Stan information for seminar

Stan is used within our project to provide statistical inference on the parameters affecting the Helium glitch within red giants. Stan allows us to harness the power of the ensemble by inferring hyperparameters shared across many thousands of red giants. This compensates for the large error associated with a single measurement of the solar-like oscillations of red giants.

Stan is defined as "a probabilistic programming language for specifying statistical models". A Stan program defines a log probability function over parameters determined by given data and constants. Stan utilises Markov chain Monte Carlo (MCMC) methods, primarily the No-U-Turn sampler (NUTS), an adaptive form of Hamiltonian Monte Carlo sampling. NUTS, automatically adapts the number of leapfrog steps in the MCMC, eliminating the need for the user to specify the tuning parameters.

We use Stan a great deal within our project to infer hyperparameters on the asymptotic expansion relation from Vrard 2010:

$$\nu_n = \left(n + \varepsilon + \frac{\alpha}{2}(n - n_{\max})^2 + \frac{\mathcal{A}\mathcal{G}}{2\pi}\sin\left(\frac{2\pi(n - n_{\max})}{\mathcal{G}} + \phi\right)\right)\langle\Delta\nu\rangle.$$

Whose parameters are defined as shown below:

Parameter	RGB	Clump
ε	$0.601 + 0.632\log\langle\Delta\nu\rangle$	
$n_{\max}$	$\nu_{\max}/\langle\Delta\nu\rangle - \varepsilon$	
α	$0.015\langle\Delta\nu\rangle^{-0.32}$	
$\mathcal{A}$	$0.06\langle\Delta\nu\rangle^{-0.88\pm0.05}$	$0.07\langle\Delta\nu\rangle^{-0.74\pm0.05}$
$\mathcal{G}$	3.08 ± 0.65	3.83 ± 0.88
ϕ	1.71 ± 0.77	-0.43 ± 0.66

These do not allow a spread of results in the ensemble of RGs, limiting the accuracy of the model, and by using Stan, better estimates of the parameters can be achieved. This is particularly important for the accurate determination of the amplitude of the glitch, denoted by $\mathcal{A}$. This can then be used to determine a law for helium enrichment as a function of metallicity.

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