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Inference offers a metric to constrain dynamical models of neutrino flavor transformation

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The multi-messenger astrophysics of compact objects presents diverse environments where neutrino flavor transformation may be important for nucleosynthesis and a detected neutrino signal. Development of efficient techniques for surveying flavor evolution solution spaces, which complement existing computational tools, could leverage progress in this field. To this end we explore statistical data assimilation (SDA) to identify solutions to a small-scale model of neutrino flavor transformation. SDA is a machine learning formula wherein a dynamical model is assumed to generate measured quantities. We use an optimization formulation of SDA wherein a cost function is extremized via the variational method. Regions of state space wherein the procedure identifies the global minimum correspond to parameter regimes in which a model solution can exist. The study seeks to infer flavor transformation histories of two mono-energetic neutrino beams coherently interacting with each other and with a matter background. We require that the solution be consistent with flavor fluxes at detection, and with constraints placed on flavor at locations along their trajectories, including the Mikheyev-Smirnov-Wolfenstein resonances. Results intimate the promise of this "variational annealing" methodology to efficiently probe fundamental questions that traditional simulation codes render difficult to access.

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