Asteroseismology of KIC 7107778: a binary comprising almost identical subgiants

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April 28, 2018

Introduction

Binary systems provide a good laboratory for studying stellar evolution due to their convenient constraints on metal abundance and age. Asteroseismology allows new ways to study binaries that previously could not due to being unresolved or non-eclipsing. The study of KIC 7107778 by Li and Bedding shows the power of asteroseismology in a very unique binary system.

Asteroseismology

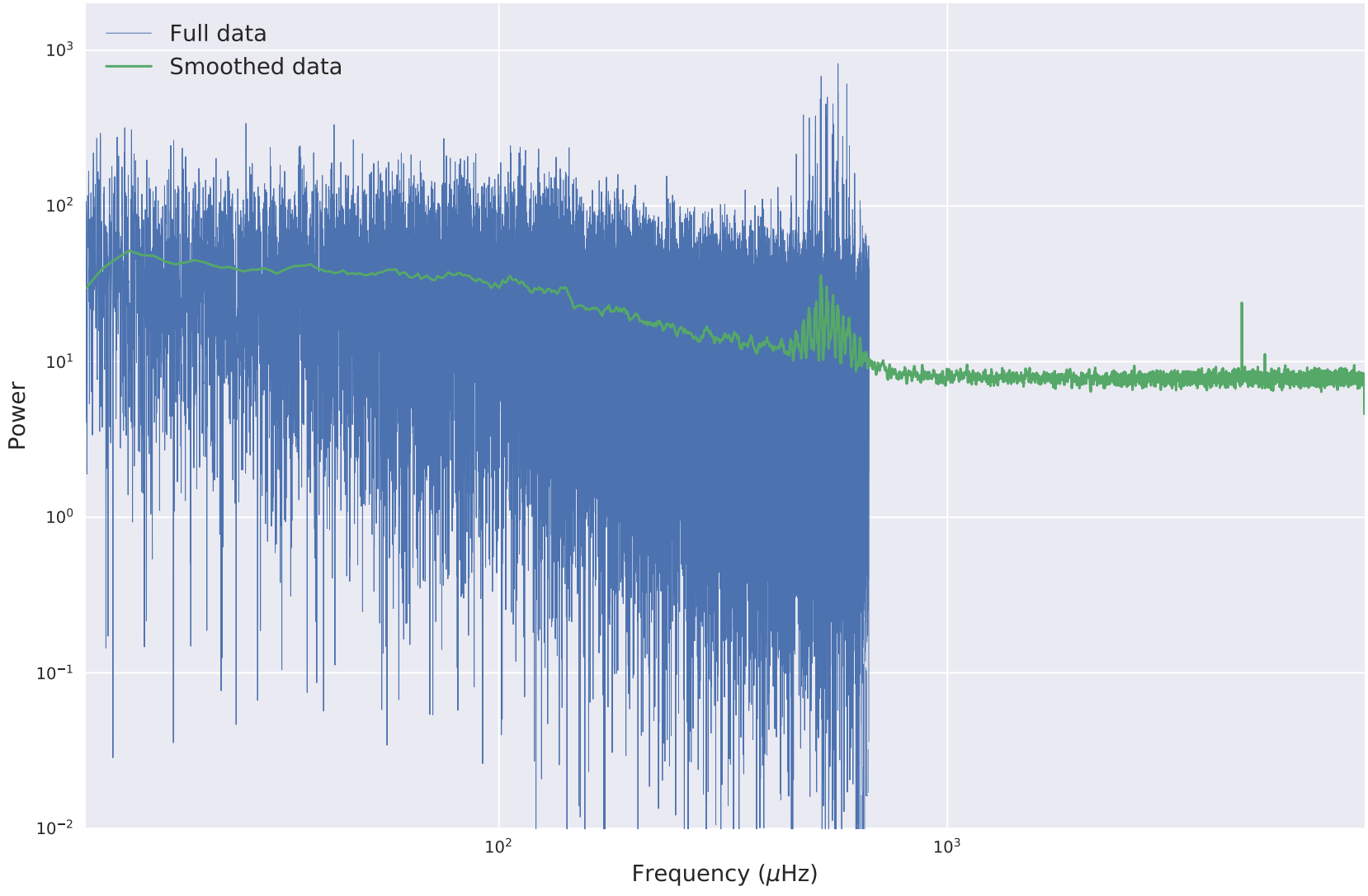
Asteroseismology is the study of how stars' brightness fluctuates. These fluctuations can be attributed to many different mechanics within stars. To analyze the periodicities we use Fourier transforms to view the data in frequency space.

KIC 7107778

Interesting features of this binary system

- Unresolved
- Widely separated
- Non-eclipsing
- Solar like oscillations from both components

Power Spectrum



Analysis Strategy

1. Model the Gaussian envelope
2. Analyze envelope and determine modes of interest
3. Model the oscillation modes

Envelope Model

$$P(\nu) = W + R(\nu)\left[\sum_{i=0}^{k} H_i(\nu) + H_0^2 \exp\left\{-\frac{(\nu - \nu_{max}^2)}{2\sigma^2}\right\}\right] \quad (1)$$

where

$$R(\nu) = \text{sinc}^2\left(\frac{\pi\nu}{2\nu_{Nyq}}\right)$$

and

$$H_i(\nu) = \frac{2\sqrt{2}}{\pi}\frac{a_i^2/b_i}{1 + (\nu/b_i)^4}$$

This is a flat noise plus response function modulating three Harvey power profiles and a Gaussian envelop.

Envelope priors

$$W \sim N(12, \sigma = 5)$$

$$a_i \sim N([59, 67, 76], \sigma = 20)$$

$$b_i \sim N([5, 150, 400], \sigma = [10, 50, 100])$$

$$H_0 \sim N(17, \sigma = 5)$$

$$\nu_{max} \sim N(568, \sigma = 5)$$

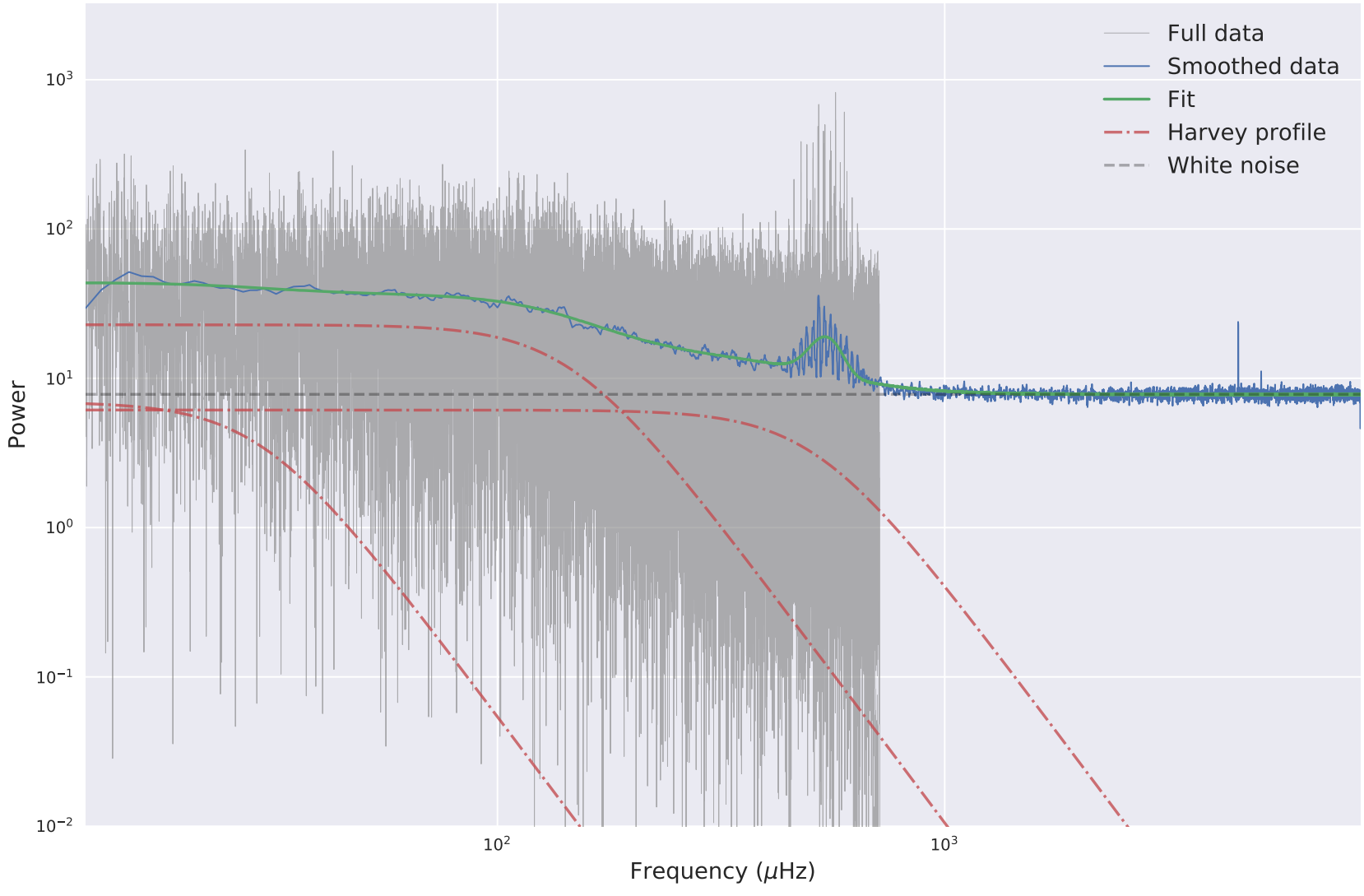
$$\sigma \sim Cauchy(55, 10)$$

Envelope posteriors

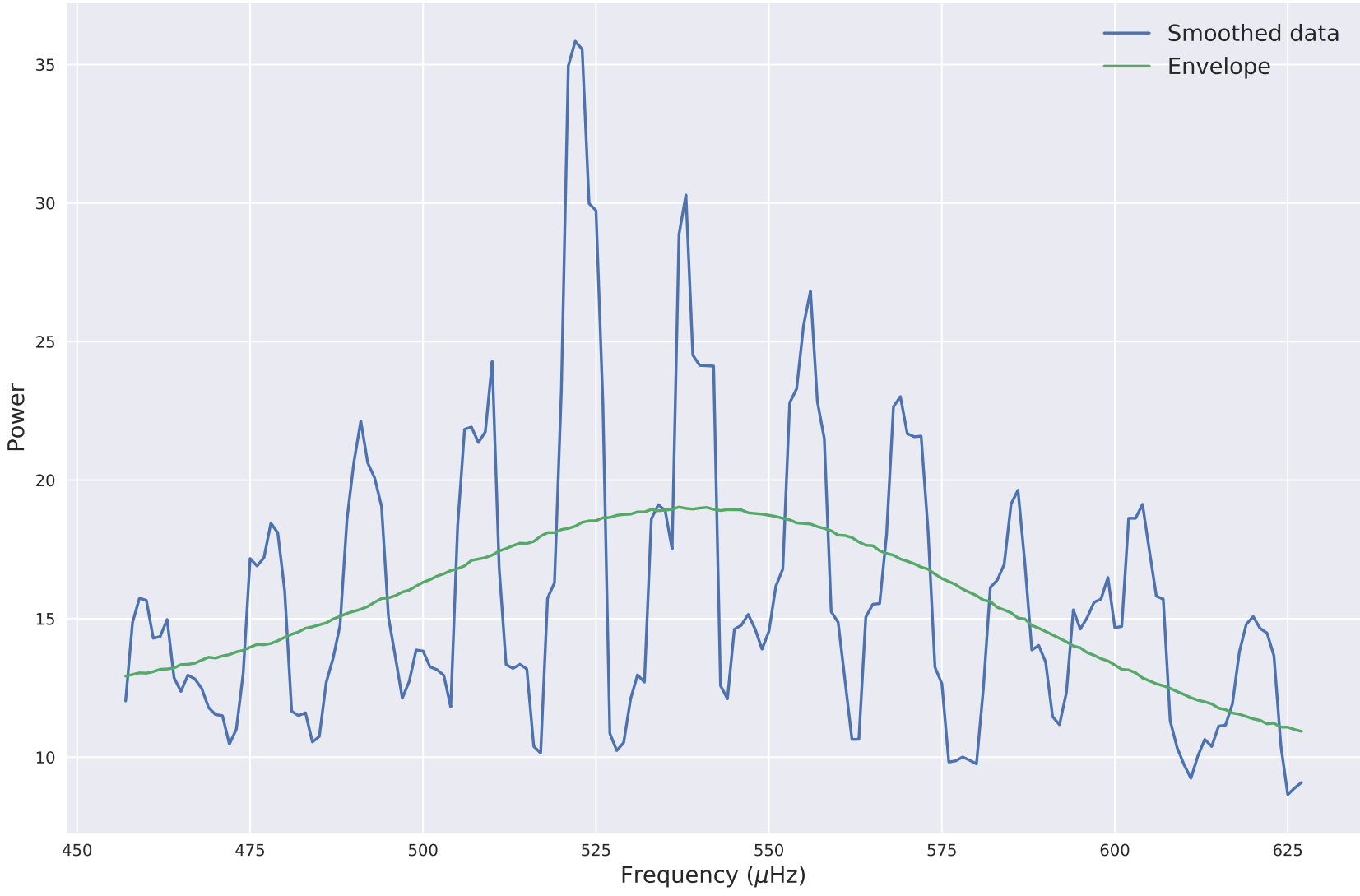
Table: Posterior Parameters

	mean	sd	2.5	97.5
a_0	15.15	0.4591	14.28	16.07
a_1	60.96	0.3549	60.29	61.66
a_2	59.23	0.4772	58.32	60.17
b_0	29.76	1.641	26.61	33.00
b_1	146.6	1.345	144.0	149.2
b_2	514.7	9.656	495.9	533.8
σ	42.57	0.9466	40.69	44.40
W	7.808	0.01144	7.786	7.831
H_0	29.82	0.3629	29.10	30.53
ν_{max}	542.2	0.8259	540.5	543.8

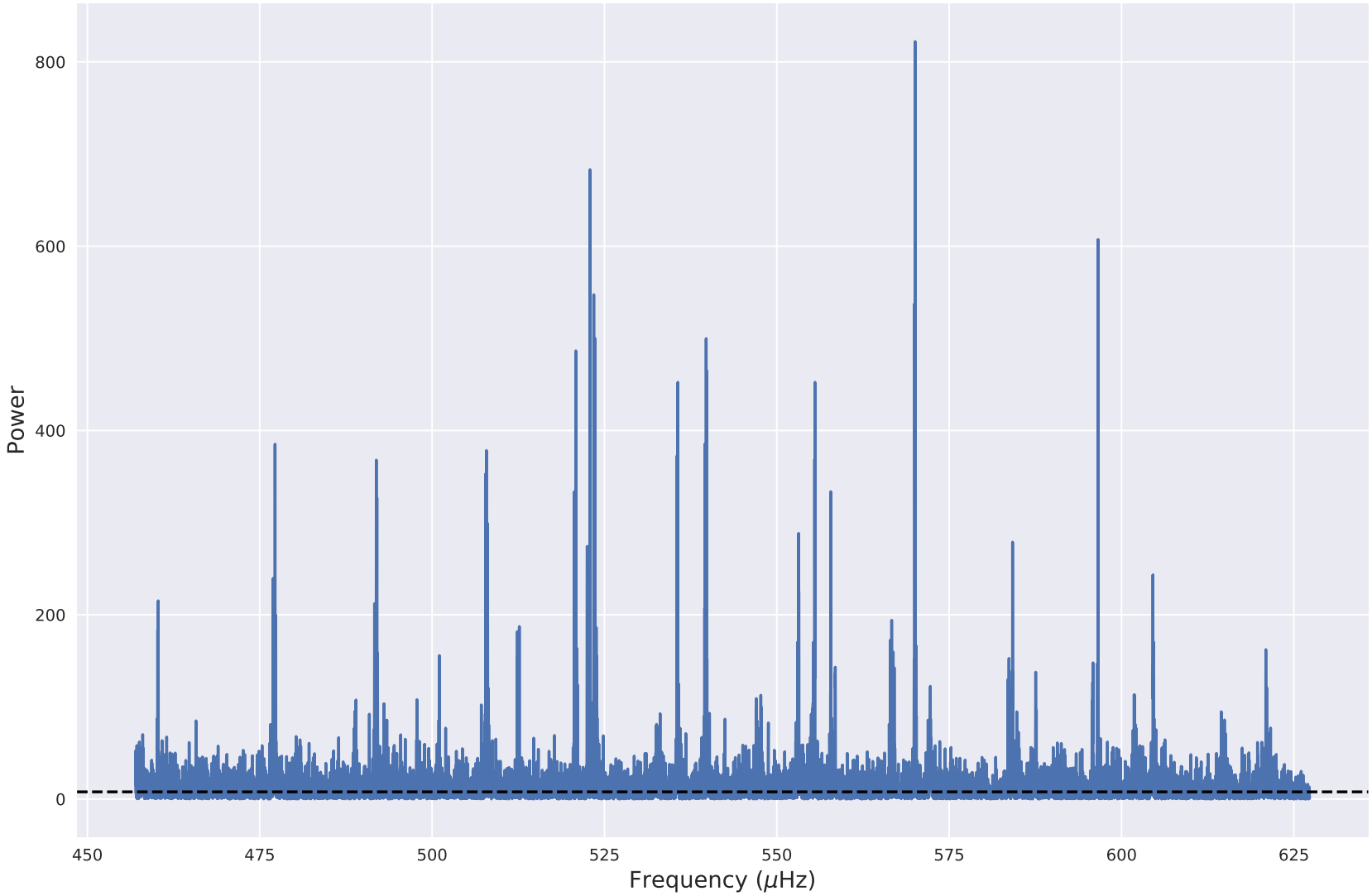
Envelope Fit



Envelope Fit



Envelope

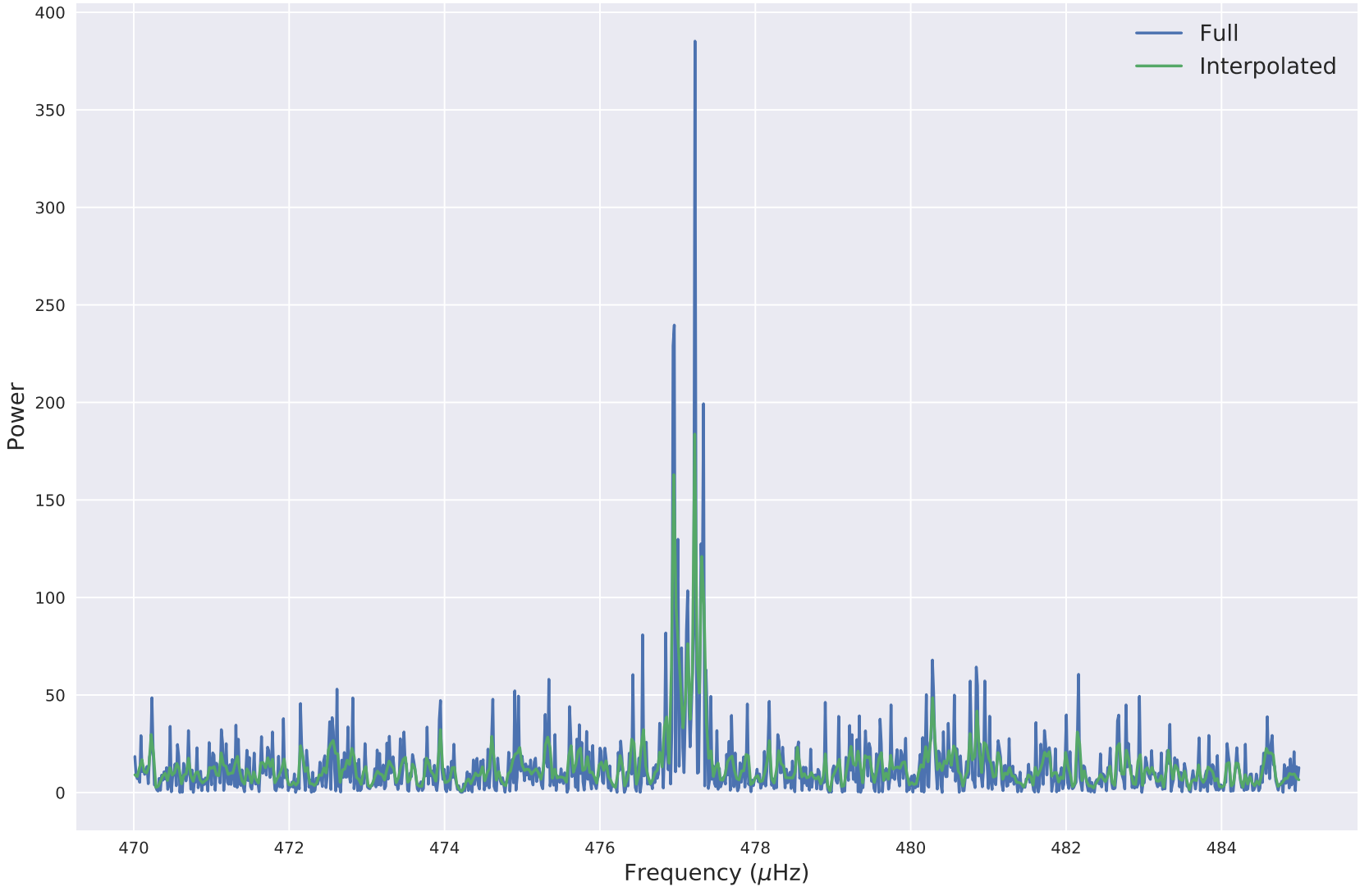

800
600
400
200
0
Power
450
475
500
525
550
575
600
625
Frequency (μHz)

Mode Model

$$P(\nu) = R(\nu)\left[\frac{A^2/\pi\Gamma}{1 + 4(\nu - \nu_0)^2/\Gamma^2}\right] \tag{2}$$

A Lorentzian modulated by the response function.

Mode Model


Full
Interpolated
Power
Frequency (μHz)
400
350
300
250
200
150
100
50
0
470
472
474
476
478
480
482
484

Mode Model

$$A \sim N(20, \sigma = 10)$$

$$\nu_0 \sim N(477, \sigma = 2)$$

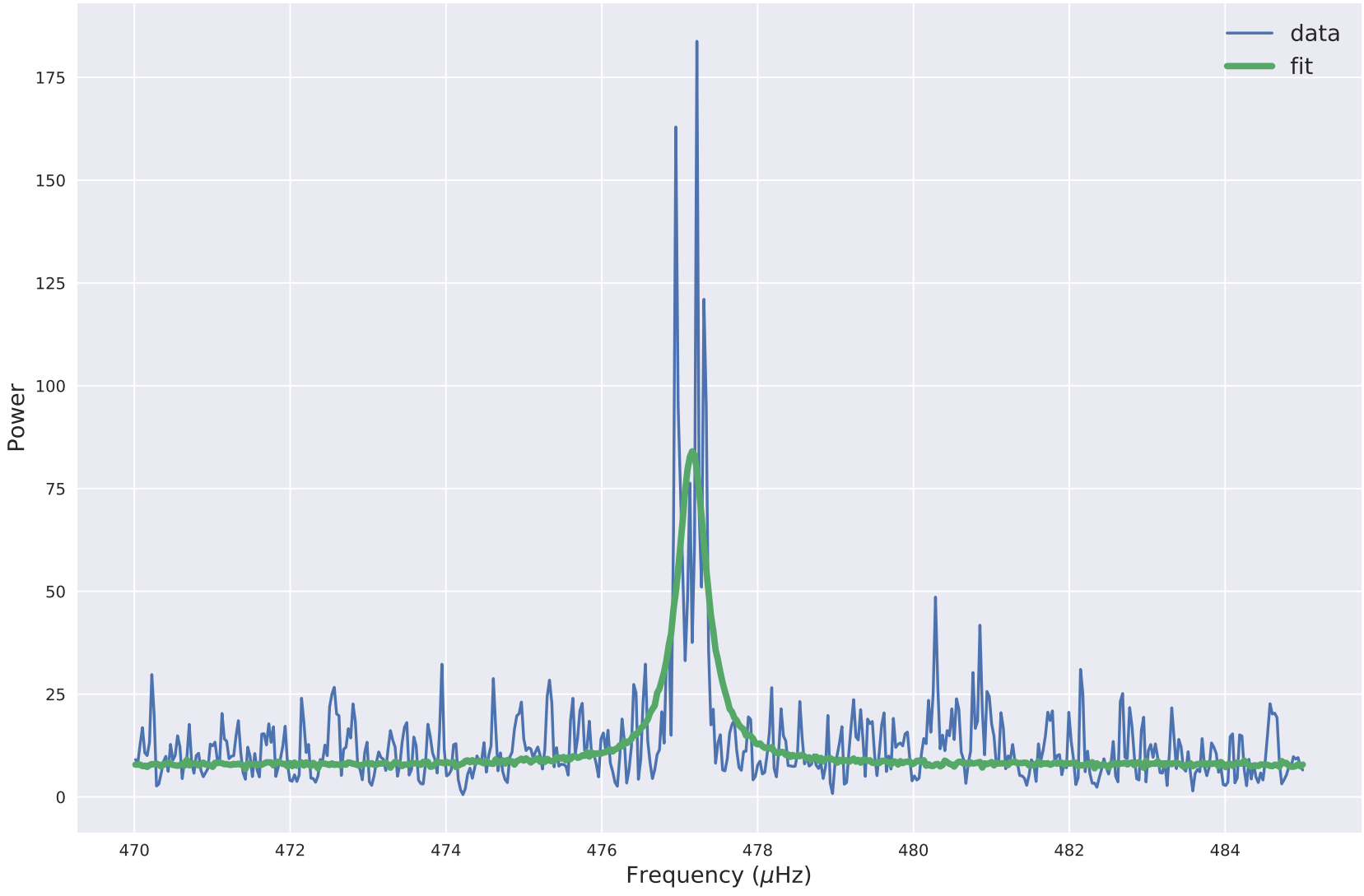
$$\Gamma \sim \text{half-Cauchy}(2)$$

Mode Model

Table: Posterior Parameters

	mean	sd	2.5	97.5
$A[ppm/\mu Hz]$	7.480	0.2237	7.057	7.938
$\nu_0[\mu Hz]$	477.2	0.01817	477.1	477.2
$\Gamma[\mu Hz]$	0.2320	0.01872	0.1948	0.2684

Mode Model


data
fit
Power
Frequency (μHz)
0
25
50
75
100
125
150
175
470
472
474
476
478
480
482
484

Conclusions

1. KIC 7107778 is comprised of two subgiant stars with overlapping, solar-like power spectra
2. The estimated stellar parameters of these stars show that they are nearly identical