Stellar variability analysis at Molėtai Astronomical Observatory

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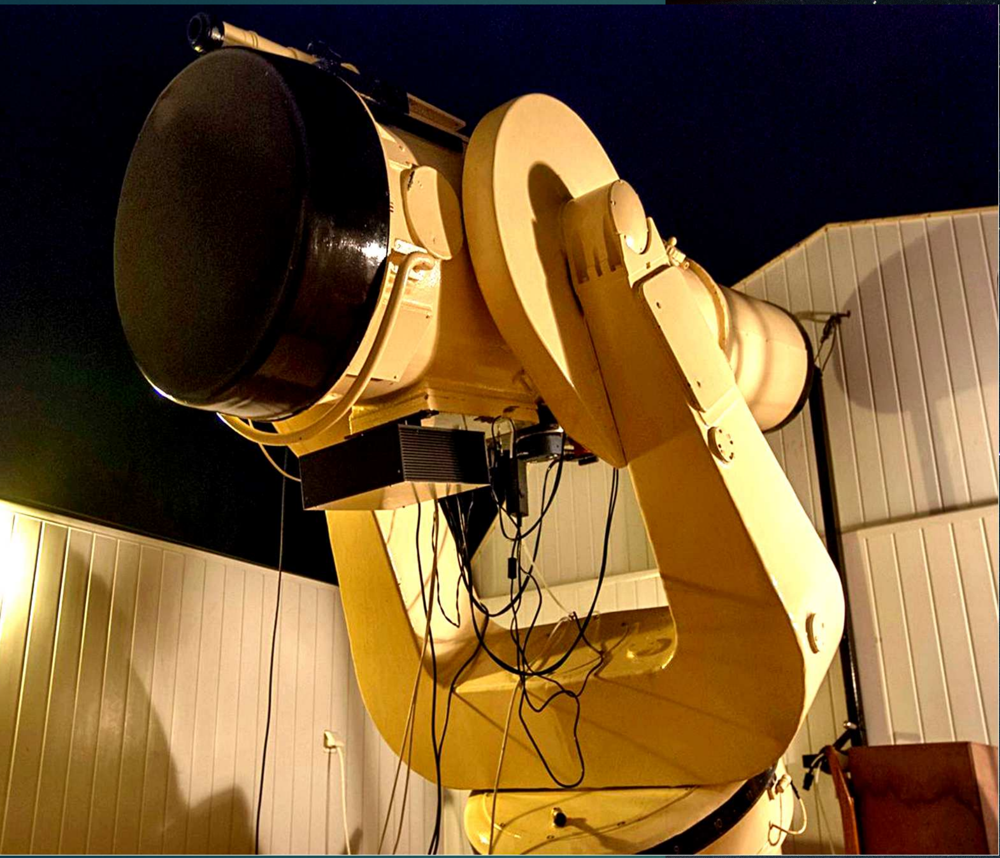
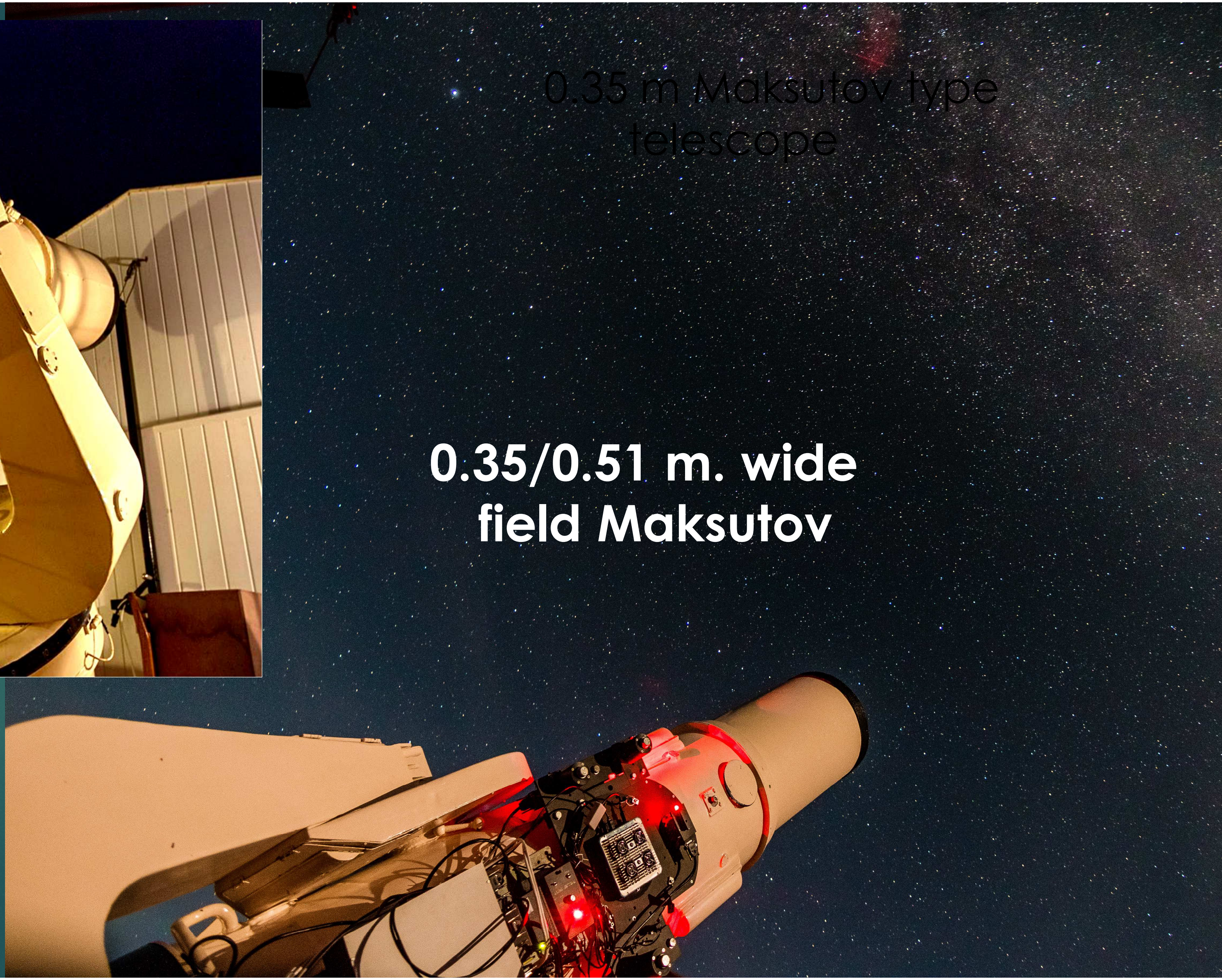
Molėtai AO, Lithuania

Telescopes at Molėtai AO

1.65 m telescope
Ritchey-Chretien




0.35 m Maksutov type telescope
0.35/0.51 m. wide field Maksutov

WET collaboration started in 1988
Moletai AO joined the WET in 1999

WET

Whole Earth Telescope

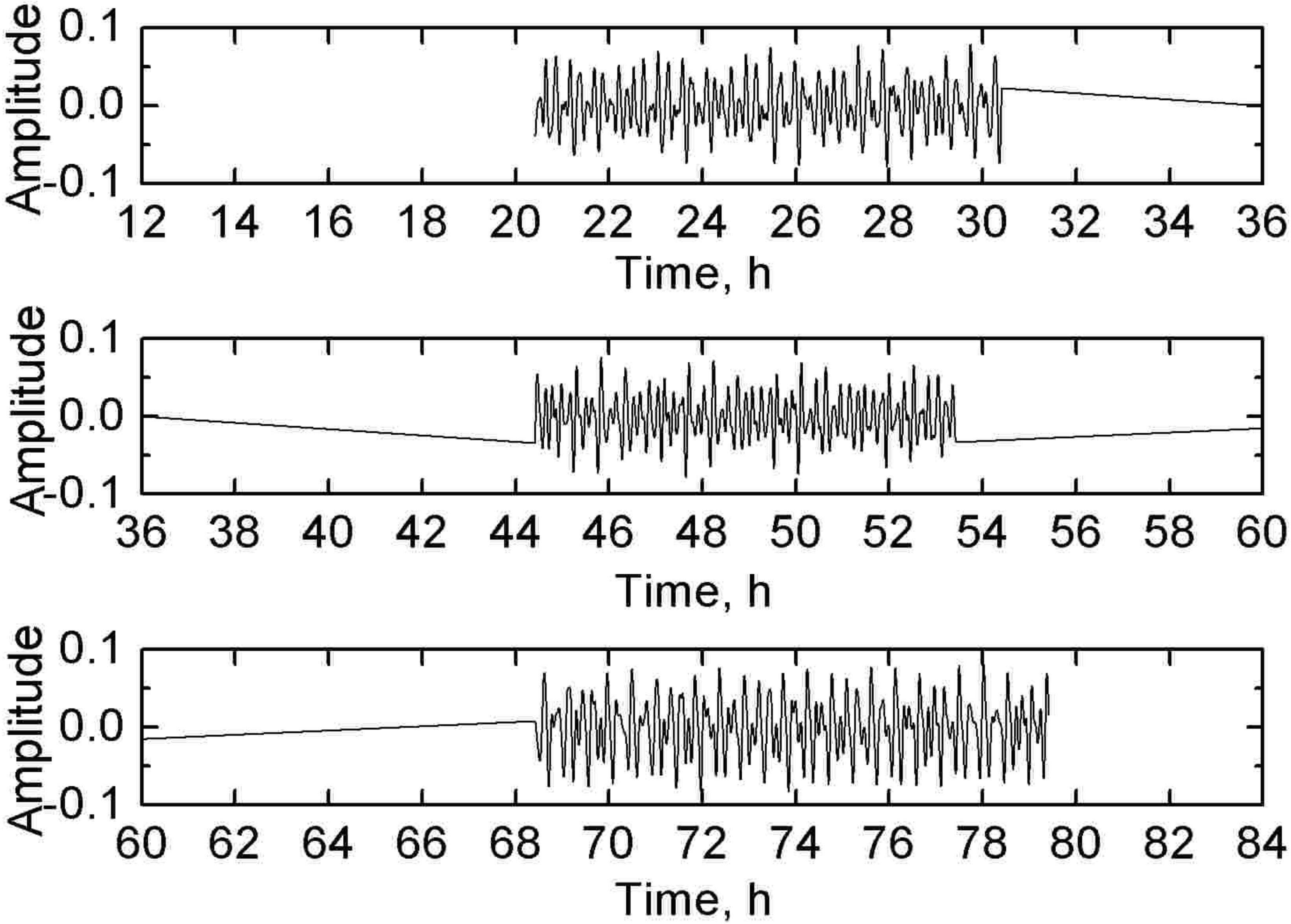
1. McDonald Observatory, Texas
2. CTAS Meyer Observatory
3. Kitt Peak National Observatory, Arizona
4. Mauna Kea Observatories, Hawaii
5. CFHT (Canada-France-Hawaii Telescope), Hawaii
6. Mt. John Observatory, New Zealand
7. Mt. Stromlo & Siding Spring Observatories (MSSSO), Australia
8. Beijing Astronomical Observatory, China
9. Vainu Bappu Observatory, India
10. Moletai Astronomical Observatory, Lithuania
11. Wise Observatory, Israel
12. South African Astronomical Observatory, South Africa
13. Mt. Suhora Observatory, Poland
14. Osservatorio di Bologna, Loiano Telescopes, Italy
15. Calar Alto Observatory, Spain
16. Observatoire du Pic du Midi, France
17. Observatoire de Haute-Provence, France
18. Observatorio del Teide, Tenerife, Spain
19. El Roque de Los Muchachos Observatory (including The Isaac Newton and the Jacobus Kapteyn Telescopes), La Palma, Spain
20. Nordic Optical Telescope, La Palma, Canary Islands
21. Observatorio do Pico dos Dias, Brazil
22. Cerro Tololo Interamerican Observatory, Chile
23. European Southern Observatory, Chile
24. SARA, Kitt Peak, Arizona
25. Mt. Cuba Astronomical Observatory, University of Delaware, USA
26. Steward Observatory, Mt. Lemmon & Mt. Bigelow, Arizona
27. Terskol Observatory, Peak Terskol, Russia
28. Institute for Astronomy and Astrophysics (IAAT), Tubingen, Germany
29. Konkoly Observatory, Hungary

The aim:

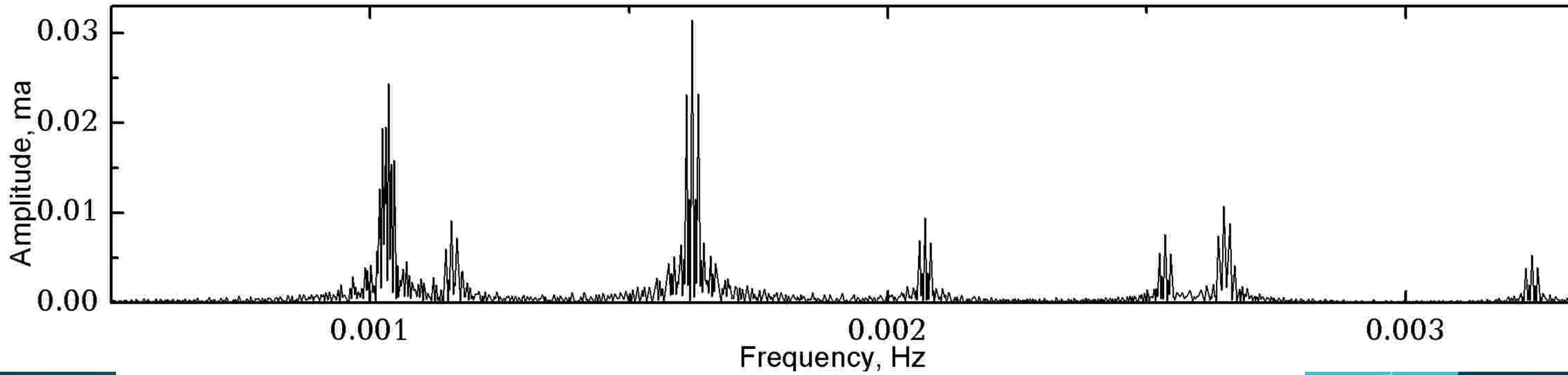
- to extend non-interrupted observations of compact pulsators and to have a stream of data long enough for resolving the complex nature of pulsations.

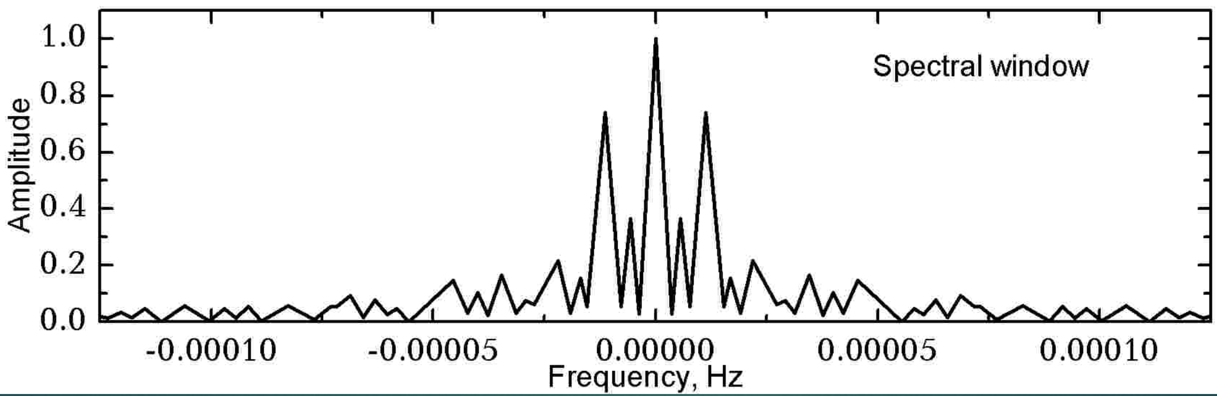
Targets – compact pulsators such as

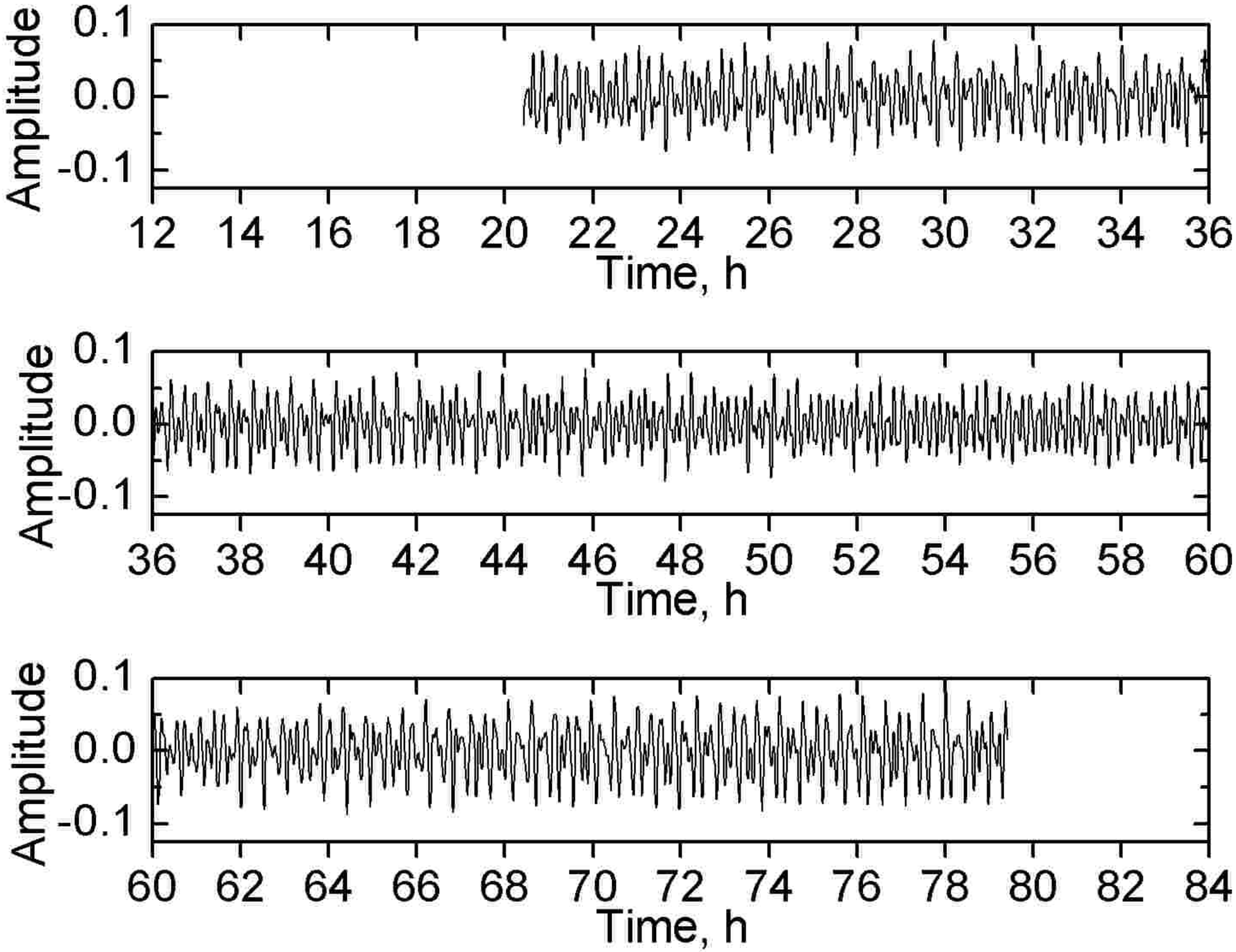
- DAV
- DBV
- DOV
- Variable progenitors of WD in planetary nebulae
- sdBV
- other short periodic variable stars



Amplitude
0.1
0.0
-0.1
12 14 16 18 20 22 24 26 28 30 32 34 36
Time, h
Amplitude
0.1
0.0
-0.1
36 38 40 42 44 46 48 50 52 54 56 58 60
Time, h
Amplitude
0.1
0.0
-0.1
60 62 64 66 68 70 72 74 76 78 80 82 84
Time, h


0.03
0.02
0.01
0.00
Amplitude, ma
0.001
0.002
0.003
Frequency, Hz


Spectral window
1.0
0.8
0.6
0.4
0.2
0.0
Amplitude
-0.00010
-0.00005
0.00000
0.00005
0.00010
Frequency, Hz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Time, h
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0.0
-0.1
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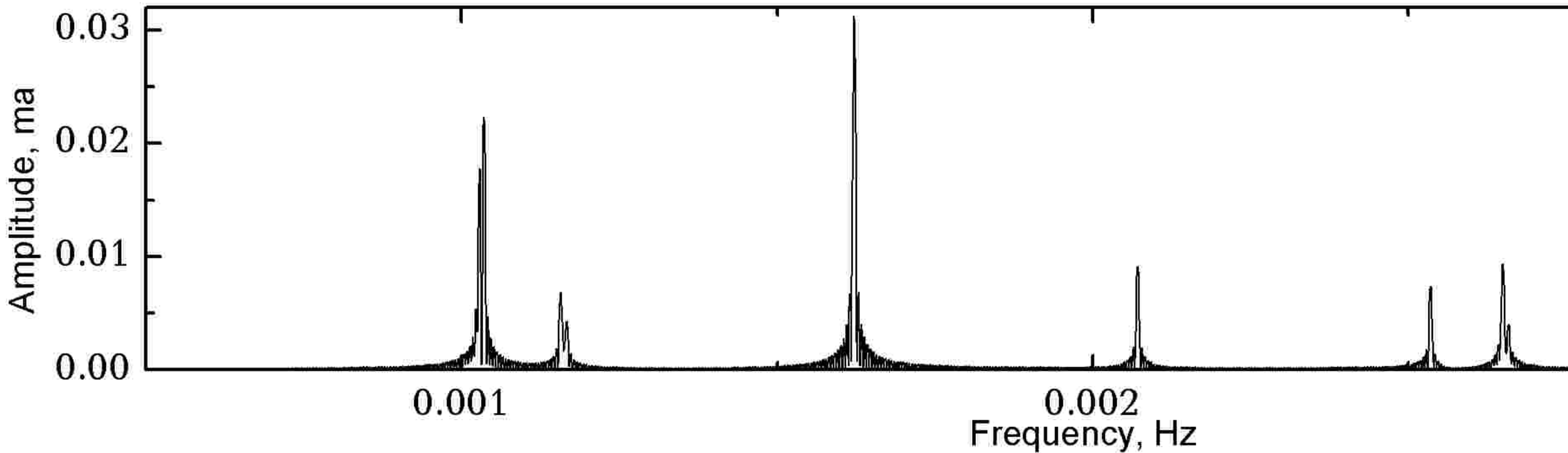
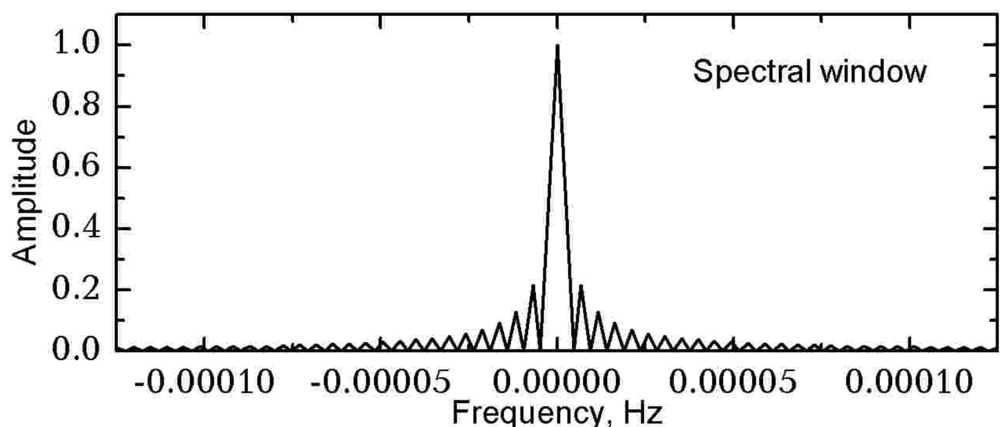
Time, h
Amplitude
0.1
0.0
-0.1
60 62 64 66 68 70 72 74 76 78 80 82 84
Time, h

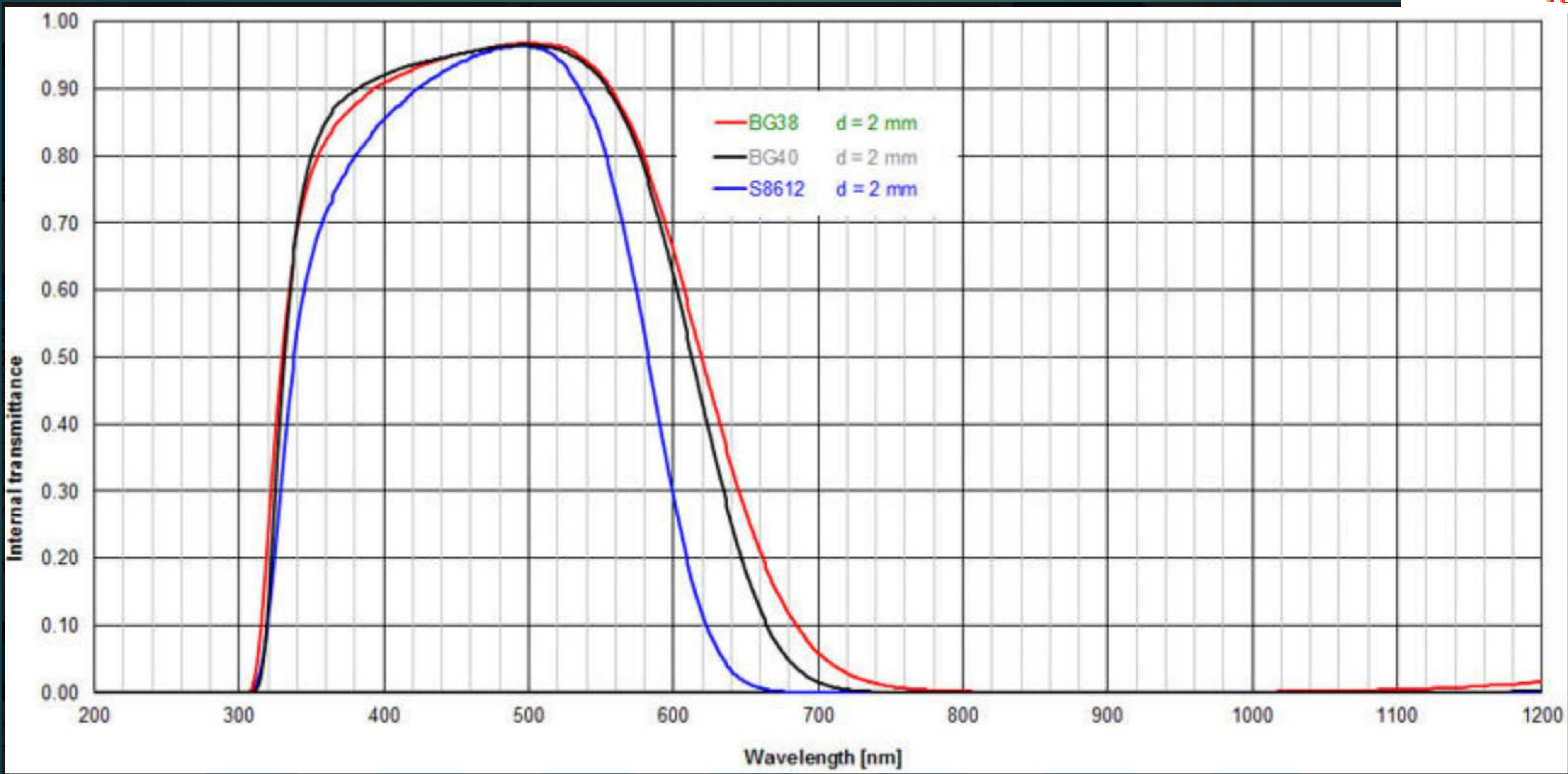


Amplitude, ma
0.03
0.02
0.01
0.00
0.001
0.002
Frequency, Hz



Spectral window
Amplitude
1.0
0.8
0.6
0.4
0.2
0.0
-0.00010
-0.00005
0.00000
0.00005
0.00010
Frequency, Hz

- BG40 or S8612 **filter** to normalize wavelength response and increase S/N ratio



- GD358 - brightest (m_V=13.7) and best studied helium atmosphere WD
- GD358 was discovered in 1982 (Winget et al. 1982)
- As a WET target observed in 1990, 1994, 2000, and 2006
- Additional nonWET individual observing runs (278 runs)

- Analysis of 34 years of photometric observations of DBV type star GD 358

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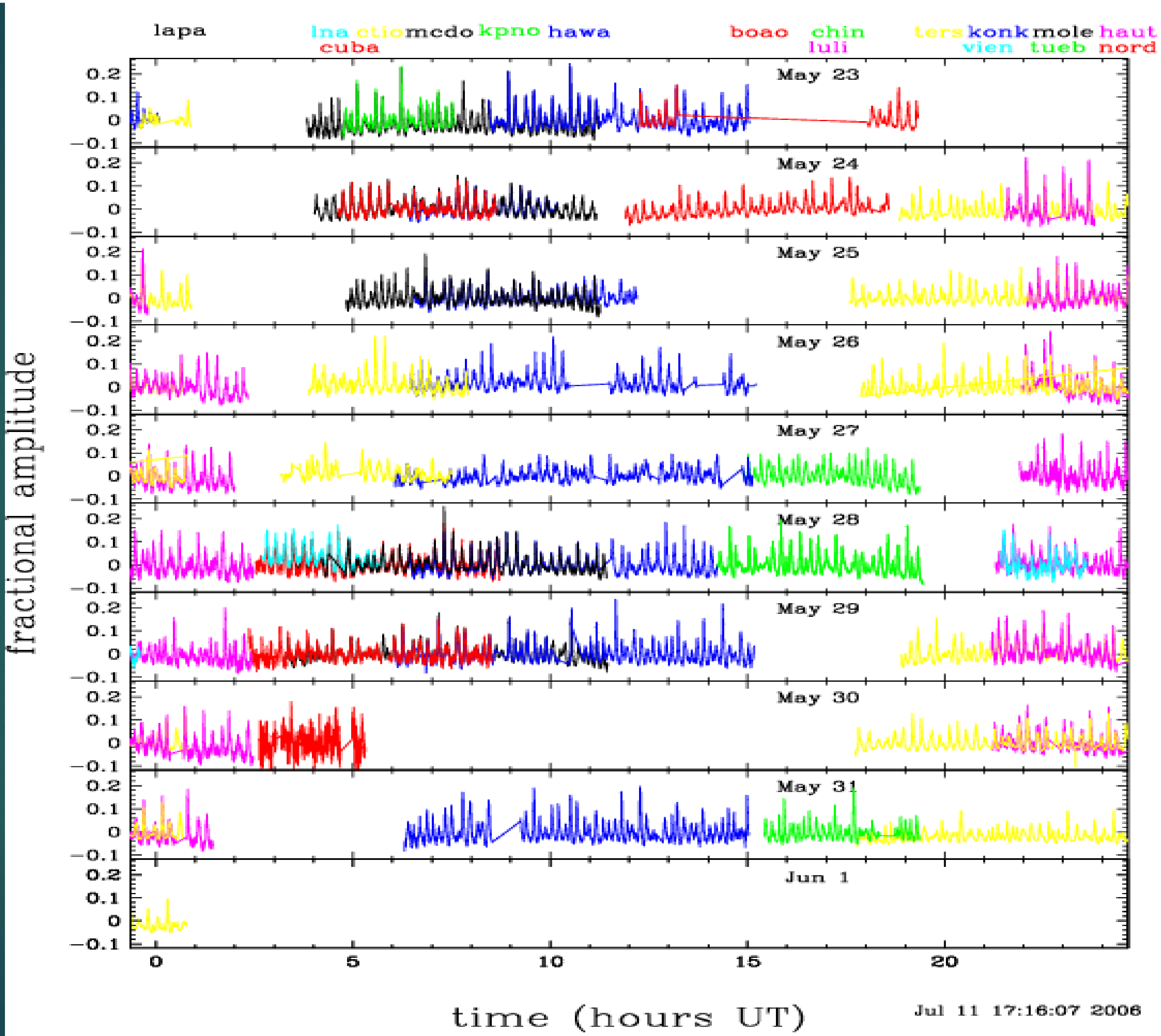
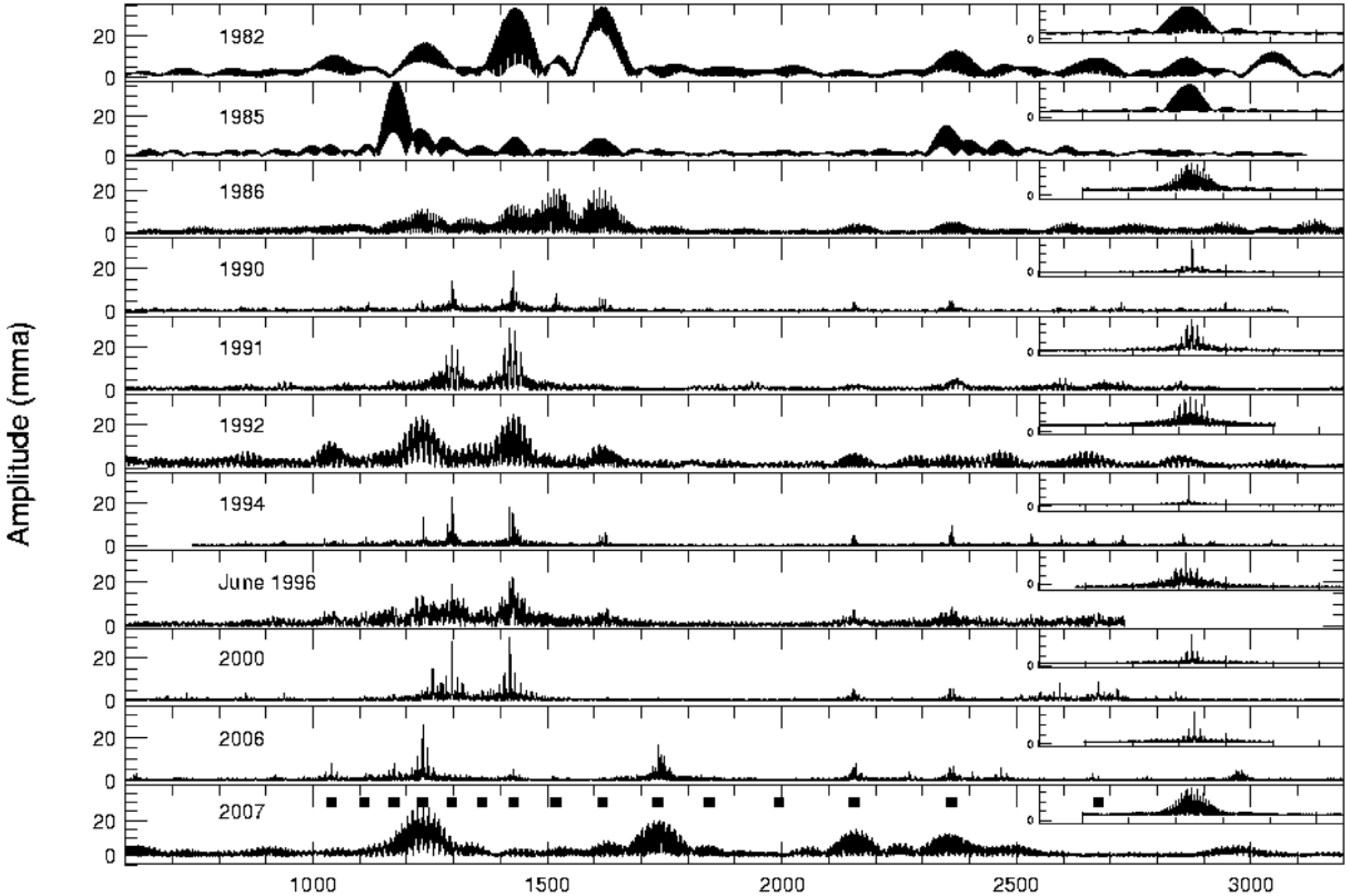
CrossMark

GD358: Three Decades of Observations for the In-depth Asteroseismology of a DBV Star

Agnès Bischoff-Kim[1], J. L. Provencal[2,3], P. A. Bradley[4], M. H. Montgomery[3,5], H. L. Shipman[2,3], Samuel T. Harrold[5], B. Howard[3], W. Strickland[6], D. Chandler[6], D. Campbell[6], A. Arredondo[6], R. Linn[6], D. P. Russell[6], D. Doyle[6], A. Brickhouse[6], D. Peters[6], S.-L. Kim[7], X. J. Jiang[8], Y-N. Mao[8], A. V. Kusakin[9], A. V. Sergeev[10,11], M. Andreev[10,11], S. Velichko[10,11], R. Janulis[12], E. Pakstiene[12], F. Aliçavuş[13], N. Horoz[13], S. Zola[14,15], W. Ogłoza[15], D. Koziel-Wierzbowska[14], T. Kundera[14], D. Jableka[14], B. Debski[14], A. Baran[15], S. Meingast[16], T. Nagel[17], L. Loebling[17], C. Heinitz[17], D. Hoyer[17], Zs. Bognár[18], B. G. Castanheira[19], and A. Erdem[20,21]

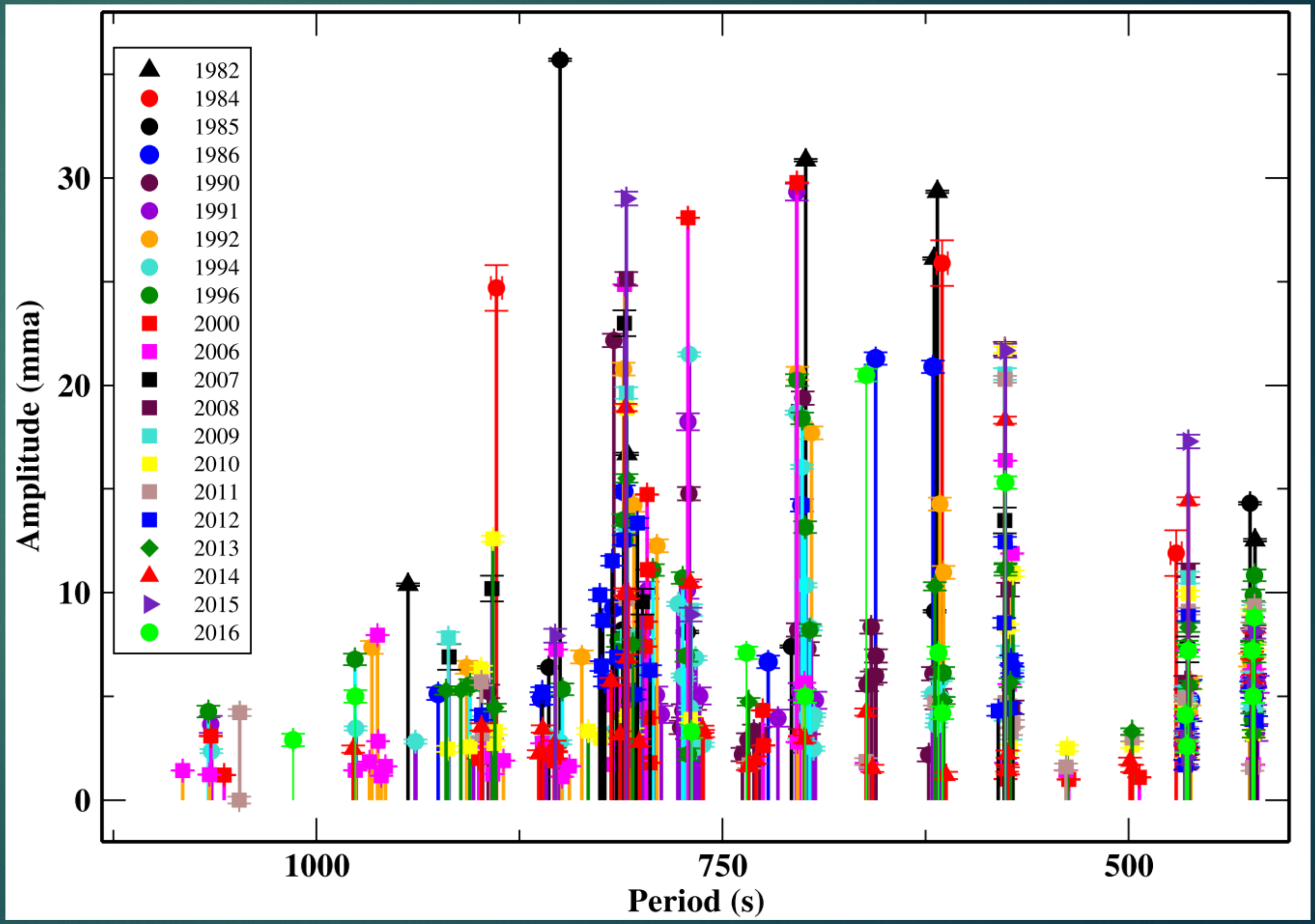
WET XCOV25(2006 May-June) LCs of GD358





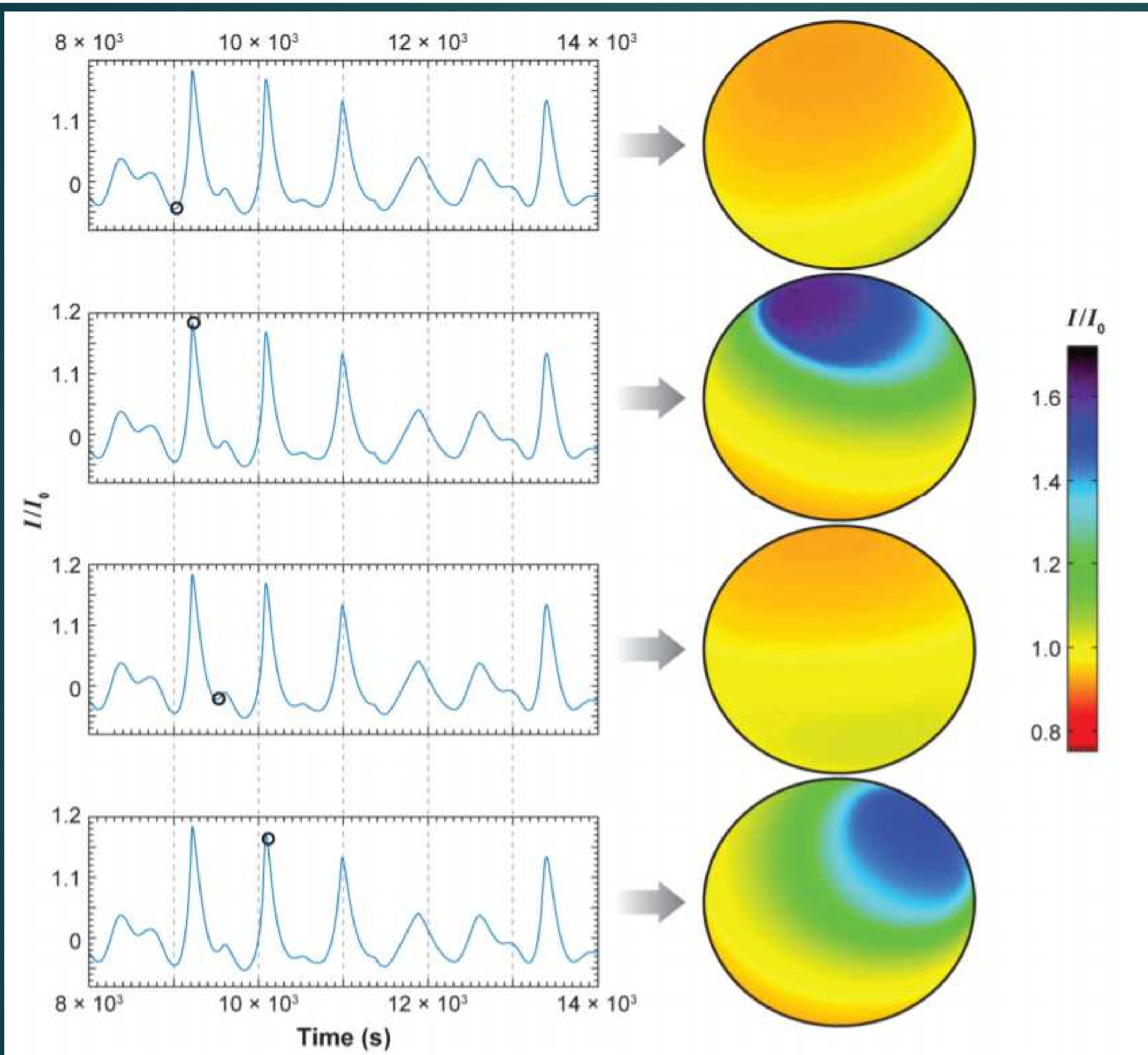
Amplitude (mma)
1982
1985
1986
1990
1991
1992
1994
June 1996
2000
2006
2007
20
0
1000
1500
2000
2500
3000

- A schematic representation of GD358's pulsation modes for all available data between 1982 and 2016. Systematic patterns of distribution in amplitude and period (frequency) are evident.
- The band near 1300 μHz (770 s) spans 25.5 μHz.
- The widest band, near 1238 μHz (807 s), spans 58 μHz



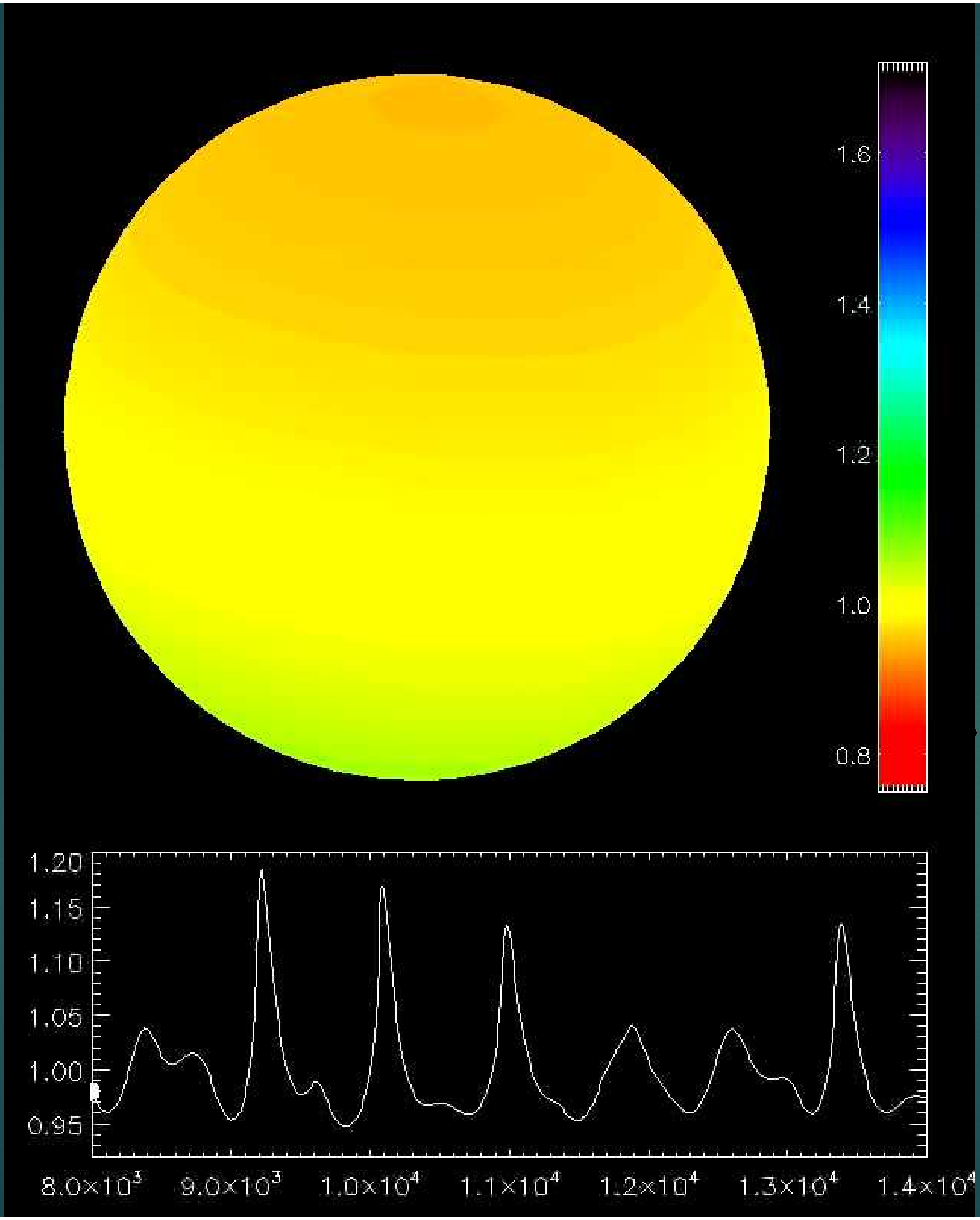
Why the frequencies are not stable?

- An unknown mechanism changes slightly frequencies
- As convection is responsible for pulsations in variable WDs, possibly the convection layer thickness changes along with surface temperature variations.



Surface brightness changes for the DBV GD 358, according to the nonlinear convection/pulsation models of Montgomery (2007).

GD 358
DBV



Montgomery, M. H.

- DBV
- GD 358 T_{eff}= 25,630 K, M_*=0.571M_{sun}
- 15 independent modes

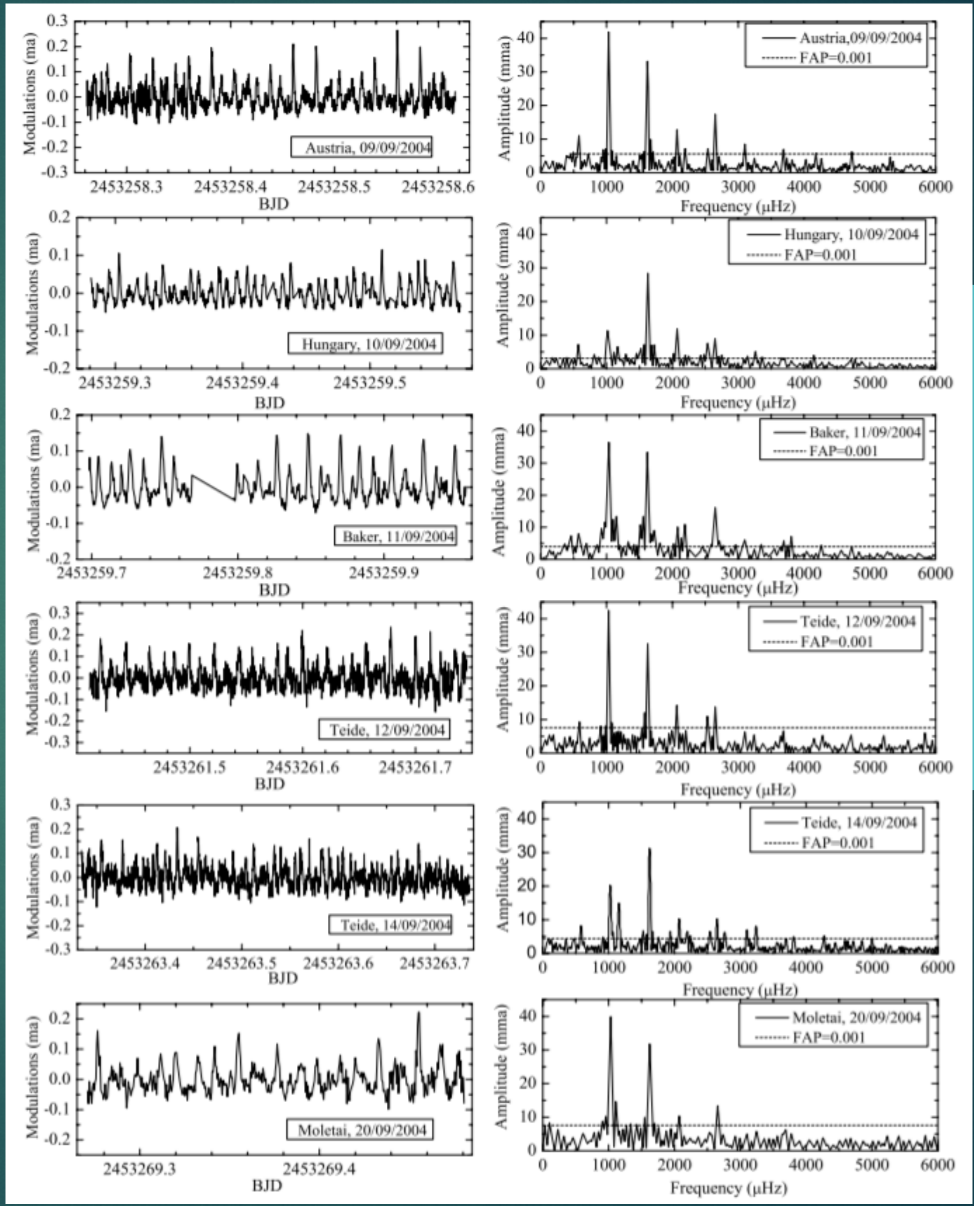
- DAV
- KIC 4552982 has similar bands (Bell et al. 2015)
- KIC 4552982 is one of the coolest DAV known (Tremblay et al. 2013)
- T_{eff} = 10,860 K, log(g) = 8.16, and M_* = 0.69 M_{sun}

- Other variable WDs may have the same bands
- For example DAV PG 2303+243, observed at Moletai AO and other observatories (Baker Obs., Vienna Obs., Konkoly Obs., Teide Obs.) observed for many years since 2004.
- T_{eff} = 11 350 K, M_* =0.609M_{sun}, log g = 8.09

- Variable WDs

ZZ Ceti

PG 2303+243



GD358

- Identified 15 ℓ=1 periods. Used for modelling with WDEC. Summary of results in the table below.

A Summary of the Results of a Number of Studies of GD358

References	$M_*/M_\odot$	$T_{\rm eff}$ K	$M_{\rm env}$	$M_{\rm He}$	Distance (pc)	O frac M_o/M_*	$X_{\rm fm}$	M_c/M_*
Bradley & Winget (1994)	0.61 ± 0.03	24,000 ± 1000	N.A.	$5.70^{+0.18}_{-0.30}$	42 ± 3	0.80	0.80	0.90
Dehner & Kawaler (1995)	0.58	24,210	2.6	6.0	N.A.	0.50	⋯	0.997
Metcalfe et al. (2000)	0.605	23,100	(2.74)	5.97	N.A.	0.80	0.50	0.90
Metcalfe et al. (2001)	0.65	22,600	⋯	2.74	N.A.	0.84	0.49	0.95
Fontaine & Brassard (2002)	0.625 ± 0.036	24,800 ± 580	2.97 ± 0.21	5.80 ± 0.37	43.0 ± 3.2	N.A.	N.A.	N.A.
Metcalfe (2003)	0.66	22,900	⋯	2.00	N.A.	0.67	0.48	0.98
this work	0.571 ± 0.001	23,650 ± 600	2.0 ± 0.1	5.5 ± 0.5	$44.5^{+8.0}_{-3.0}$	0.50	0.195	0.90
Nitta et al. (2012)	0.506 ± 0.04	23,740 ± 92	⋯	⋯	N.A.	N.A.	N.A.	N.A.
Bédard et al. (2017)	0.57 ± 0.03	24,940 ± 1020	⋯	⋯	36.6 ± 4.5	N.A.	N.A.	N.A.

Note. The last two rows are spectroscopic results. M_c/M_* is the mass coordinate at which point the oxygen abundance drops to zero.

Other projects on objects with variable brightnes

- Search for new exoplanets (transits, TTV, TDV)
- Search for new variable stars and eclipsing binary stars
- Photometric time series observations of asteroids (in collaboration with Poland)
- Spectroscopic observations of binary stars (Echelle spectrograph VUES)
- Spectroscopic characterization of potential targets of TESS, JWST, PLATO
- Gaia alerts photometric observations at MAO (joint Poland-Lithuania projects on search of single stellar mass black hole).

Thank you!