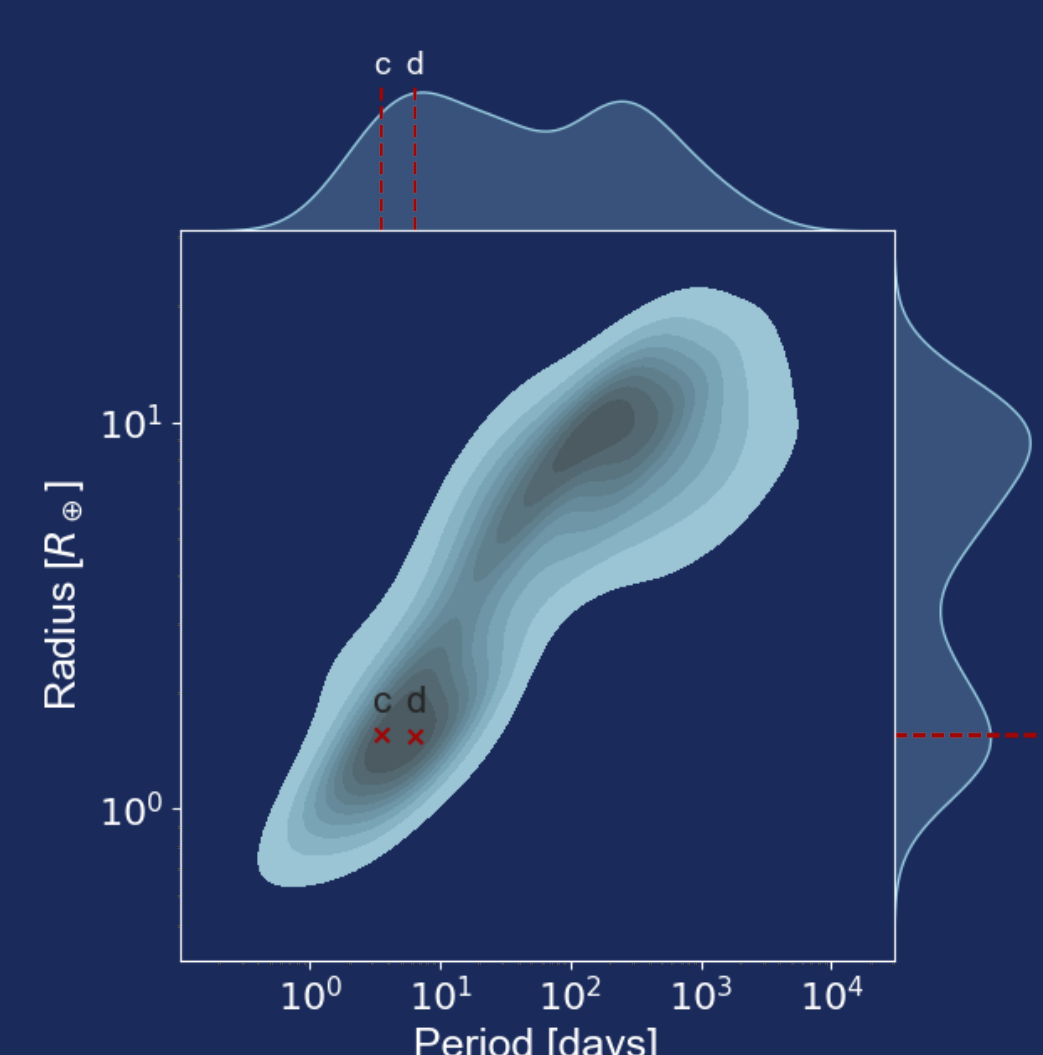


Fig 7. Posterior joint radius-period distribution for planets c and d for system TOI-469.

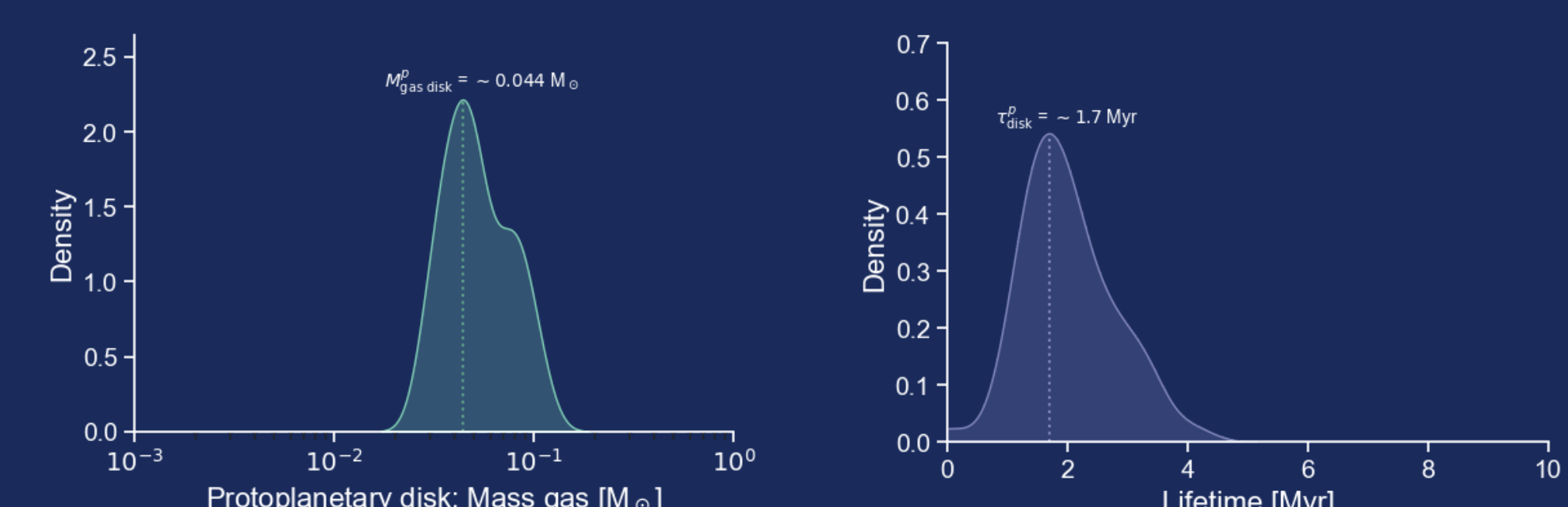


Fig 8. Prediction of protoplanetary disk properties for the system TOI-469