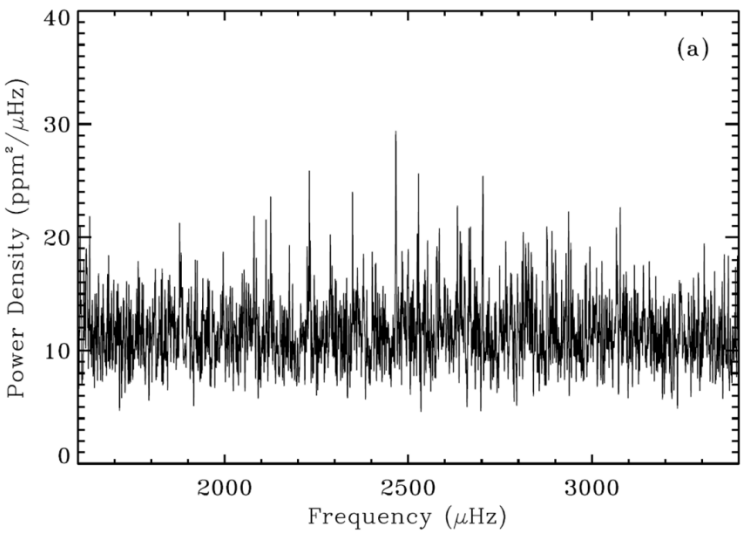
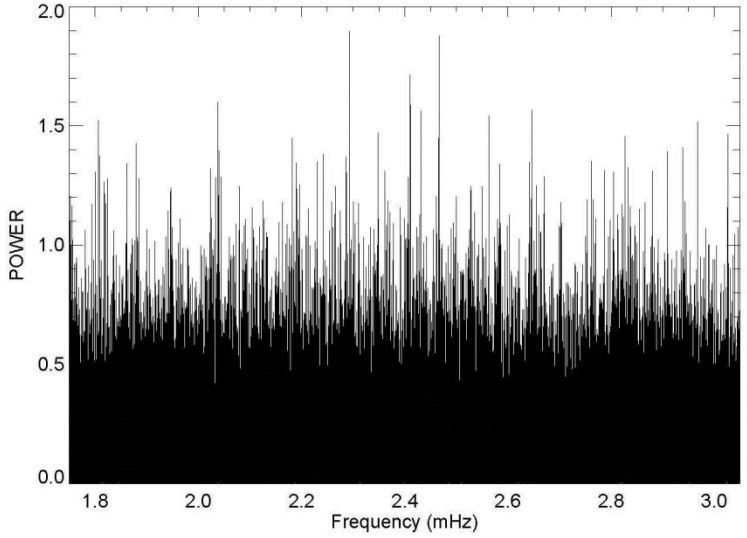
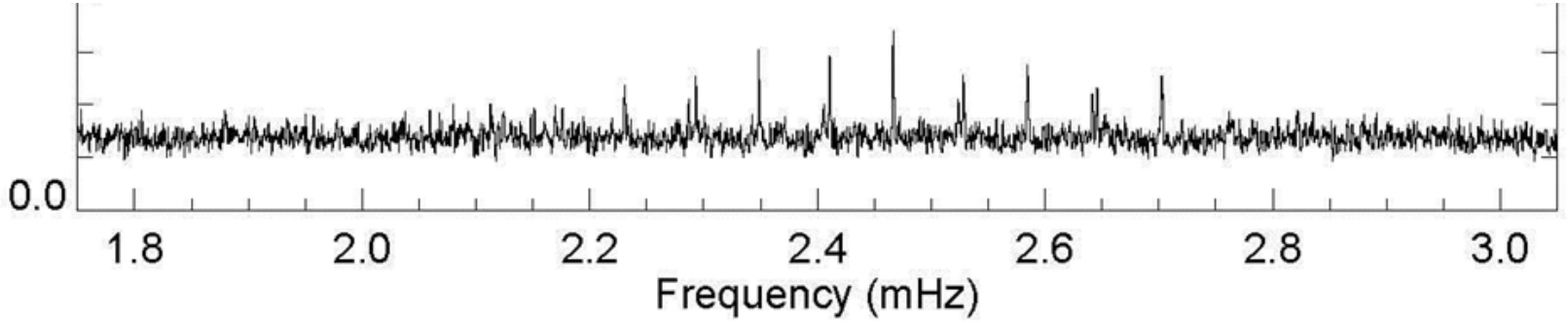
Analysis of low SNR data

Hans Kjeldsen, Stellar Astrophysics Centre, Aarhus University, Denmark







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KEPLER'S FIRST ROCKY PLANET: KEPLER-10b*

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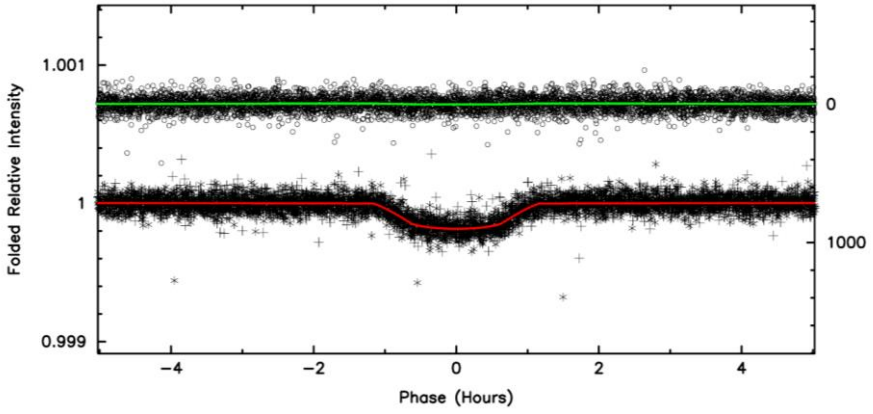
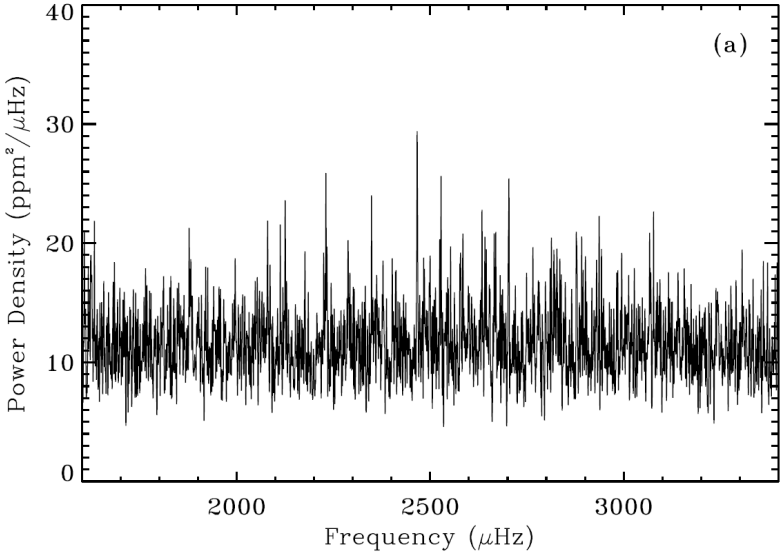
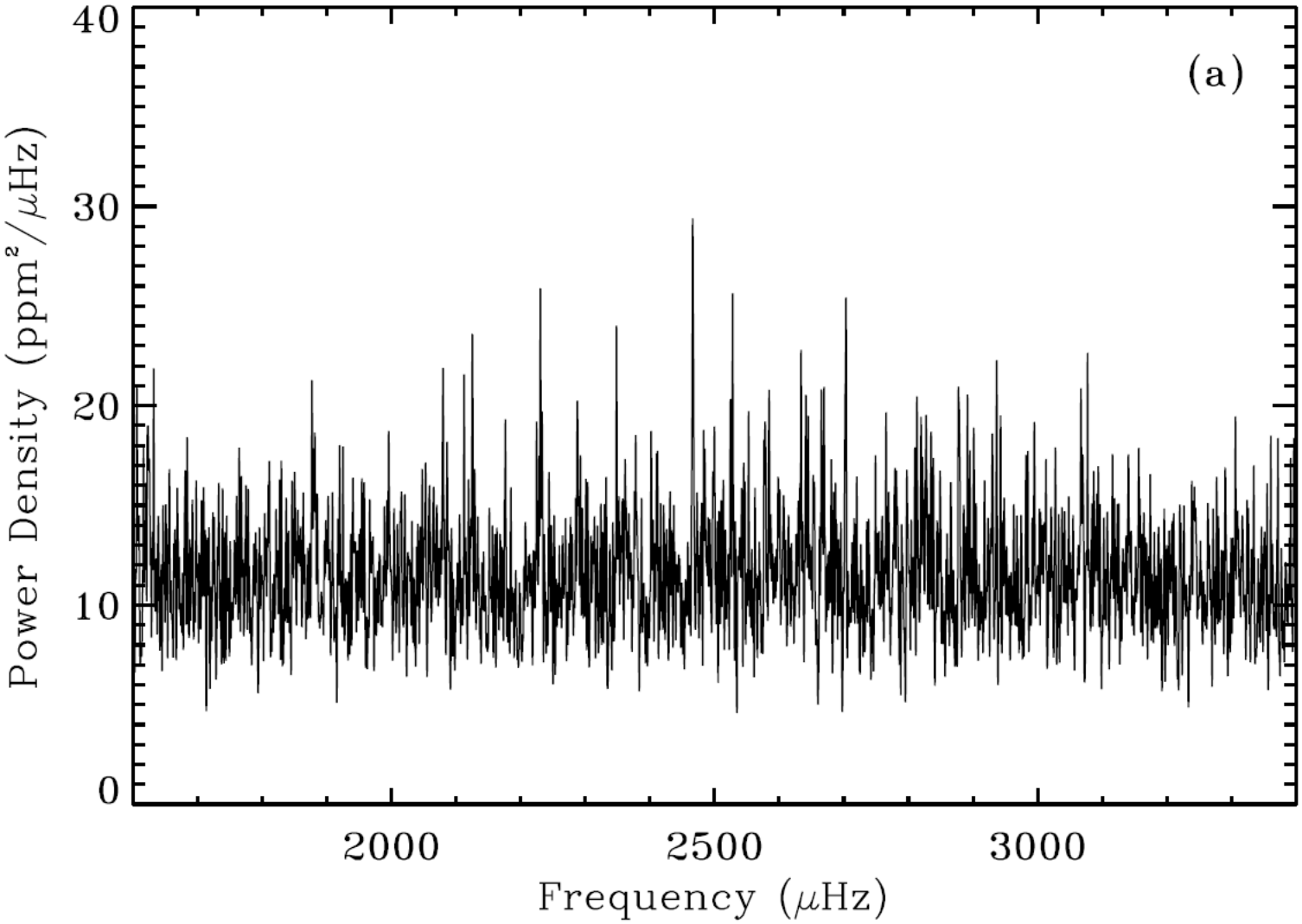
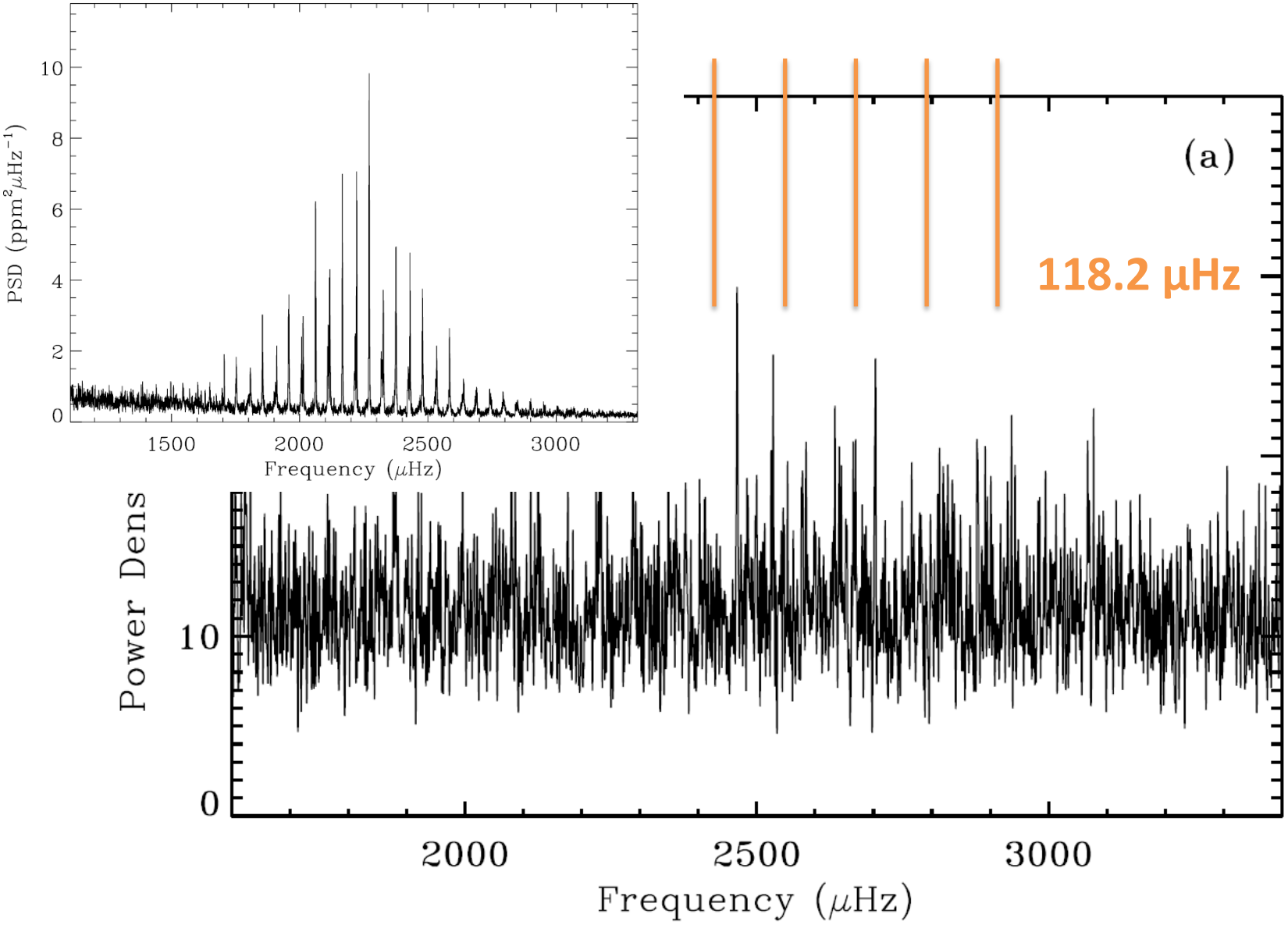
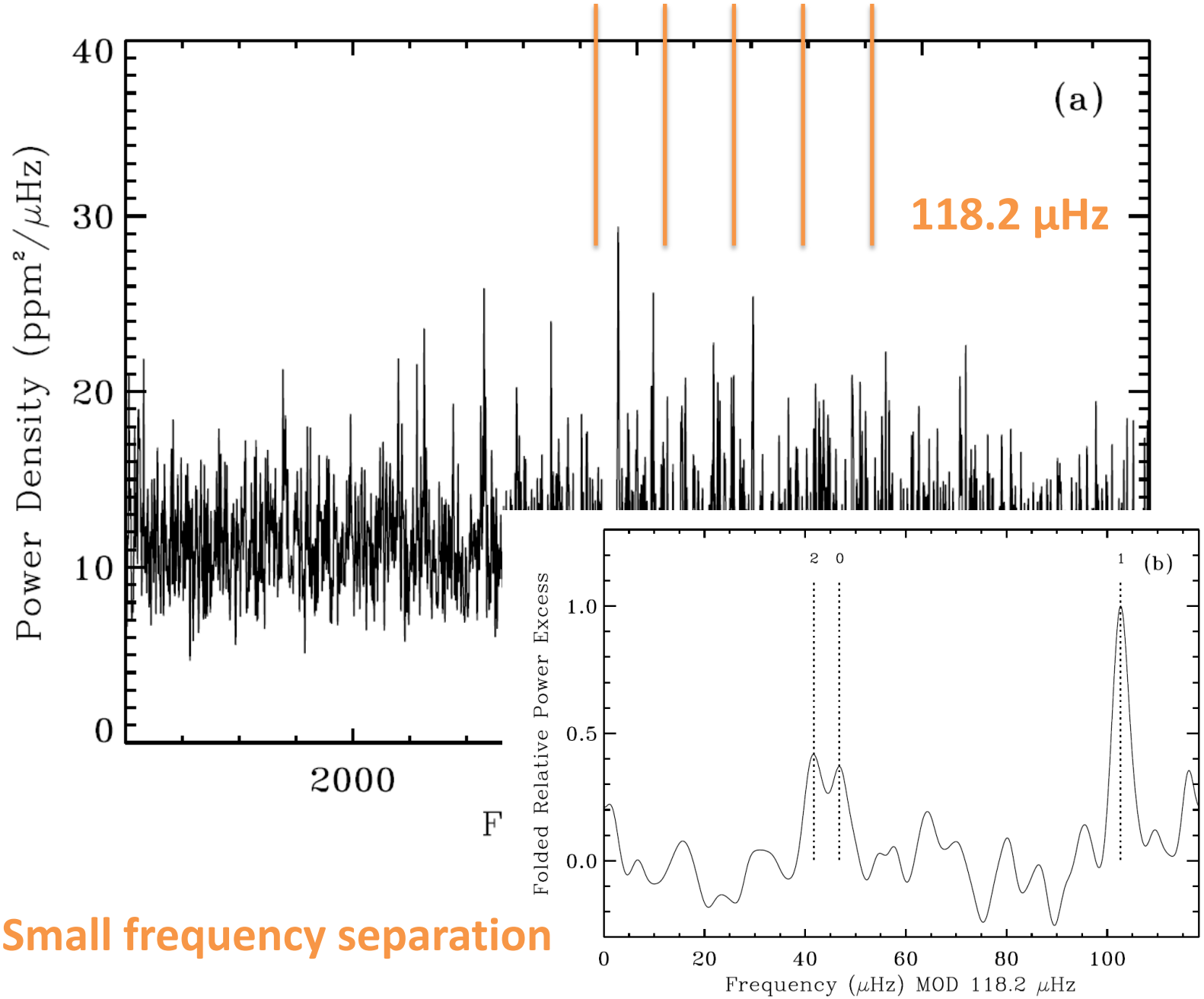





(a)
Power Density (ppm²/μHz)
0
10
20
30
40
2000
2500
3000
Frequency (μHz)



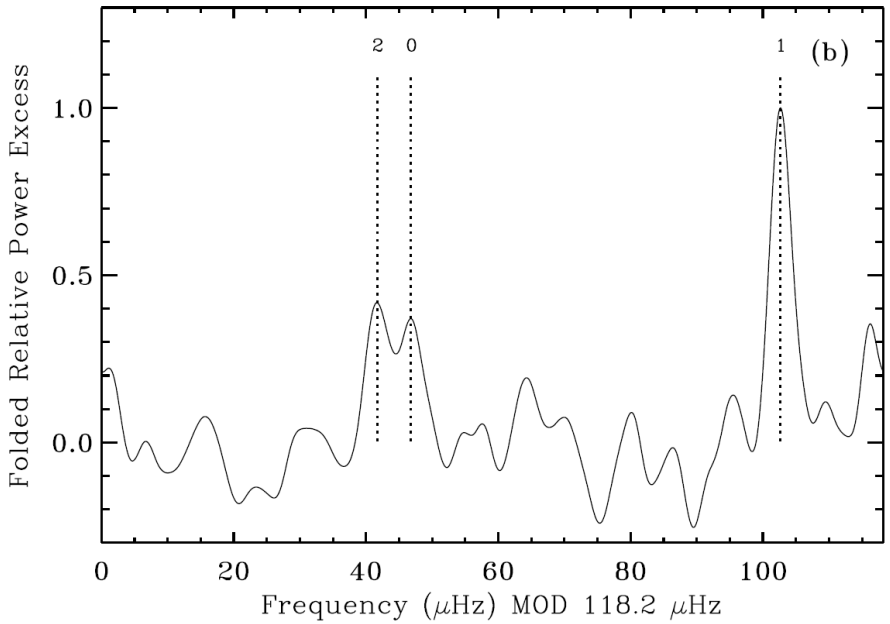
Large frequency separation



Small frequency separation

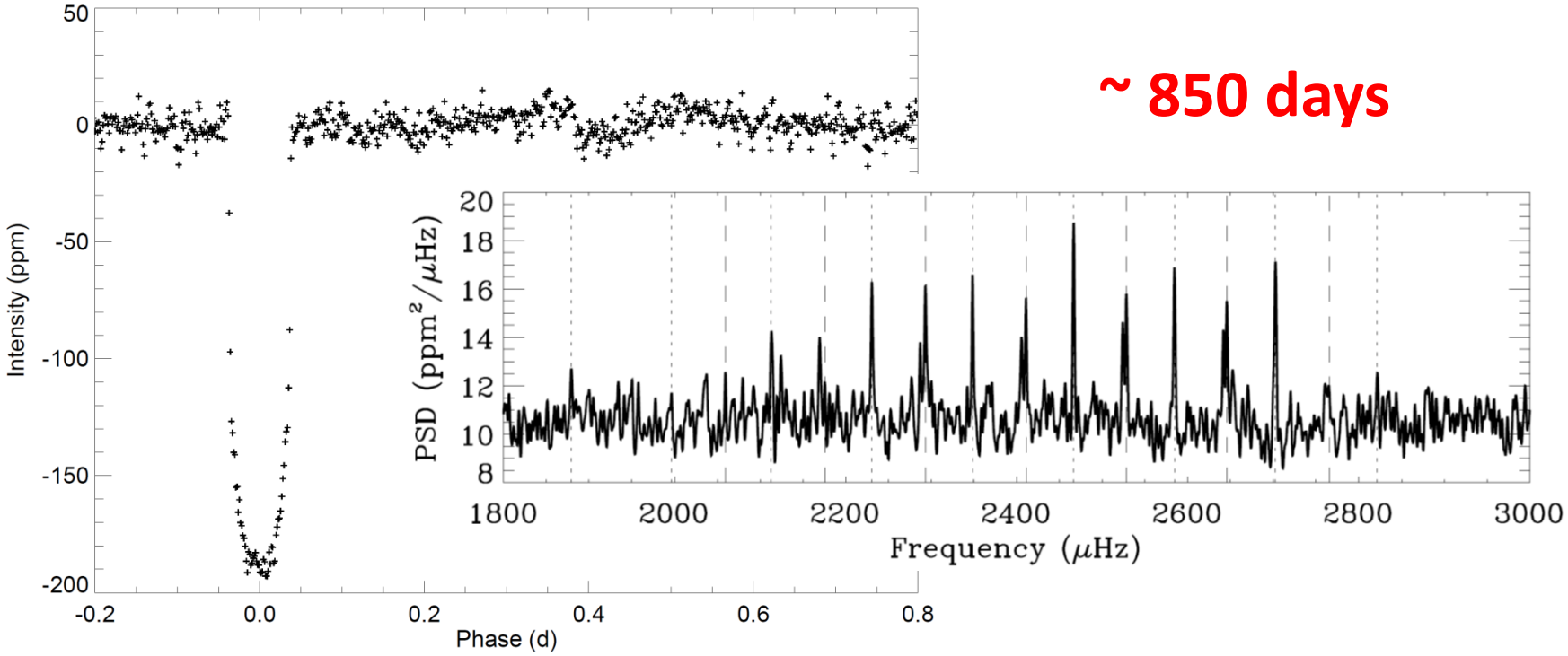
Mass (Msun)	0.995 ± 0.060	(6%)
Radius (Rsun)	1.056 ± 0.021	(2 %)
Age (Gyr)	11.9 ± 4.5	(38%)

- Batalha et al. 2011

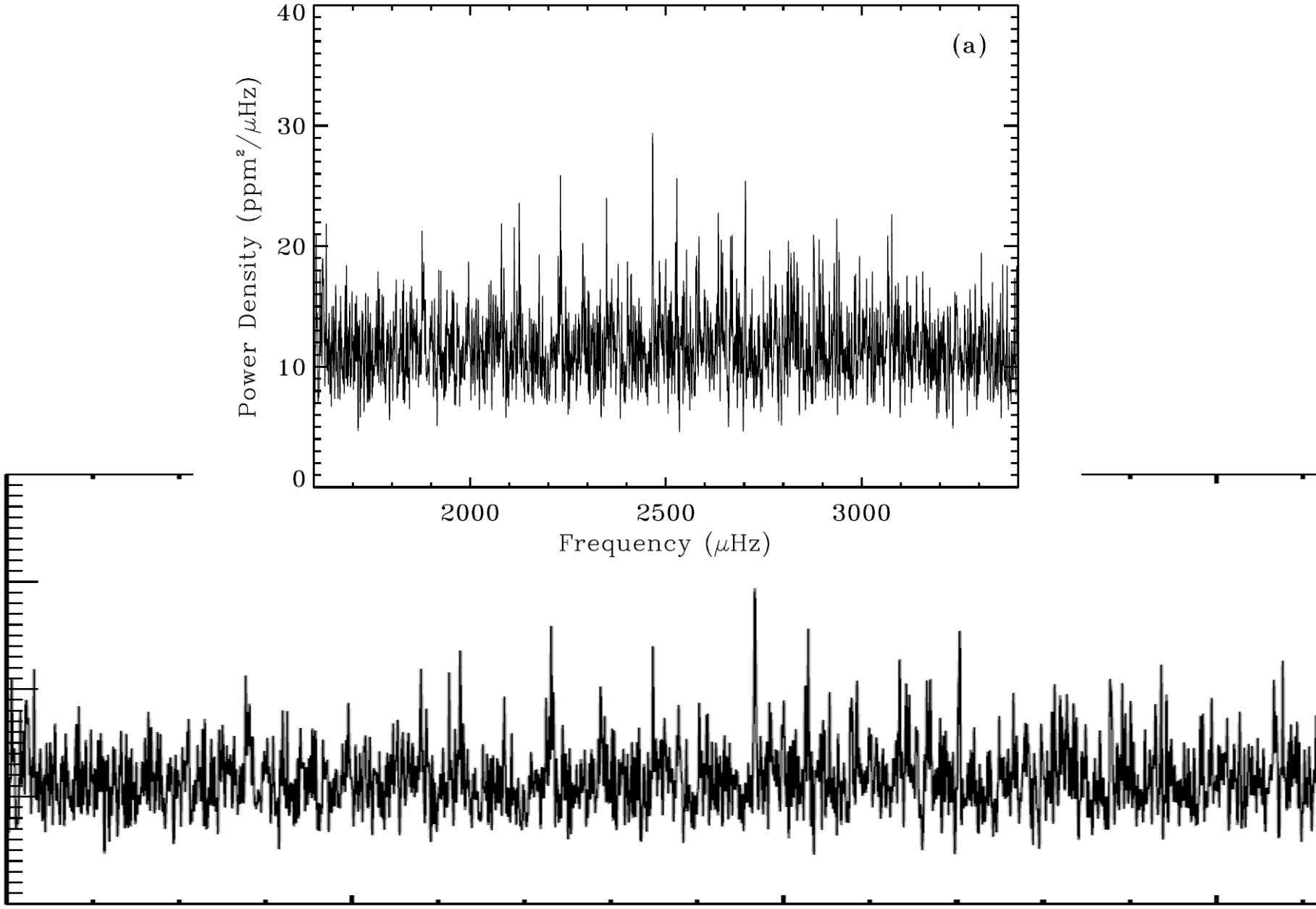


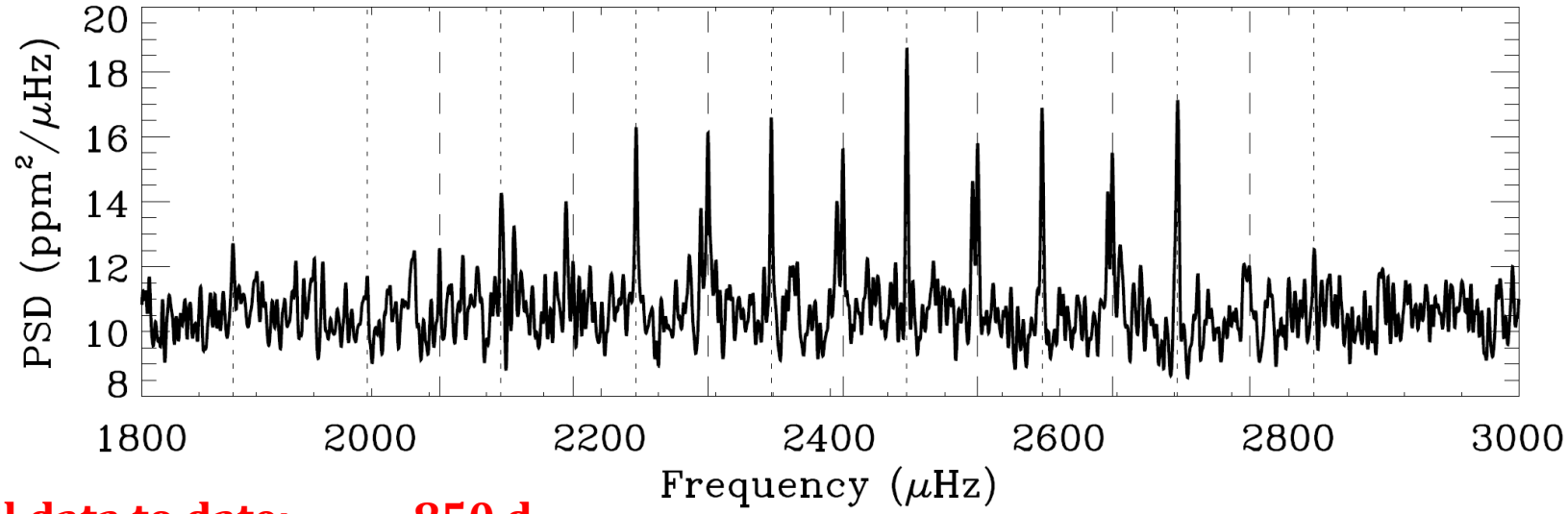
Analysis of more than two years of data….

Alexandra Fogtmann-Schulz, Brian Hinrup, Vincent Van Eylen, Jørgen Christensen-Dalsgaard, Hans Kjeldsen, Victor Silva Aguirre and Brandon Tingley
Stellar Astrophysics Centre, Department of Physics and Astronomy, Aarhus University, Denmark.



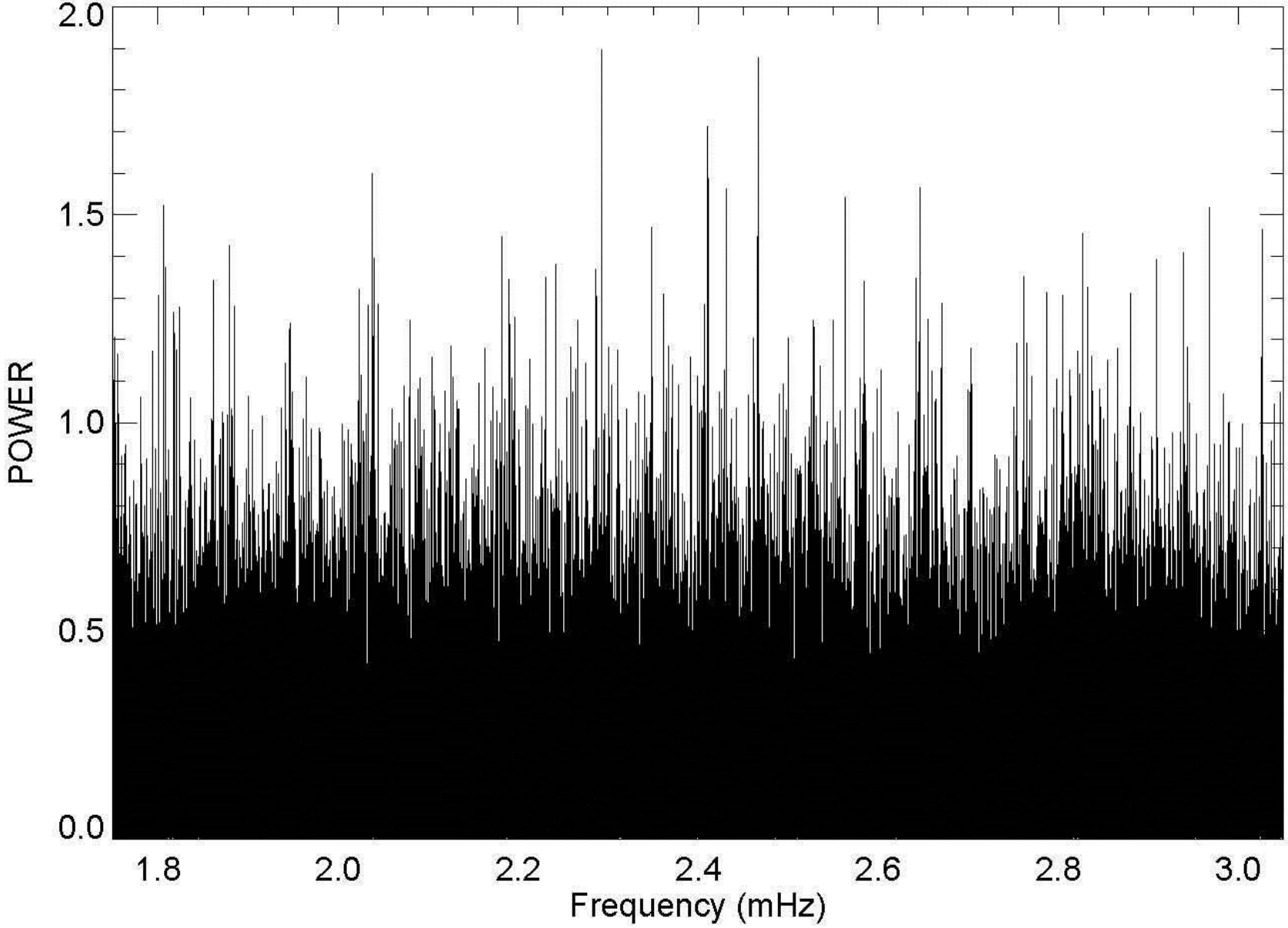
~ 850 days

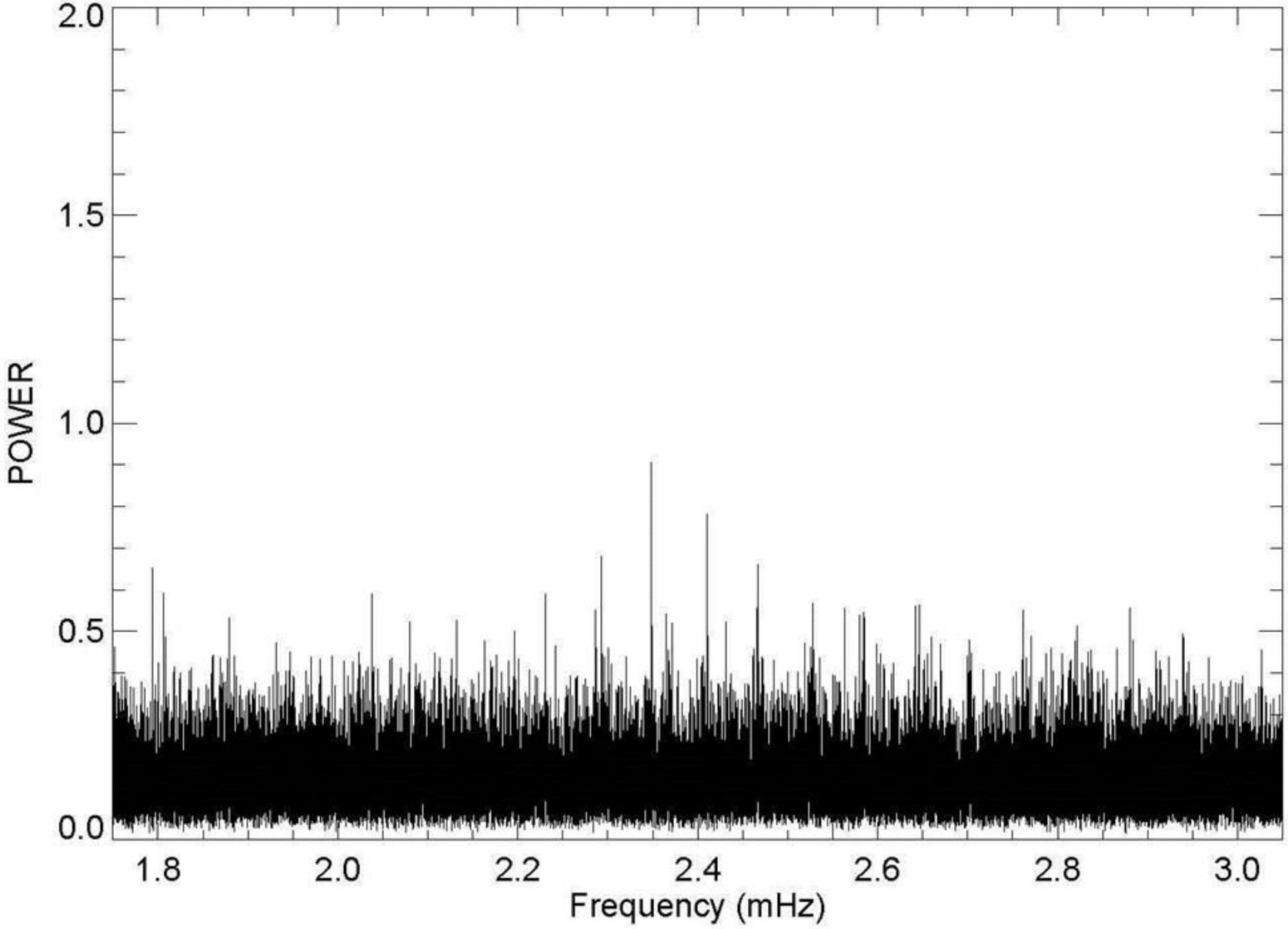

(a)
Power Density (ppm²/μHz)
0
10
20
30
40
2000
2500
3000
Frequency (μHz)

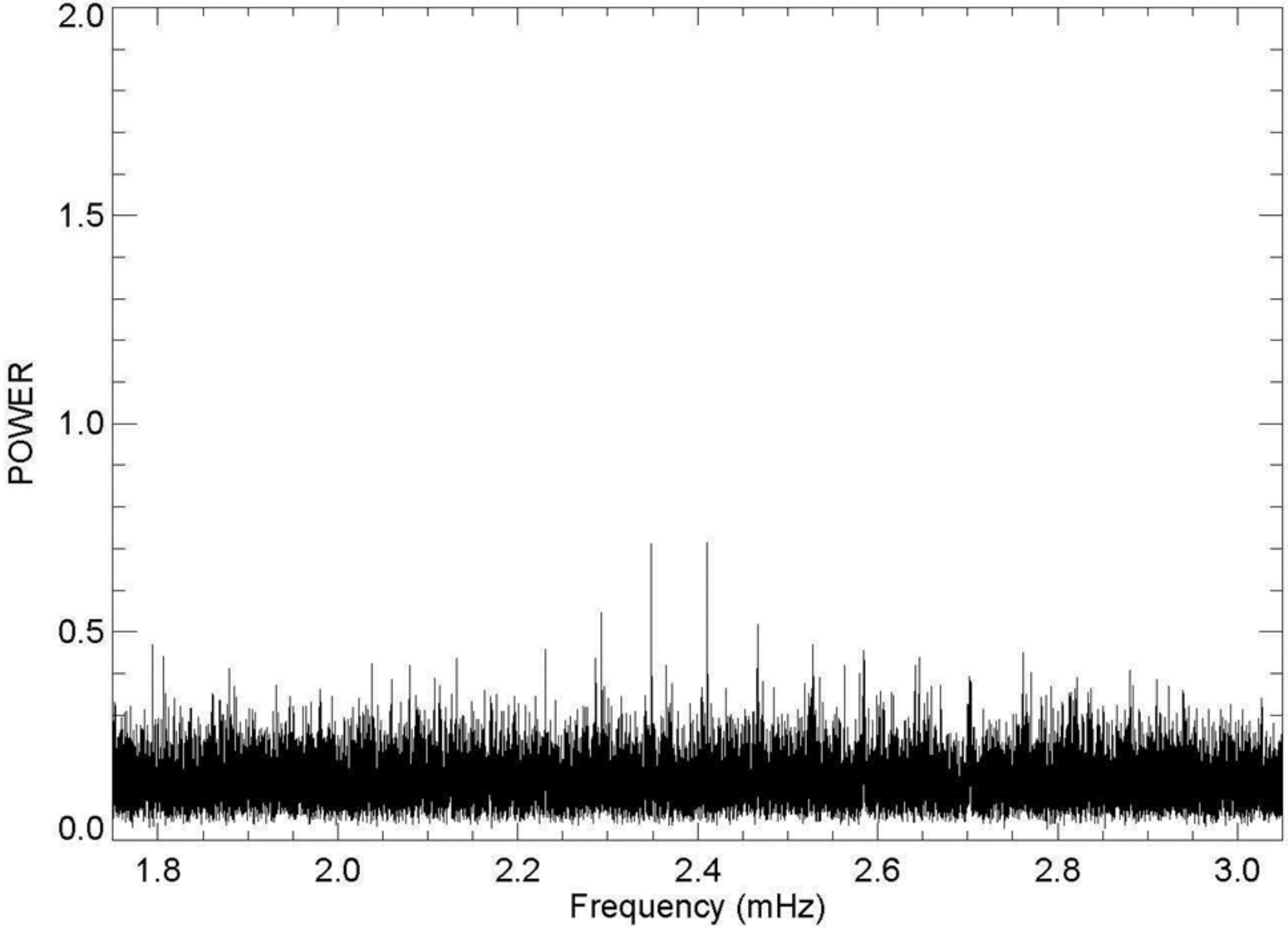


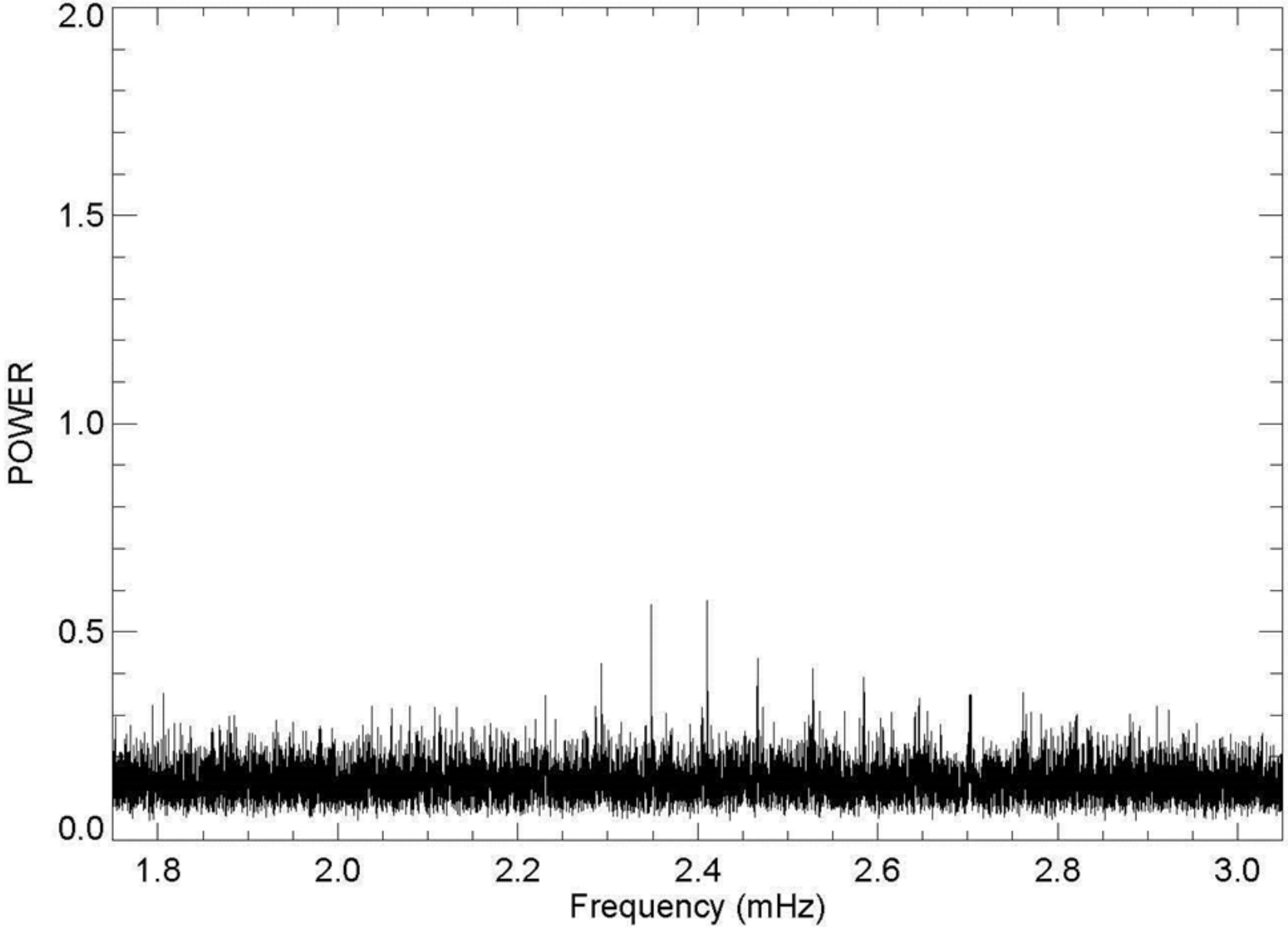
All data to date: 850 d

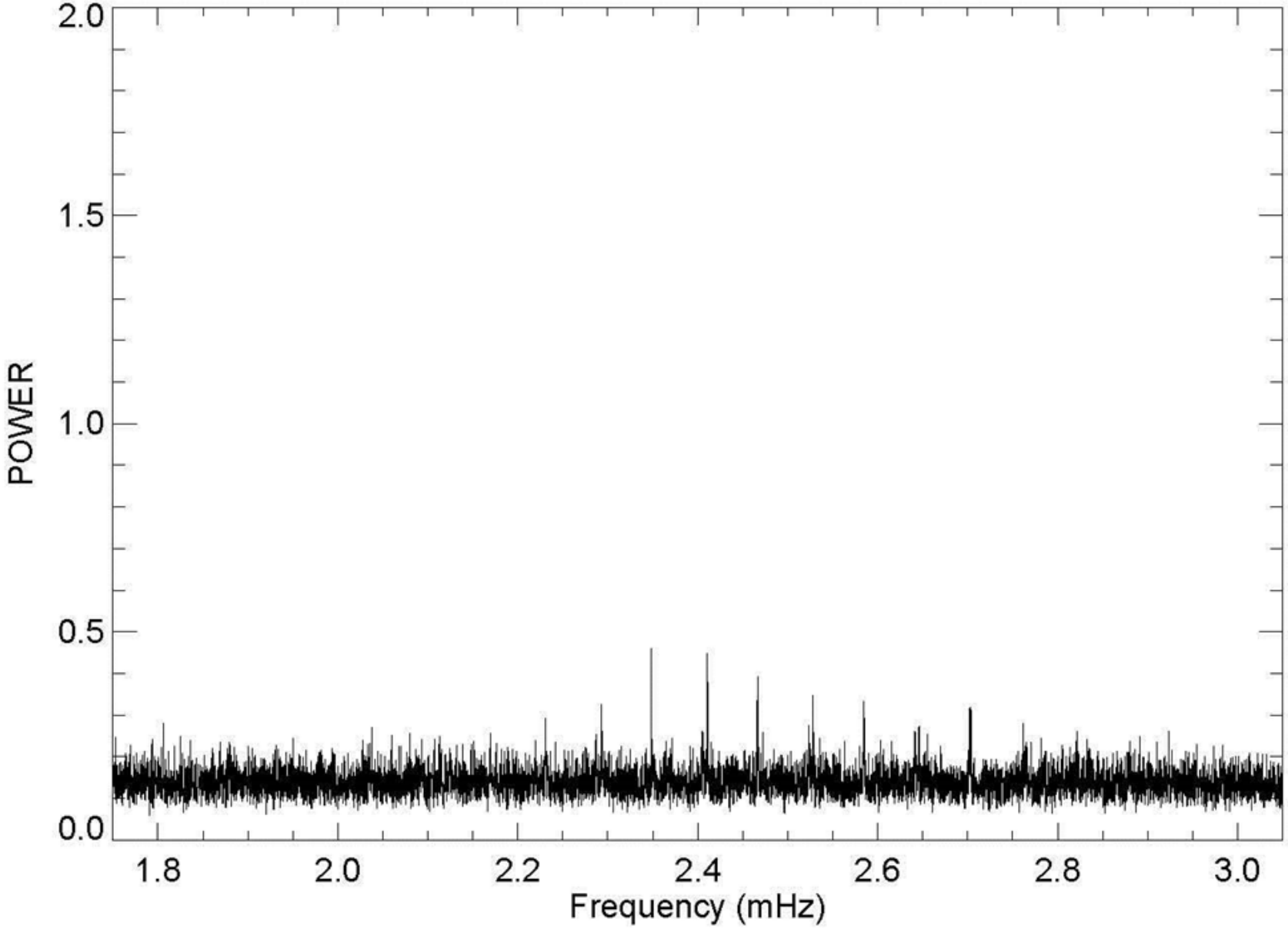
Batalha et al. 2011: 275d

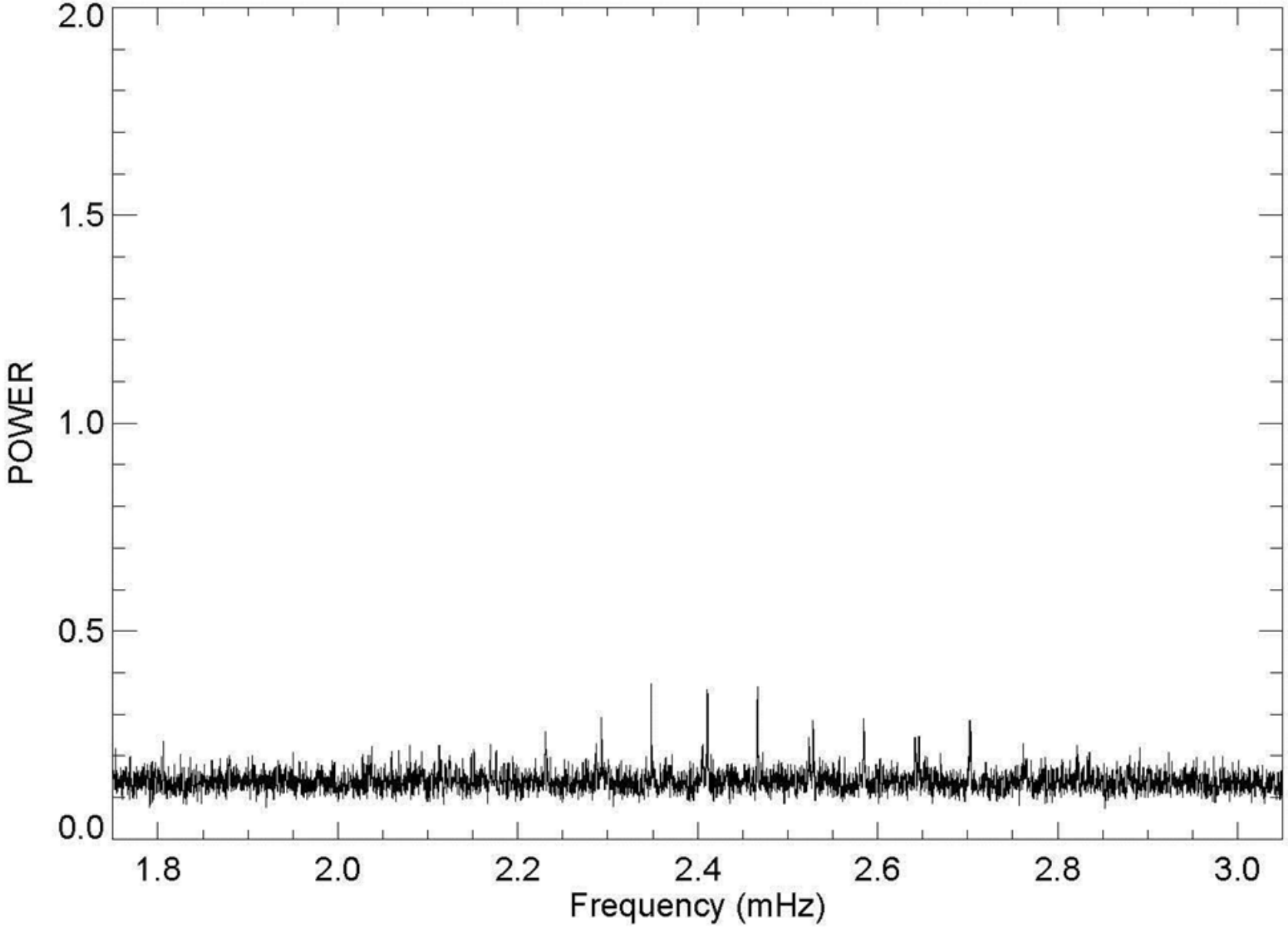

2.0
1.5
1.0
0.5
0.0
POWER
1.8
2.0
2.2
2.4
2.6
2.8
3.0
Frequency (mHz)

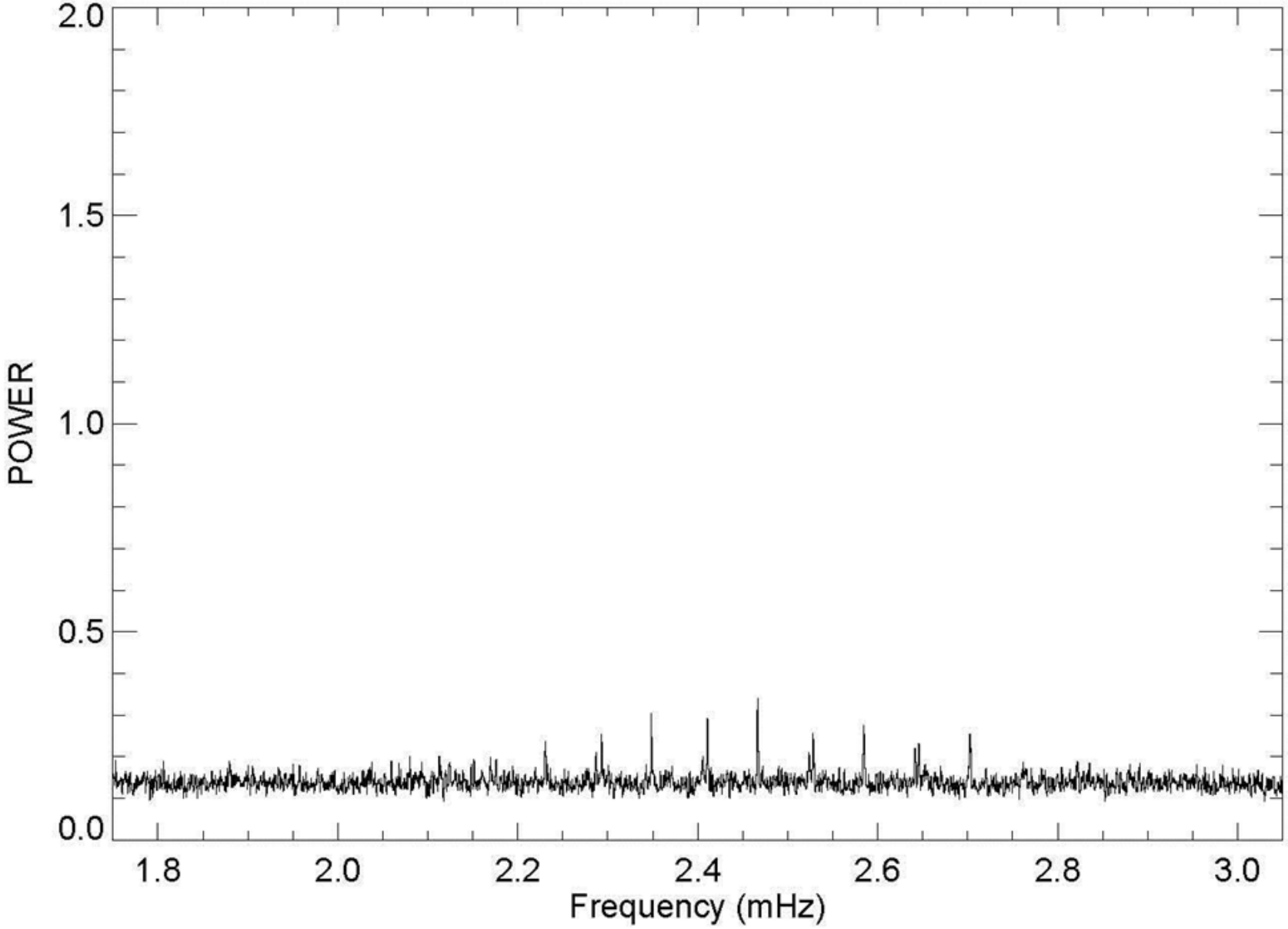

2.0
1.5
1.0
0.5
0.0
POWER
1.8
2.0
2.2
2.4
2.6
2.8
3.0
Frequency (mHz)

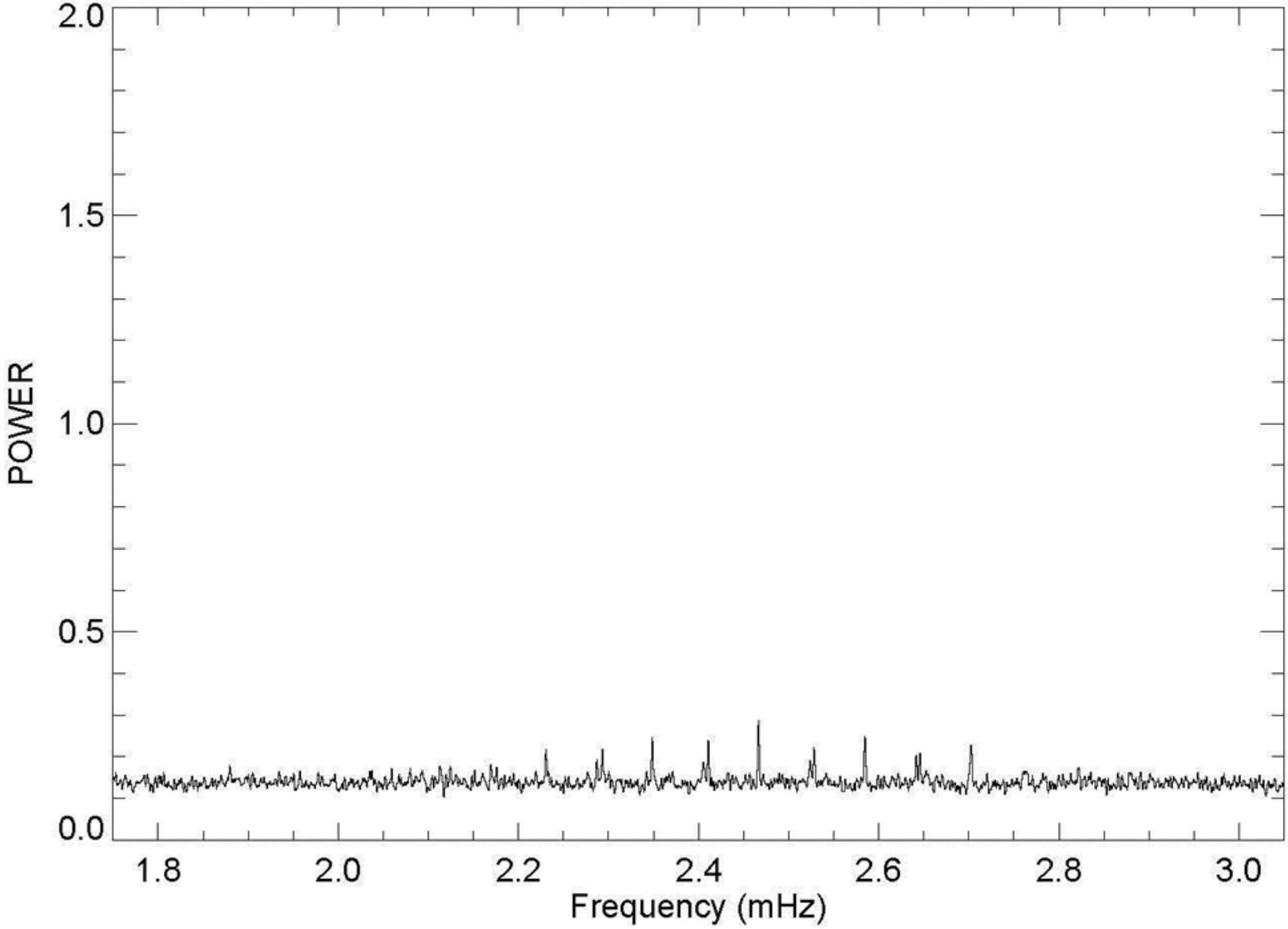

2.0
1.5
1.0
0.5
0.0
POWER
1.8
2.0
2.2
2.4
2.6
2.8
3.0
Frequency (mHz)

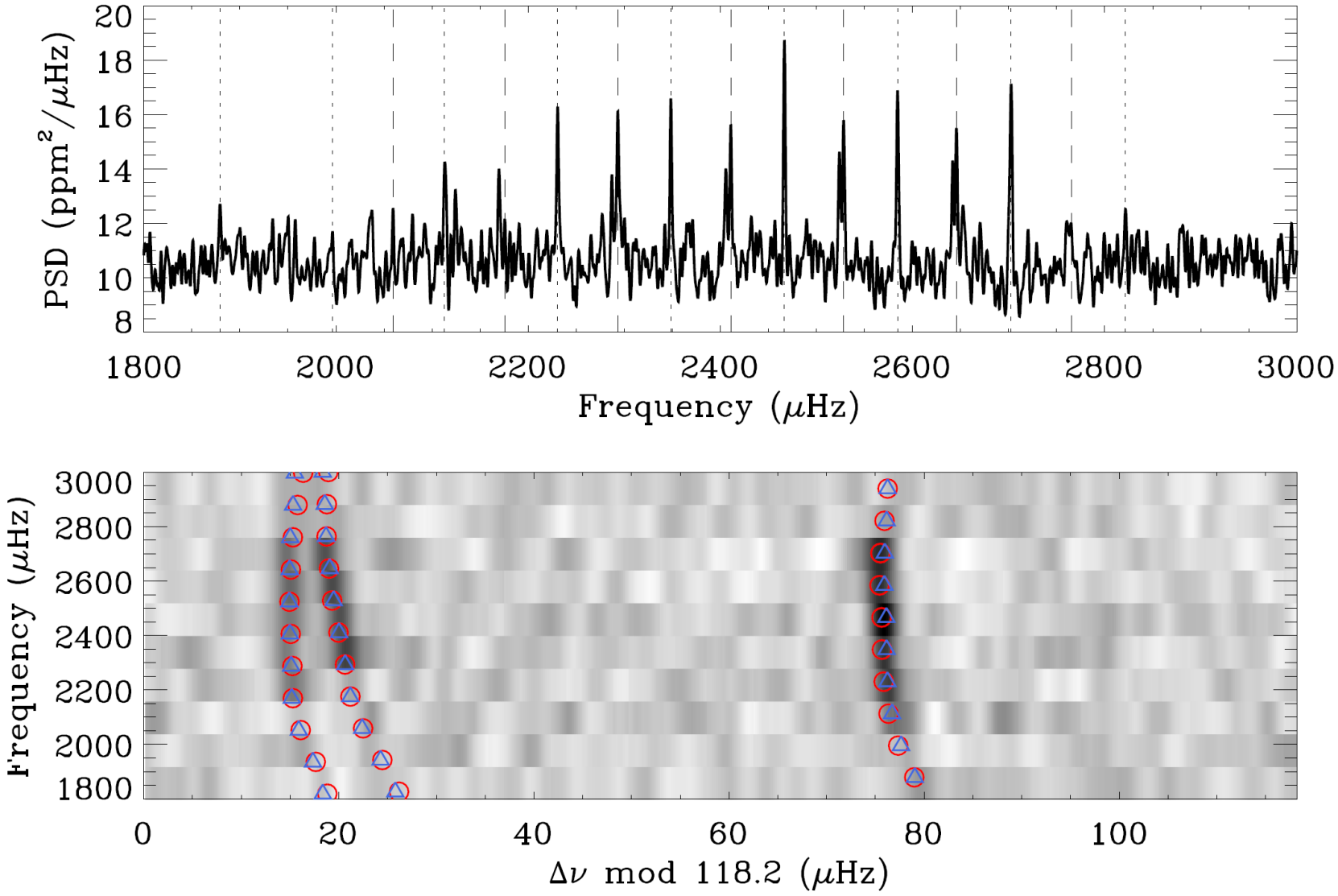

2.0
1.5
1.0
0.5
0.0
POWER
1.8
2.0
2.2
2.4
2.6
2.8
3.0
Frequency (mHz)


2.0
1.5
1.0
0.5
0.0
POWER
1.8
2.0
2.2
2.4
2.6
2.8
3.0
Frequency (mHz)


2.0
1.5
1.0
0.5
0.0
POWER
1.8
2.0
2.2
2.4
2.6
2.8
3.0
Frequency (mHz)


2.0
1.5
1.0
0.5
0.0
POWER
1.8
2.0
2.2
2.4
2.6
2.8
3.0
Frequency (mHz)


2.0
1.5
1.0
0.5
0.0
POWER
1.8
2.0
2.2
2.4
2.6
2.8
3.0
Frequency (mHz)

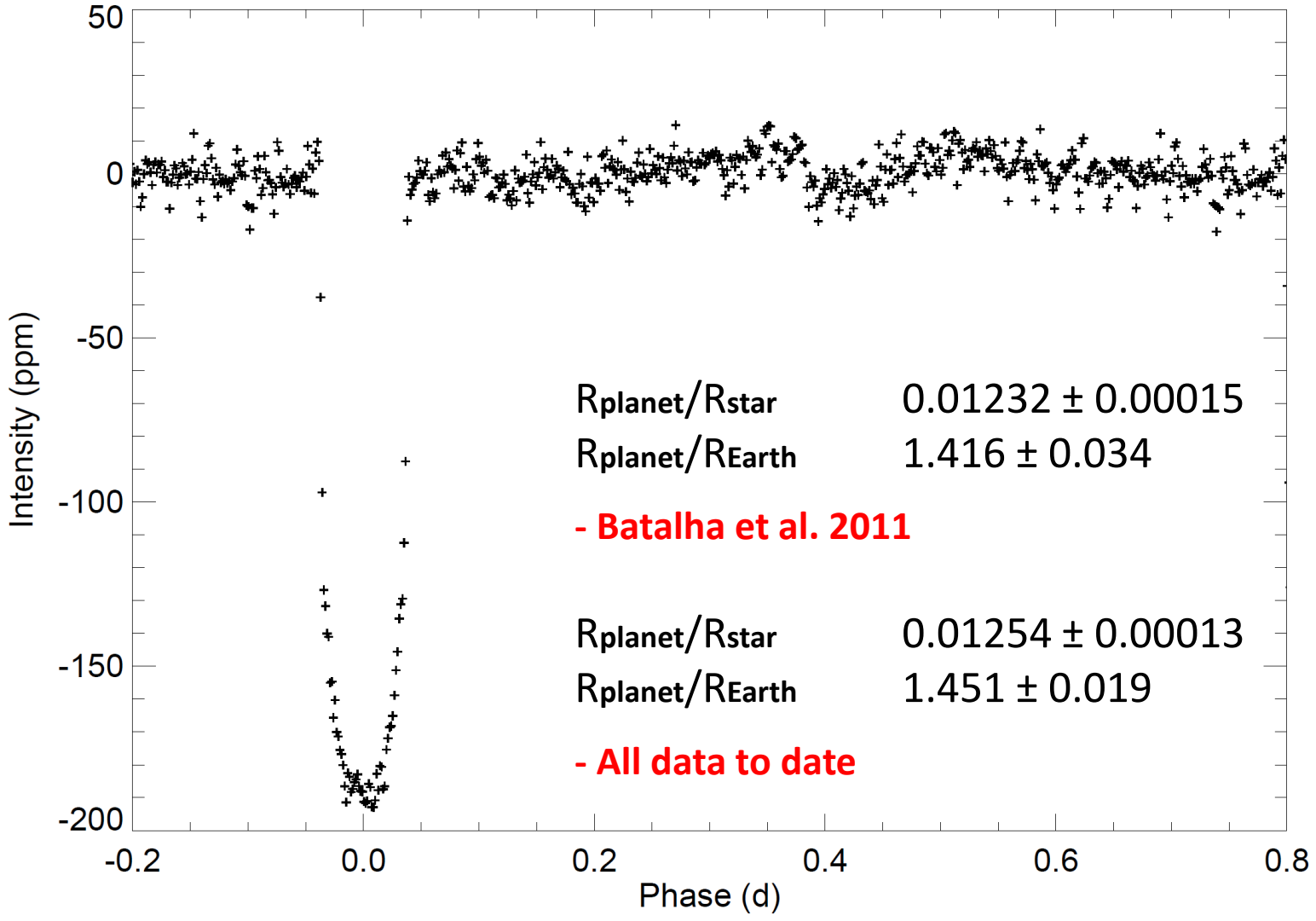

PSD (ppm²/μHz)
20
18
16
14
12
10
8
1800
2000
2200
2400
2600
2800
3000
Frequency (μHz)
Frequency (μHz)
3000
2800
2600
2400
2200
2000
1800
0
20
40
60
80
100
Δν mod 118.2 (μHz)

Mass (Msun)	0.995 ± 0.060
Radius (Rsun)	1.056 ± 0.021
Age (Gyr)	11.9 ± 4.5

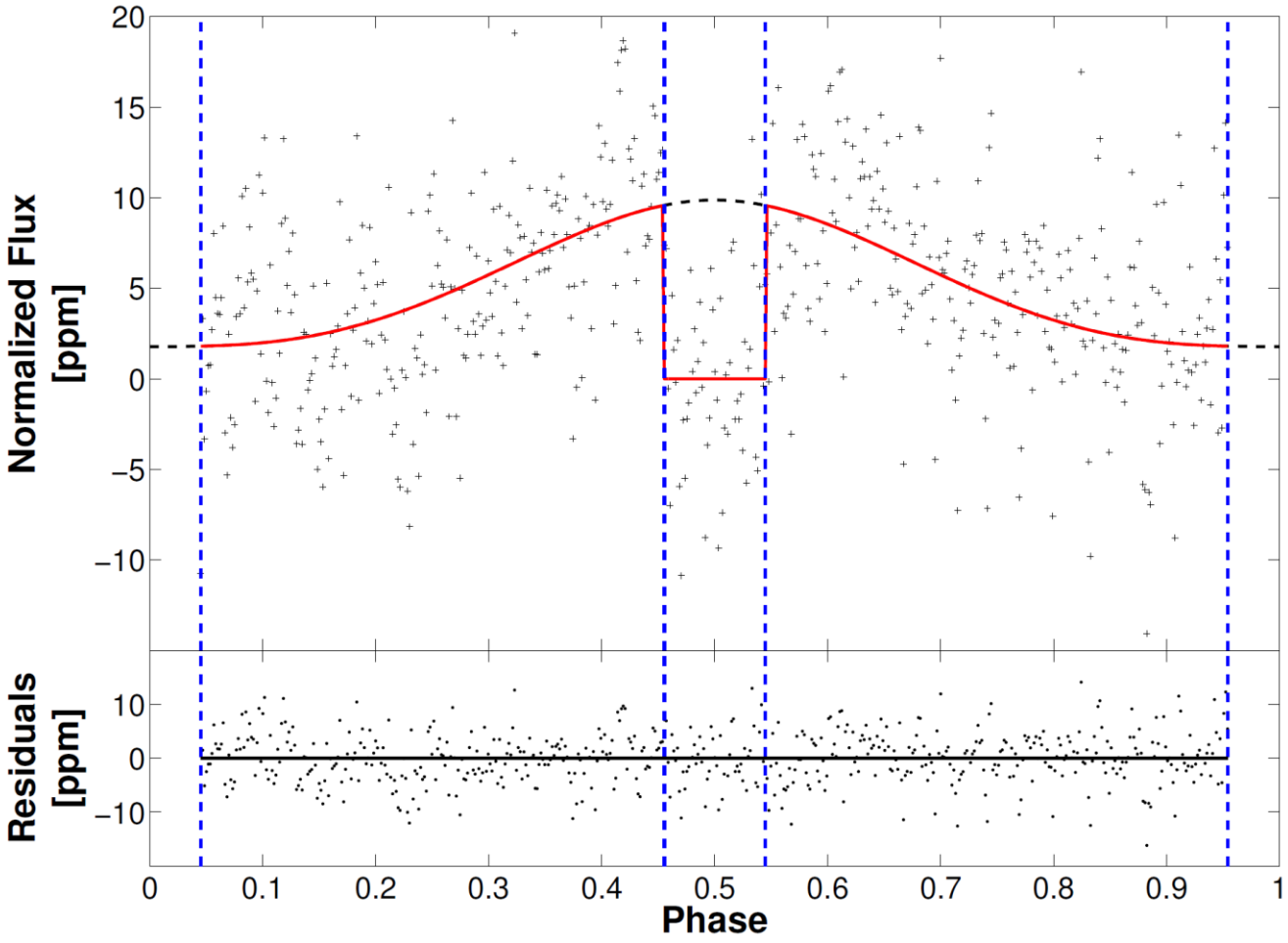
- Batalha et al. 2011

Mass (Msun)	0.913 ± 0.022
Radius (Rsun)	1.065 ± 0.009
Age (Gyr)	10.4 ± 1.4

- All data to date


50
0
-50
-100
-150
-200
Intensity (ppm)
-0.2
0.0
0.2
0.4
0.6
0.8
Phase (d)
Rplanet/Rstar 0.01232 ± 0.00015
Rplanet/REarth 1.416 ± 0.034
- Batalha et al. 2011
Rplanet/Rstar 0.01254 ± 0.00013
Rplanet/REarth 1.451 ± 0.019
- All data to date

$\delta_{\mathrm{occultation}}$ (ppm) 9.9 ± 1.0



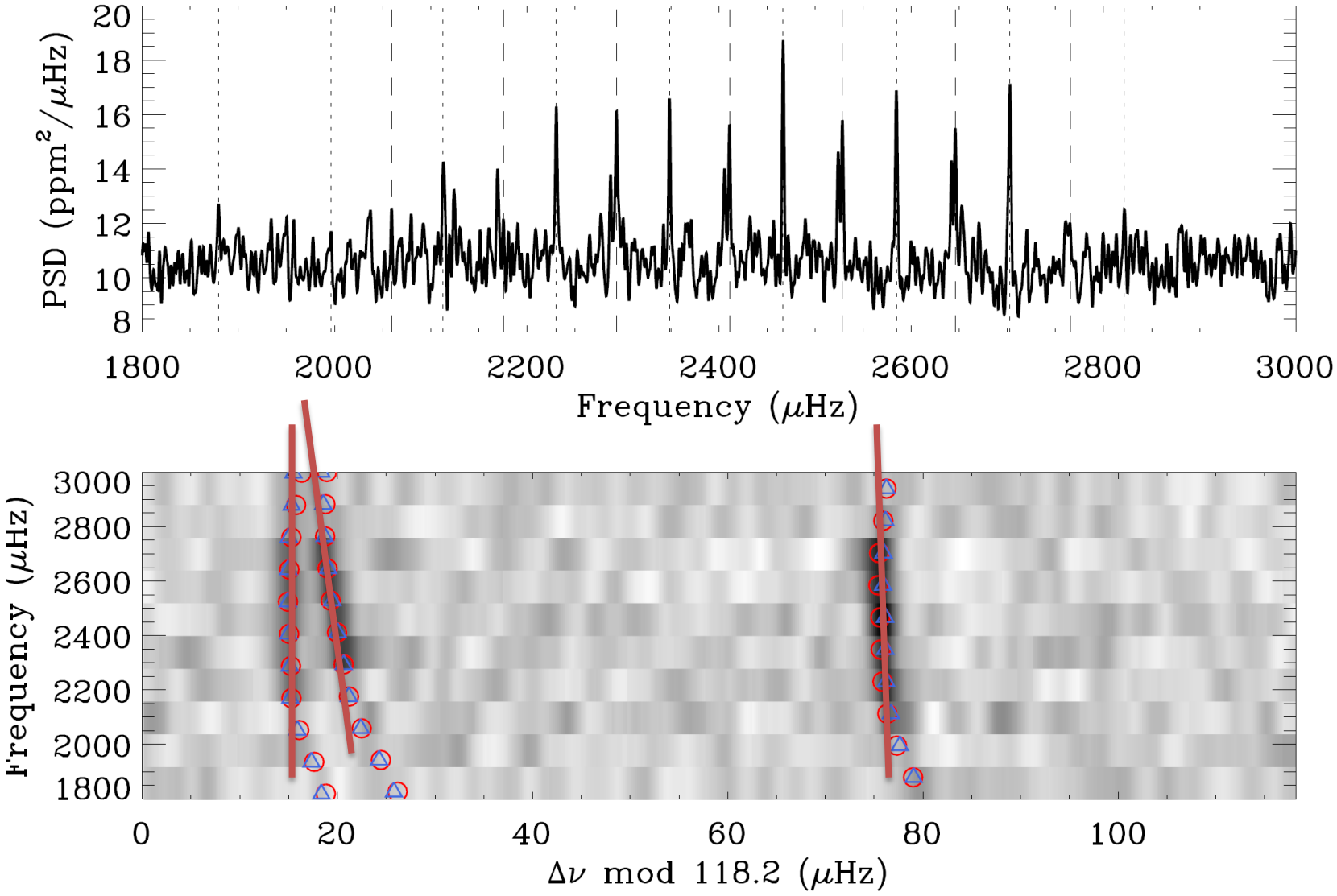
Kepler-10:

Mass (Msun)	0.913 ± 0.022	(2.4%)
Radius (Rsun)	1.065 ± 0.009	(0.85%)
Age (Gyr)	10.4 ± 1.4	(13%)

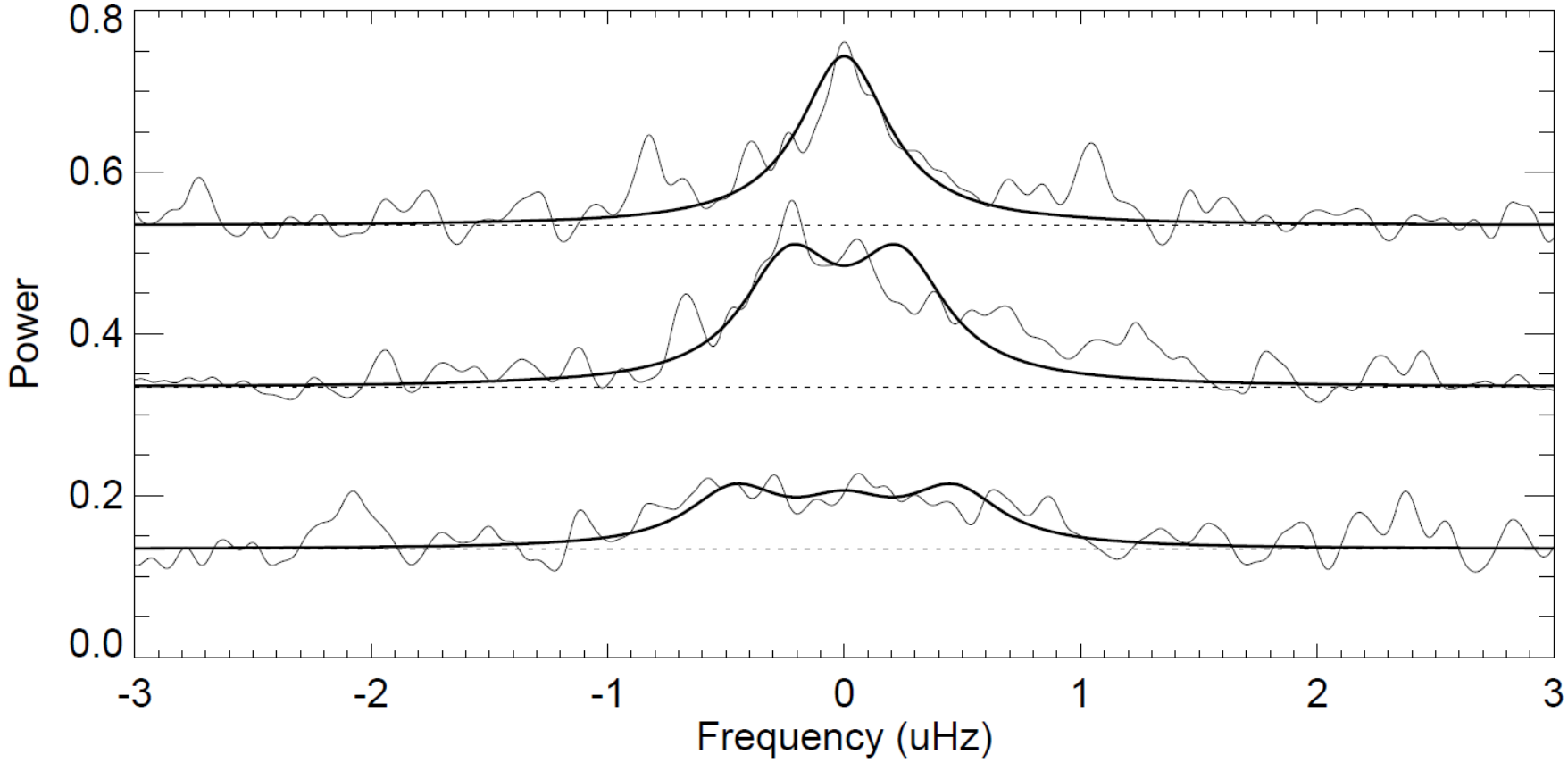
Kepler-10b:

R_{planet}/R_{star}	0.01254 ± 0.00013	(1.0%)
R_{planet}/R_{Earth}	1.451 ± 0.019	(1.3%)

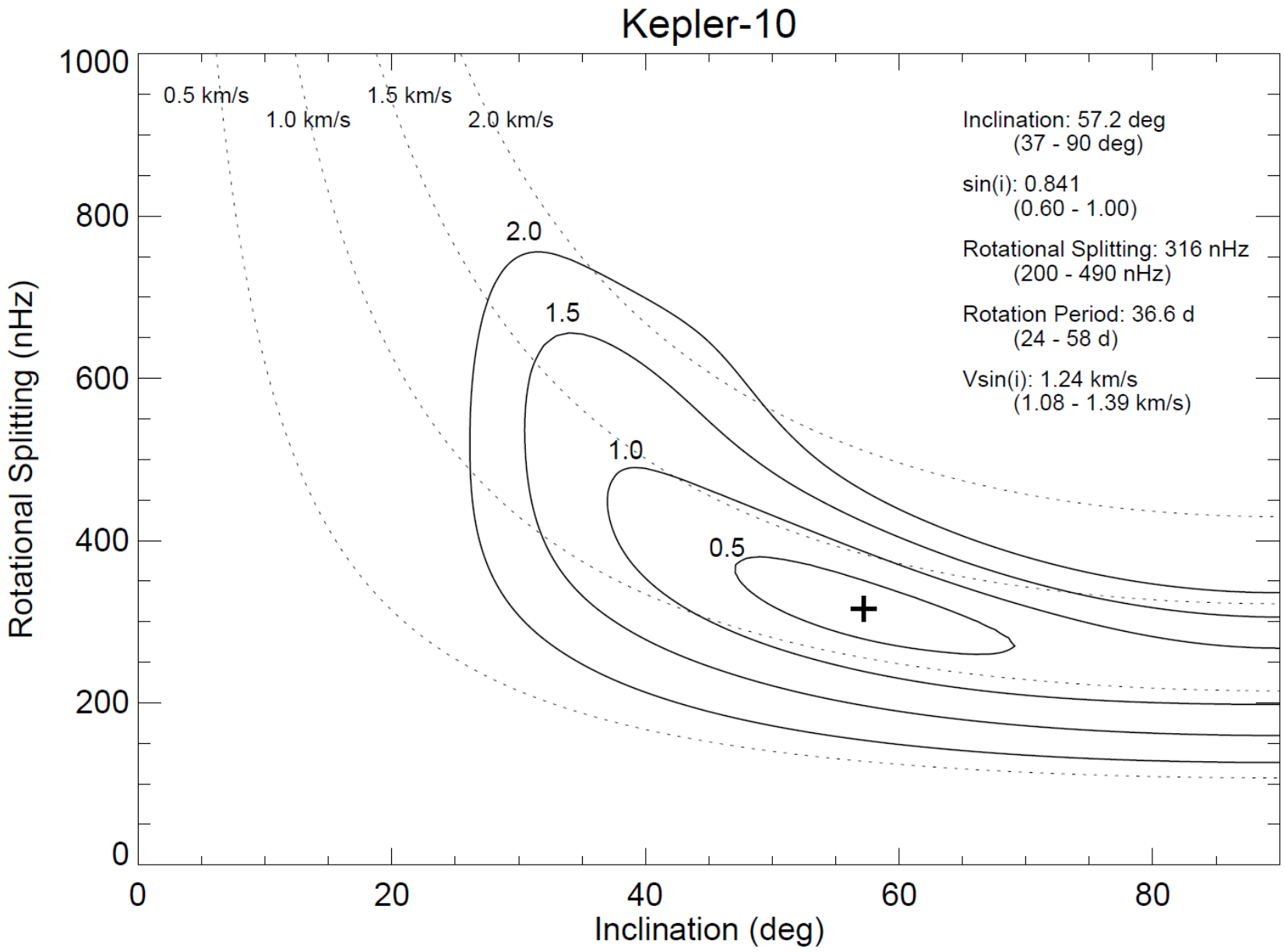
The key is to extend the length of the time series

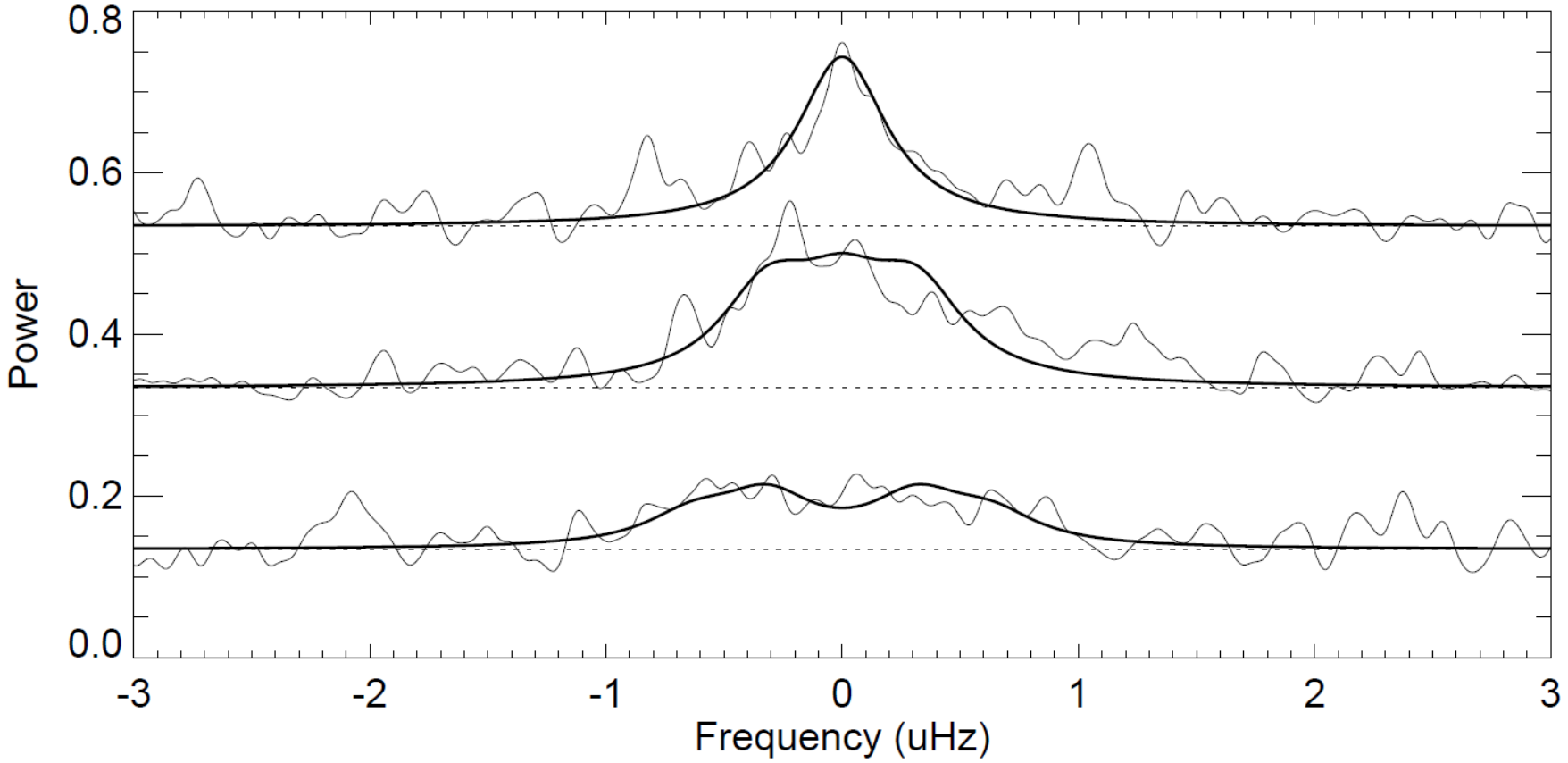

PSD (ppm²/μHz)
20
18
16
14
12
10
8
1800
2000
2200
2400
2600
2800
3000
Frequency (μHz)
Frequency (μHz)
3000
2800
2600
2400
2200
2000
1800
0
20
40
60
80
100
Δν mod 118.2 (μHz)

Rotation?



i = 90 deg


Kepler-10
0.5 km/s
1.0 km/s
1.5 km/s
2.0 km/s
Inclination: 57.2 deg
(37 - 90 deg)
sin(i): 0.841
(0.60 - 1.00)
Rotational Splitting: 316 nHz
(200 - 490 nHz)
Rotation Period: 36.6 d
(24 - 58 d)
Vsin(i): 1.24 km/s
(1.08 - 1.39 km/s)
2.0
1.5
1.0
0.5
Rotational Splitting (nHz)
Inclination (deg)
0
200
400
600
800
1000
0
20
40
60
80


0.8
0.6
0.4
0.2
0.0
Power
-3
-2
-1
0
1
2
3
Frequency (uHz)

Kepler-10 frequencies

Power spectrum can be found via:
http://astro.phys.au.dk/~hans/Kepler10/AMPLITUDE_SPECTRUM.txt

FRQ(μHz) AMP(ppm) PHASE 0.000000

FRQ	ERR	l	n
1879.51	0.21	1	14
1934.18	0.26	2	14
1996.43	0.29	1	15
2059.37	0.22	0	16
2112.69	0.21	1	16
2169.72	0.20	2	16
2175.91	0.22	0	17
2230.66	0.15	1	17
2287.09	0.18	2	17
2293.20	0.15	0	18
2348.48	0.13	1	18
2405.81	0.20	2	18
2410.80	0.13	0	19
2466.60	0.11	1	19
2523.72	0.19	2	19
2528.10	0.15	0	20
2584.59	0.13	1	20
2641.69	0.17	2	20
2645.83	0.16	0	21
2702.47	0.14	1	21
2761.50	0.25	2	21
2763.67	0.26	0	22
2821.87	0.23	1	22