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Title: Flexible non-parametric models for the simultaneous inference of systematics and astrophysical signals in Kepler light curves
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Abstract: The unprecedented photometric precision and stability of the light curves from Kepler present an interesting problem for probabilistic inference. It is well known that there are many significant systematic effects and artifacts in the data with magnitudes similar to---or larger than---many of the signals of interest. Standard practice involves removing these trends by robustly estimating a continuum level and then modeling the residuals as the sum of a physical signal (a transit model or stellar variability) and independent or rigidly correlated noise. We present a generalization to this method that allows the systematic trends to be simultaneously modeled as a flexible stochastic process. In practice, this method is implemented as a Gaussian process and we describe how it can be used as a drop-in replacement for the likelihood function of the data in any existing analysis code. We demonstrate the feasibility of scaling this method to large datasets by exploiting the sparsity of the problem using state-of-the-art sparse linear algebra libraries. To demonstrate the benefits of this method, we fit both simulated transits and previously known planetary systems and show that we recover reliable estimates of the planetary parameters and the uncertainties in these measurements. Using this model and a flexible non-parametric limb darkening model, we discuss the prospects for making photometric measurements of the surface brightness of stars with multiple transiting planets. As a final demonstration, we outline a transit search method based on our flexible systematics model.

All of the software associated with the project is available online (<https://github.com/dfm/bart>) and licensed under the MIT license. This research builds on collaborations between astronomers and statisticians forged during a three week workshop on "Modern Statistical and Computational Methods for Analysis of Kepler Data" at SAMSI in June 2013.