Extra-solar Planets via Bayesian MCMC Modeling

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Abstract

A remarkable array of new ground based and space based astronomical tools are providing astronomers access to other solar systems with over 450 planets discovered to date. This remarkable successes on the part of the observers has spurred a significant effort to improve the statistical tools for analyzing data in this field. Much of the recent work has highlighted a Bayesian MCMC approach as a way to better understand parameter uncertainties and degeneracies and to compute model probabilities.

I will describe a Bayesian multi-planet Kepler periodogram based on a new hybrid or fusion Markov chain Monte Carlo algorithm which incorporates parallel tempering, simulated annealing and genetic crossover operations. Each of these features facilitate the detection of a global minimum in chi-squared in a multi-modal environment. By combining all three, the algorithm greatly increases the probability of realizing this goal.

The fusion MCMC is controlled by a unique two stage adaptive control system that automates the tuning of the proposal distributions for efficient exploration of the model parameter space even when the parameters are highly correlated. The fusion MCMC algorithm is implemented in *Mathematica* using parallized code and run on an 8 core PC. To date, the algorithm has facilitated the detection of three new planets. Most recently, it was used to resolve the issue of a disputed second planet in 47 Ursae Majoris and provide evidence of a new third planet.

*http://www.physics.ubc.ca/ gregory/gregory.html