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RTFAST-S: emulation of x-ray reflection around black holes

Bayesian analysis has begun to be more widely adopted in X-ray spectroscopy, but it has largely been constrained to relatively simple physical models due to limitations in X-ray modelling software and computation time. As a result, Bayesian analysis of numerical models with high physics complexity have remained out of reach. This is a challenge, for example when modelling the X-ray emission of accreting black hole X-ray binaries, where the slow model computations severely limit explorations of parameter space and may bias the inference of astrophysical parameters. We present RTFAST-Spectra: a neural network emulator that acts as a drop-in replacement for the spectral portion of the RTDIST flavour of the reltrans black hole X-ray reverberation model suite. This is the first emulator for the reltrans model suite and the first emulator for a state-of-the-art x-ray reflection model incorporating relativistic effects with 17 physically meaningful model parameters. We use Principal Component Analysis to create a light-weight neural network that is able to preserve correlations between complex atomic lines and simple continuum, enabling consistent modelling of key parameters of scientific interest. We achieve a O(100) times speed up over the original model in the most conservative conditions with O(1%) precision over all 17 free parameters in the original numerical model, taking full posterior fits from months to hours on a laptop.

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