Application of Bayesian model inadequacy criterion for multiple data sets to radial velocity models of exoplanet systems

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We present a simple mathematical criterion for determining whether a given statistical model does not describe several independent sets of measurements, or data modes, adequately. We derive this criterion for two data sets and generalise it to several sets by using the Bayesian updating of the posterior probability density. To demonstrate the usage of the criterion, we apply it to observations of exoplanet host stars by re-analysing the radial velocities of HD 217107, Gliese 581, and \u{psion} Andromedae and show that the currently used models are not necessarily adequate in describing the properties of these measurements. We show that while the two data sets of Gliese 581 can be modelled reasonably well, the noise model of HD 217107 needs to be revised. We also reveal some biases in the radial velocities of \u{psion} Andromedae and report updated orbital parameters for the recently proposed 4-planet model. Because of the generality of our criterion, no assumptions are needed on the nature of the measurements, models, or model parameters. The method we propose can be applied to any astronomical problems, as well as outside the field of astronomy, because it is a simple consequence of the Bayes' rule of conditional probabilities.

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