SIGS - Seismic Inferences for Glitches in Stars

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Introduction

Asteroseismology is a method that studies the internal structure of pulsating stars by interpreting their frequency spectra. Different frequencies correspond to different oscillation modes that provide information about the interior of a star. Acoustic glitches are the regions where the sound speed undergoes an abrupt variation due to a localized sharp change in the stratification.

In this poster, a new set of codes, to become publicly available, are presented. These use the frequencies of oscillation of solar-type stars, together with some of the stellar atmospheric parameters, to automatically measure and characterize these acoustic glitches in these stars. Both the glitch at the base of the convective zone and at the helium ionization zones are simultaneously measured [2], using low-degree data.

Fitting Functions

Fitting Function for Frequencies: [3] [4]

$$\nu \simeq \nu_s +$$
$$+A_{BCZ}\left(\frac{\nu_r}{\nu}\right)^2 \cos\left(4\pi\tau_{BCZ}\nu + 2\phi_{BCZ}\right) +$$
$$+A_{HeII}\left(\frac{\nu_r}{\nu}\right)\sin^2\left(2\pi\beta_{HeII}\nu\right)\cos\left(4\pi\tau_{HeII}\nu + 2\phi_{HeII}\right)$$

Fitting Function for Second Differences: [5]

$$\nu = \sum_{k=0}^{\delta} c_k \nu^{-k}$$
$$+\left(\frac{A^*_{BCZ}}{\nu^2}\right)^2 \sin\left(4\pi\tau_{BCZ}\nu + 2\phi_{BCZ}\right) +$$
$$+\left[A^*_{HeII}\nu \exp\left(-\beta^*_{HeII}\nu^2\right)\right]\sin\left(4\pi\tau_{HeII}\nu + 2\phi_{HeII}\right)$$

τ_{BCZ} $\Rightarrow$ Acoustic depth at the Base of the Convective Zone

τ_{HeII} $\Rightarrow$ Acoustic depth at the Helium Second Ionization Zone

References

[1] R. A. Garcia et al. The acoustic low-degree modes of the Sun measured with 14 years of continuous GOLF & VIRGO measurements, Journal of Physics: Conference Series, Volume 271, Number 1, 2011

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[3] M. J. P. F. G. Monteiro, J. Christensen-Dalsgaard, & M. J. Thompson. Seismic study of overshoot at the base of the solar convective envelope. A&A, 283:247–262, March 1994

[4] M. J. P. F. G. Monteiro and M. J. Thompson. Seismic analysis of the second ionization region of helium in the Sun - I. Sensitivity study and methodology. Monthly Notices of the Royal Astronomical Society, 361:1187–1196, August 2005

[5] A. Mazumdar, et al. Acoustic glitches in solar-type stars from Kepler. Astronomische Nachrichten, 333:1040–1043, December 2012.

Acknowledgements

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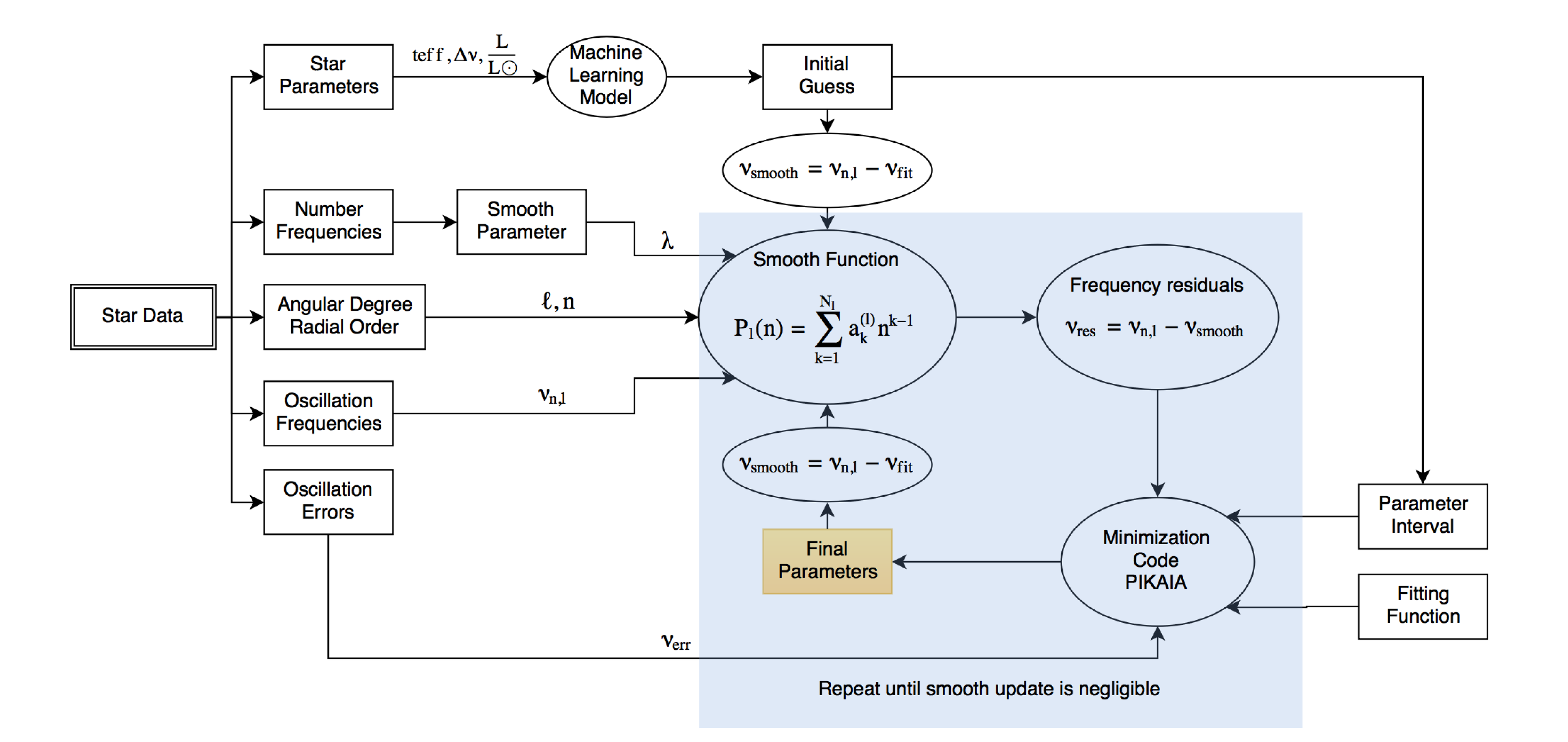
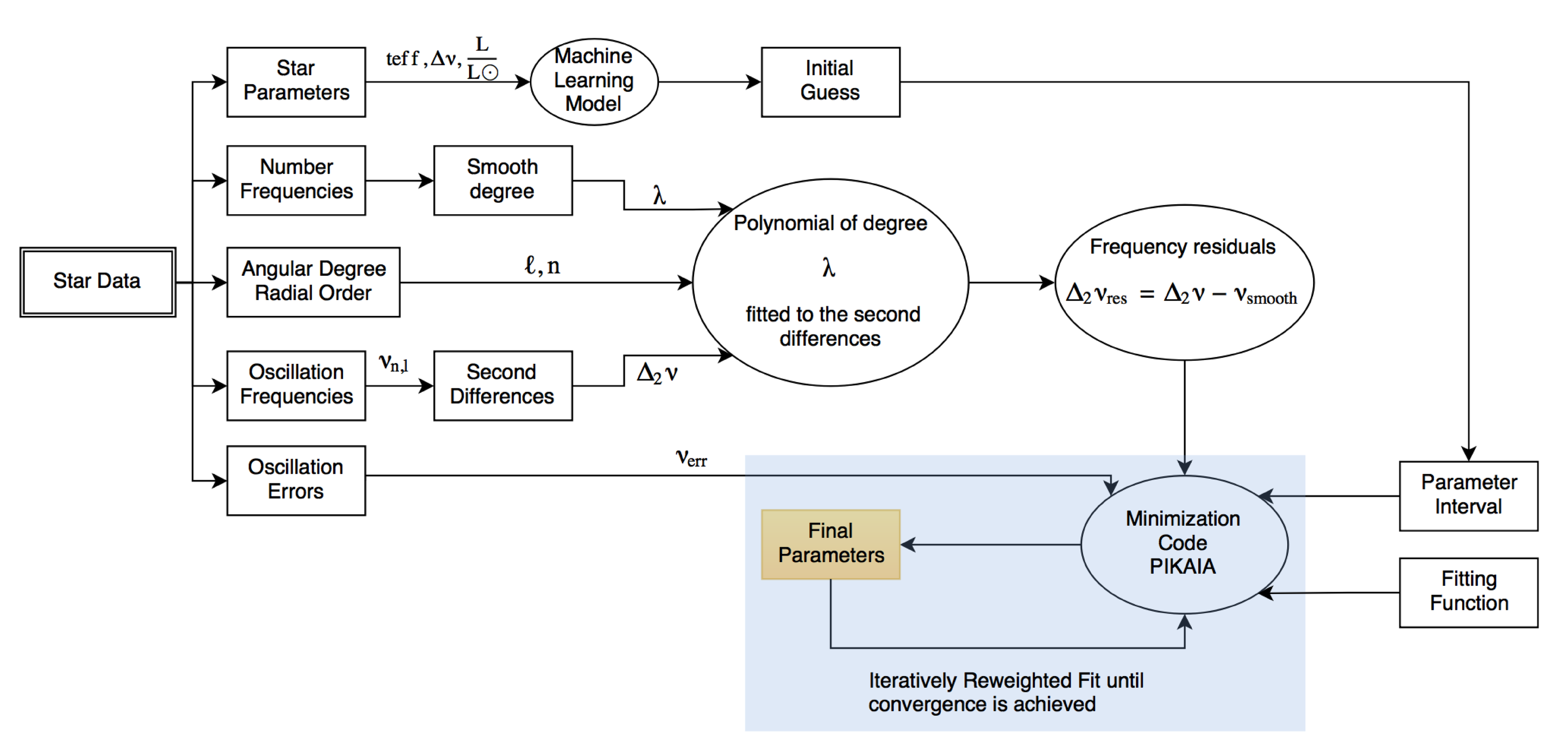
SIGS Frequencies Code Workflow



SIGS 2nd Differences Code Workflow



Code Validation

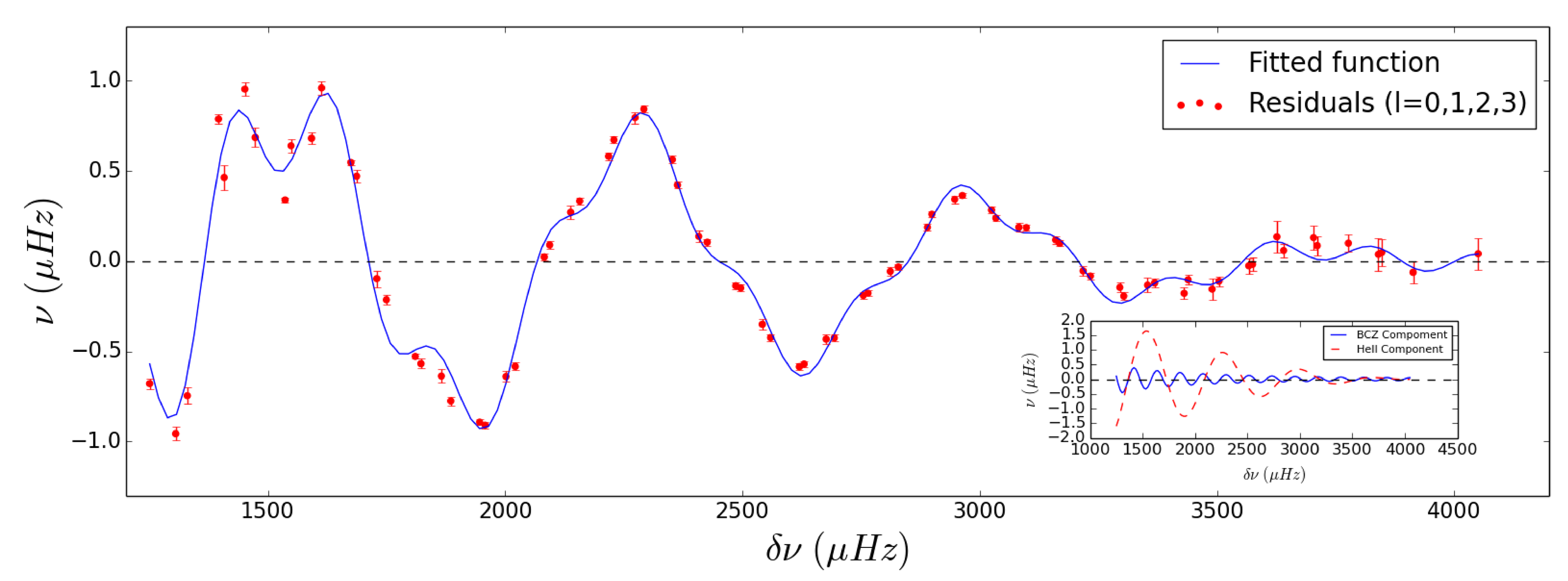


Figure 1: Residual frequencies after the smooth removal are adjusted to the frequencies fitting function. Both components (base of the convective zone, BCZ, and helium second ionization zone, HeII) are separated and showed in the inserted plot (78 solar frequencies [1] are used in the fitting).

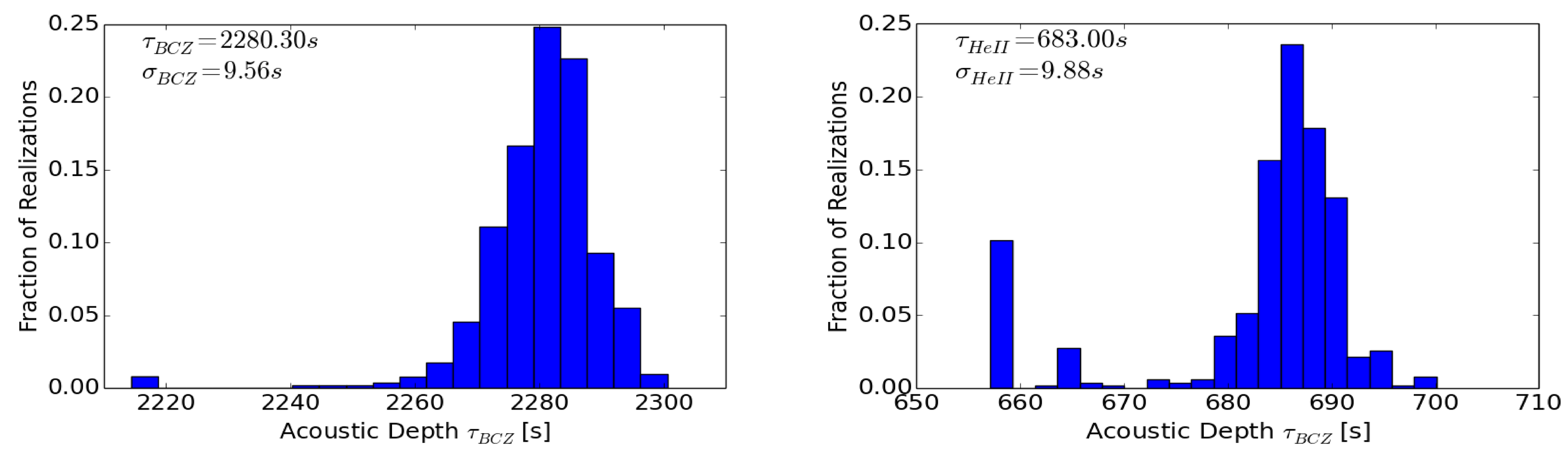


Figure 2: Histograms of the fitted values of τ_{BCZ} (on the left) and τ_{HeII} (on the right) for 500 Monte Carlo realizations of the oscillation frequencies.