The GATS project and pulsating stars

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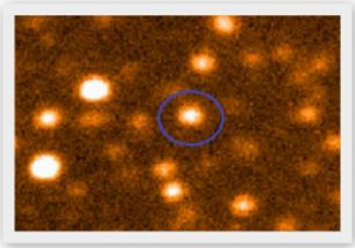
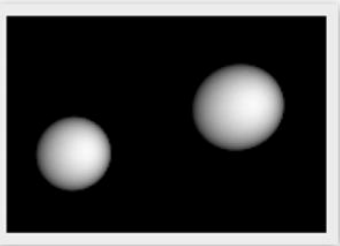
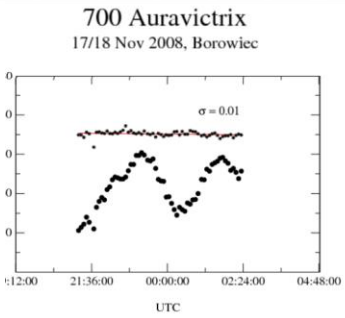
fot. Anna Marciniak



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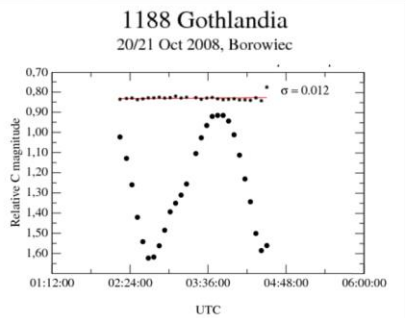
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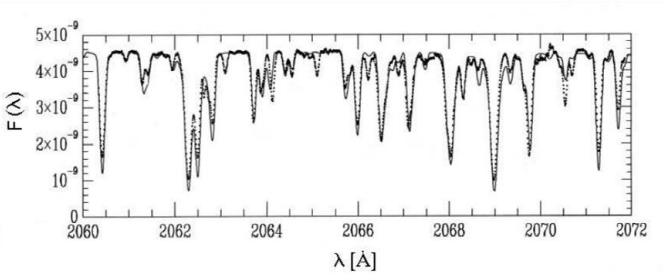
F (λ)
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2×10⁻⁹
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2060
2062
2064
2066
2068
2070
2072
λ [Å]

Team, collaborators

Uniwersytet Wrocławski

Ewa Niemczura

UAM

GLOBAL ASTROPHYSICAL TELESCOPE SYSTEM

GATS team

Krzysztof Kamiński head of PST2

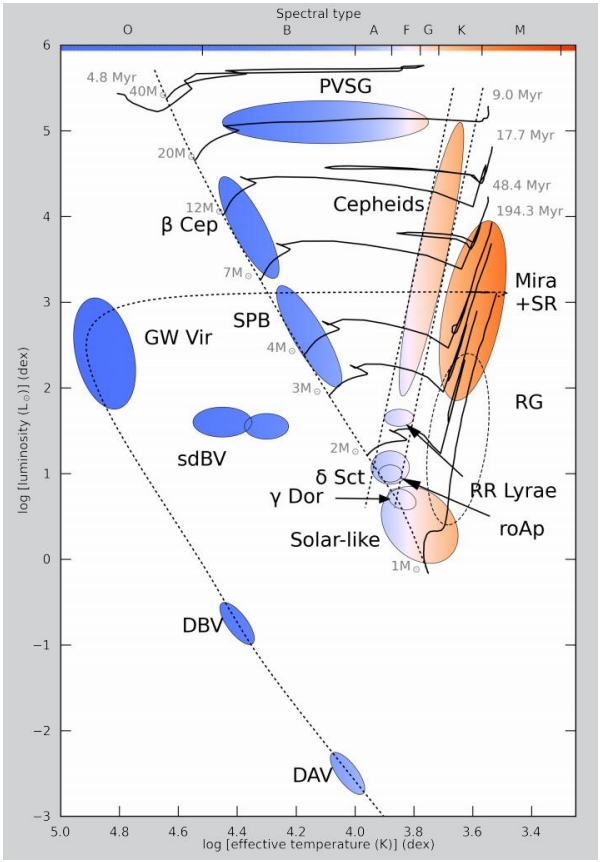
Wojciech Dimitrov head of PST1

Wojciech Borczyk

Monika Kamińska

Chemical composition and pulsations of B-type stars

The zoo of pulsating stars

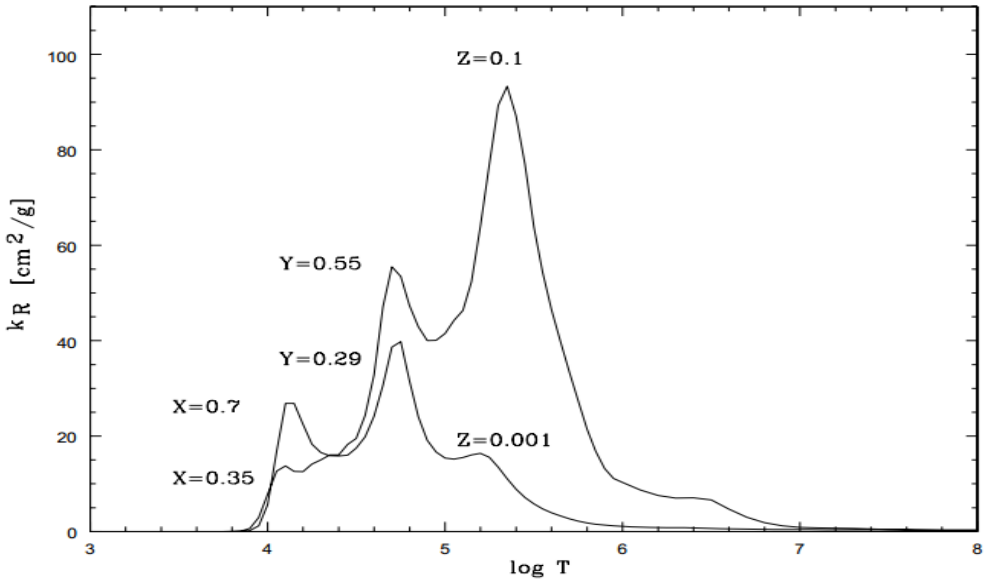


(Degroote, 2010)

Chemical composition and pulsations of B-type stars

Why do some stars pulsate?

Most of the pulsations are considered to be caused by the **κ mechanism**
- opacity mechanism



(Kubiak M.)

1. hydrogen and helium ionization H+ (He+) zones

- **$1.1 \cdot 10^4$ K**

2. Second helium ionization zones He++

- **$5 \cdot 10^4$ K**

3. Z-bump - transition of the iron-group elements (Fe)

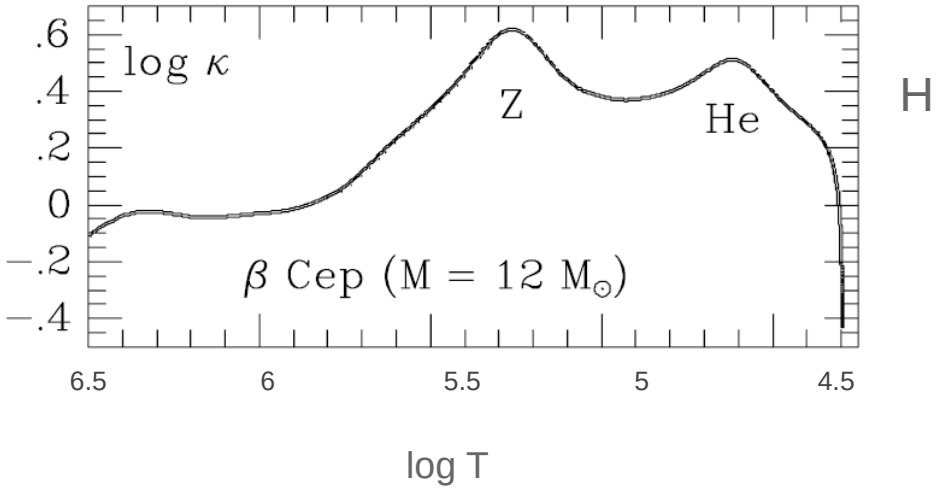
- **$2 \cdot 10^5$ K**

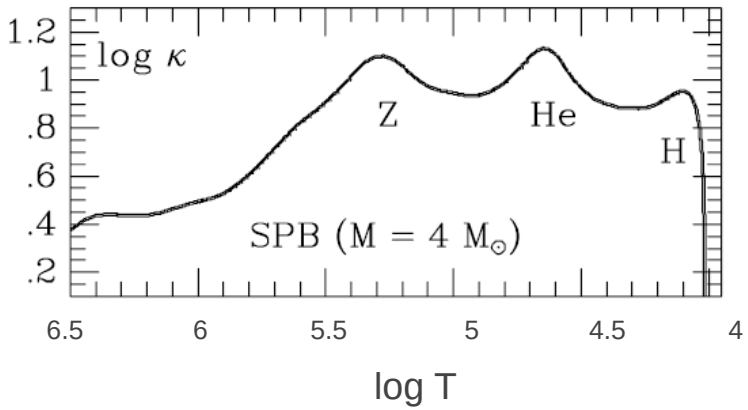
4. DOB - “deep opacity bump” partial ionization zone of C, O

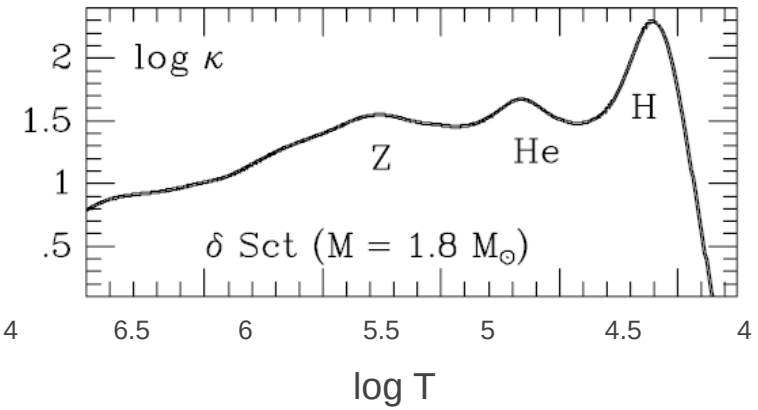
Chemical composition and pulsations of B-type stars

X = 0.7

Z = 0.02

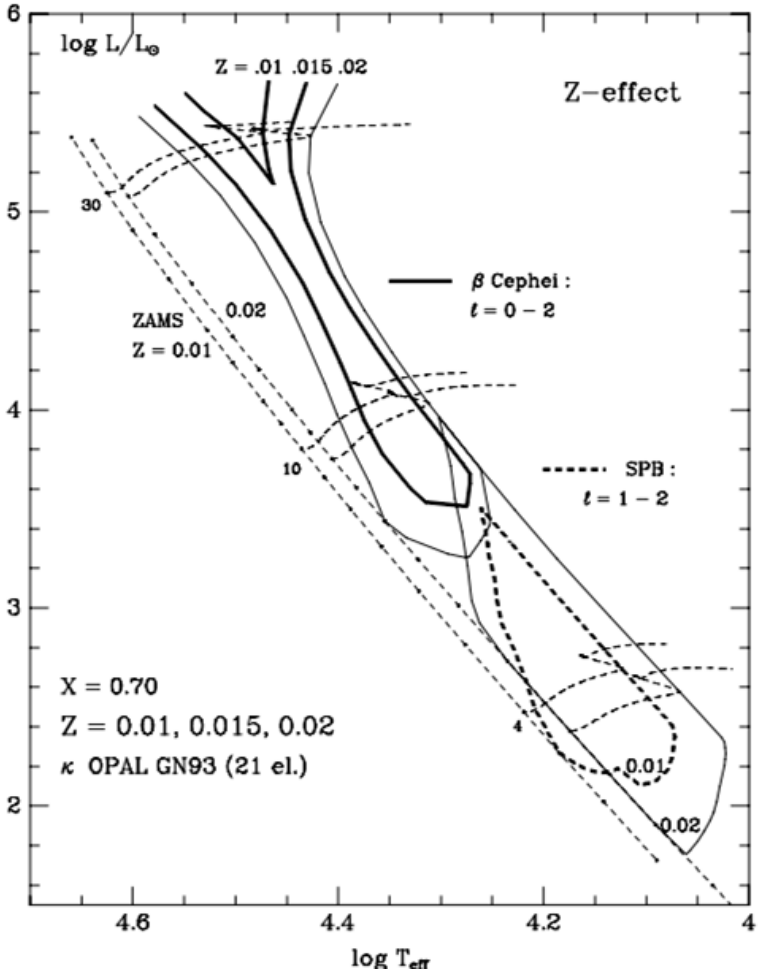


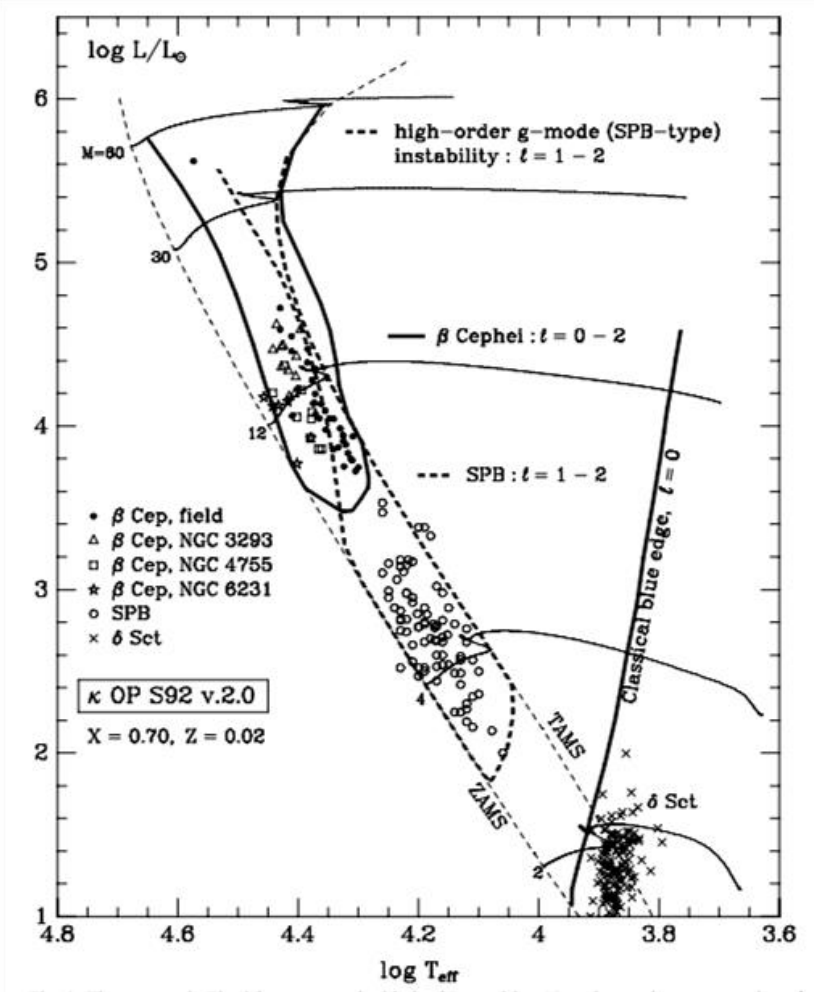




(Pamyatnykh 1999)

Chemical composition and pulsations of B-type stars

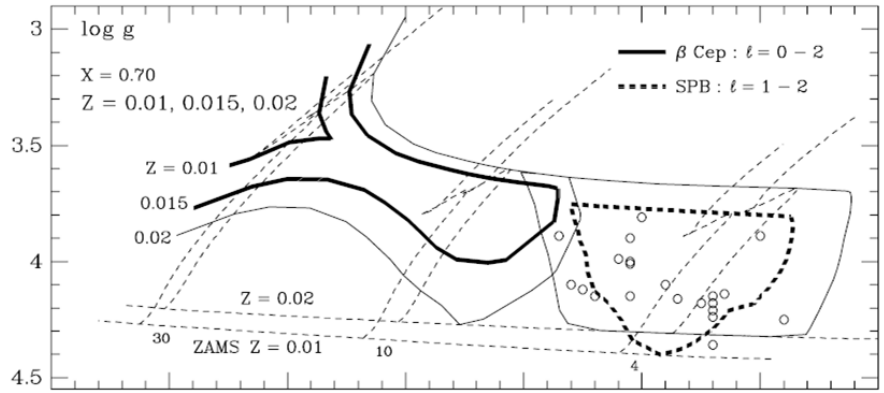




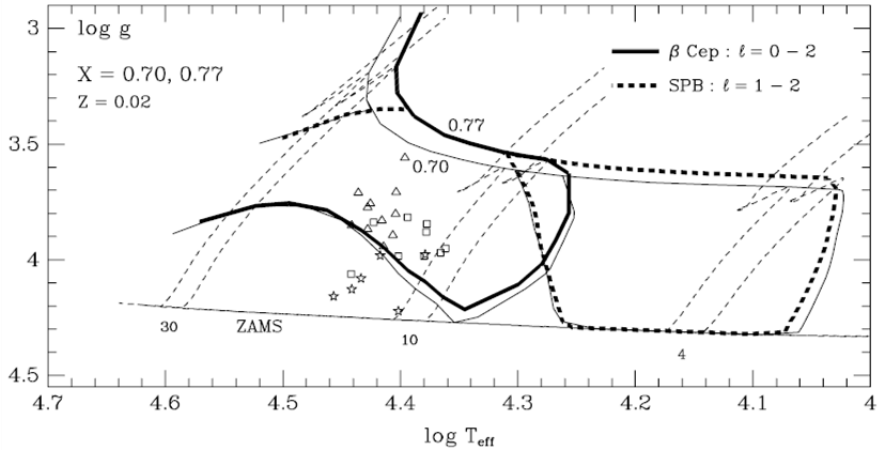
(Pamyatnykh 1999)

Chemical composition and pulsations of B-type stars

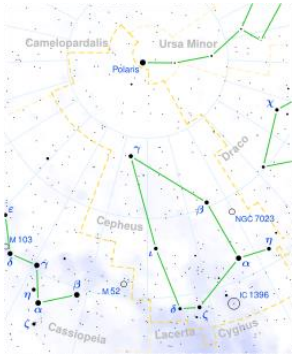
Z



X



(Pamyatnykh 1999)



Chemical composition and pulsations of B-type stars

The **ß Cephei** stars are:

- massive (M: 7 - 20 solar masses);
- hot (Teff : 18000 - 35000 K);
- early B-type stars (spectral type: B0.5 - B3) with luminosity classes V – III;
- exhibit short period variations of brightness, radial velocity and line profiles;

- are low radial order p/g-mode pulsators (pulsation periods: 2 - 12 hours);

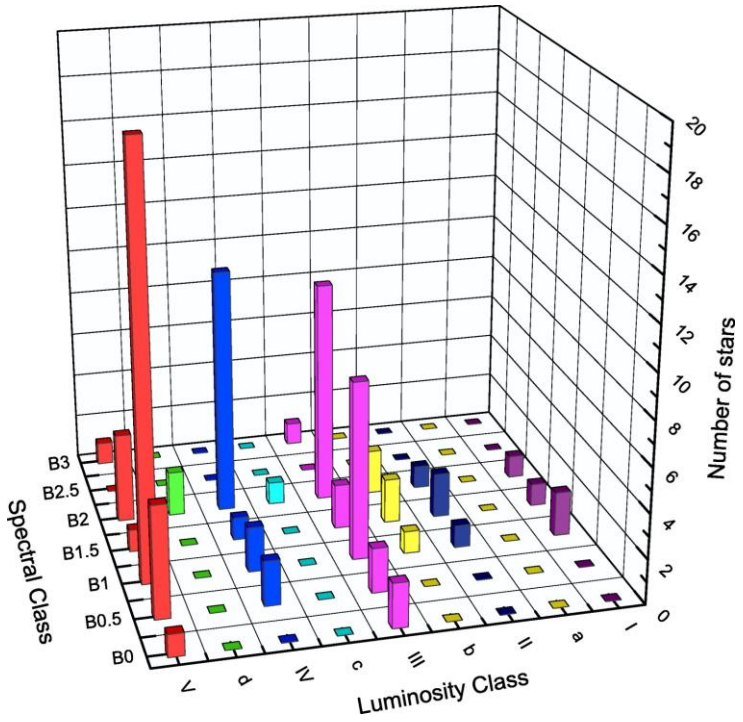
The **SPB** stars are:

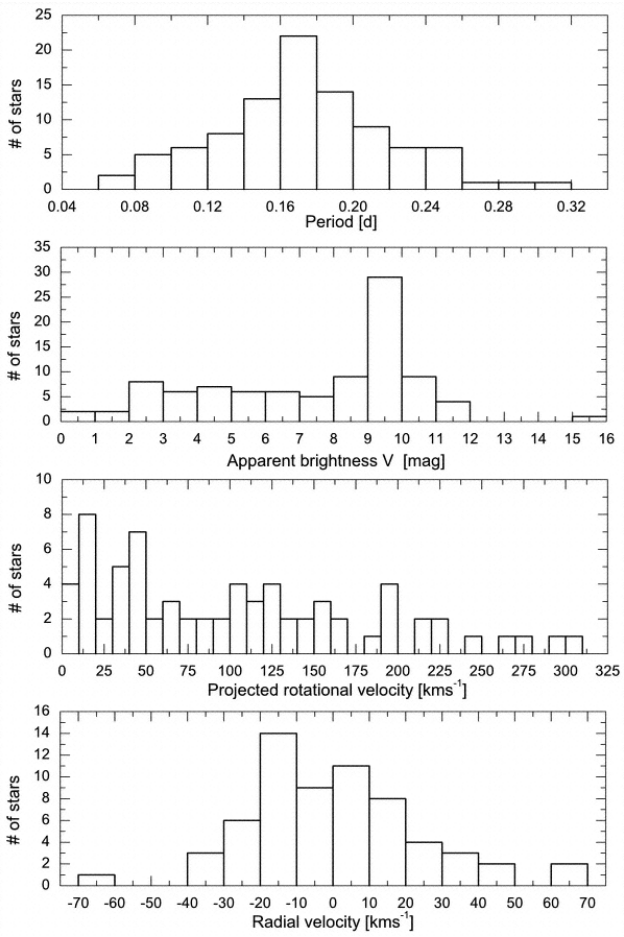
- massive (M: 3 – 8 solar masses);
- hot (Teff: 10000 – 20000 K);
- main sequence B-type stars (spectral type: B3 - B8) with luminosity classes V – III;
- exhibit period variations of brightness, radial velocity and line profiles;

- are high-order low-degree g-mode pulsators (pulsation periods: 1 – 3 days);

- their pulsations are driven by the classical k mechanism operating in the layer of the metal opacity bump at T = 200 000 K.

Chemical composition and pulsations of B-type stars





“Catalog of Galactic ß Cephei Stars”

(Stankov and Handler, 2005)

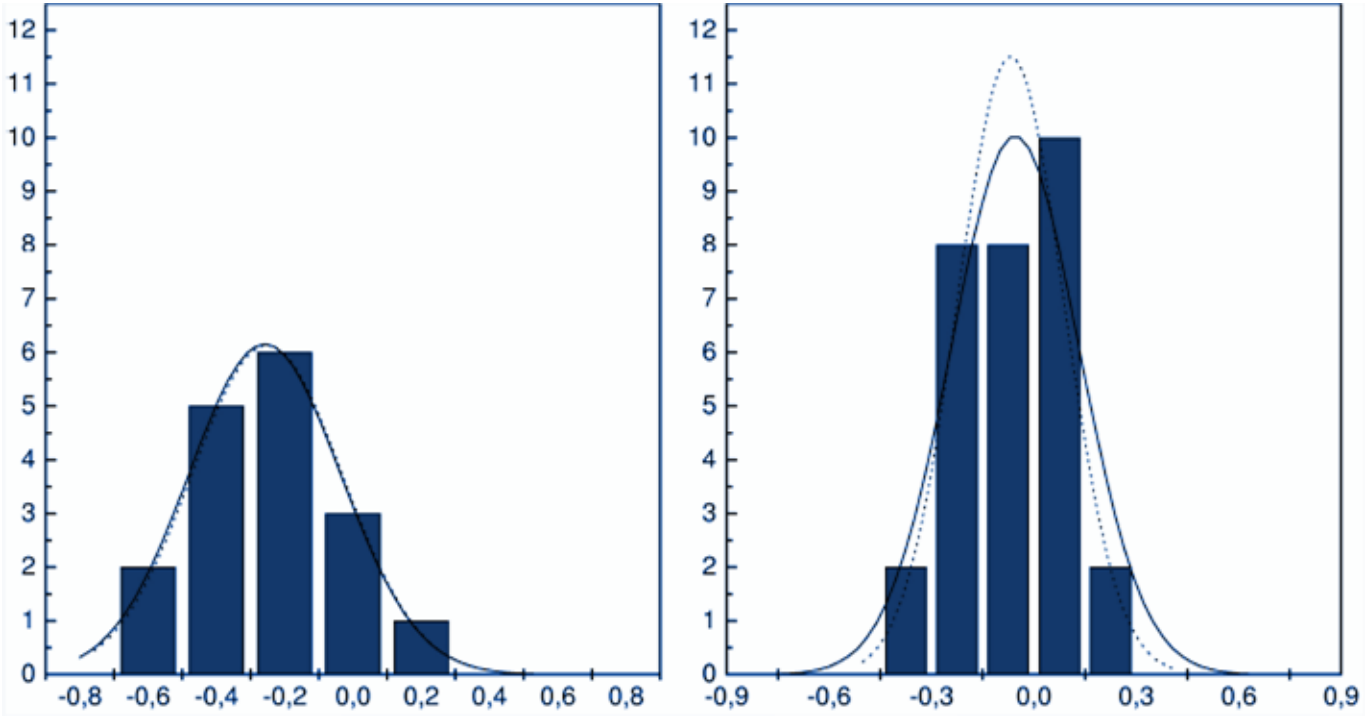
Chemical composition and pulsations of B-type stars

ß Cephei

monoperiodic

multiperiodic

N



[m/H]

[m/H]

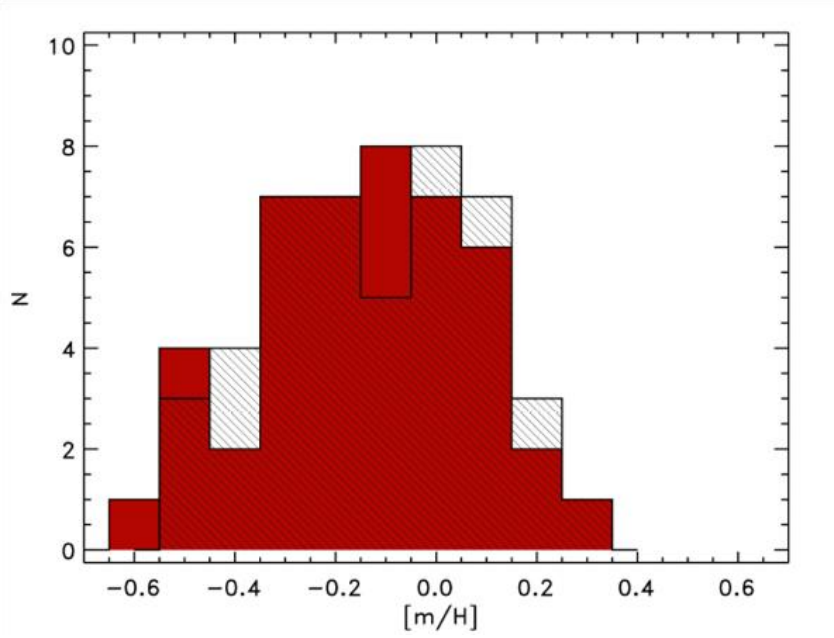
Low-resolution ultraviolet spectra (from IUE satellite)

(Niemczura & Daszynska-Daszkiewicz, 2005)

Chemical composition and pulsations of B-type stars

ß Cephei

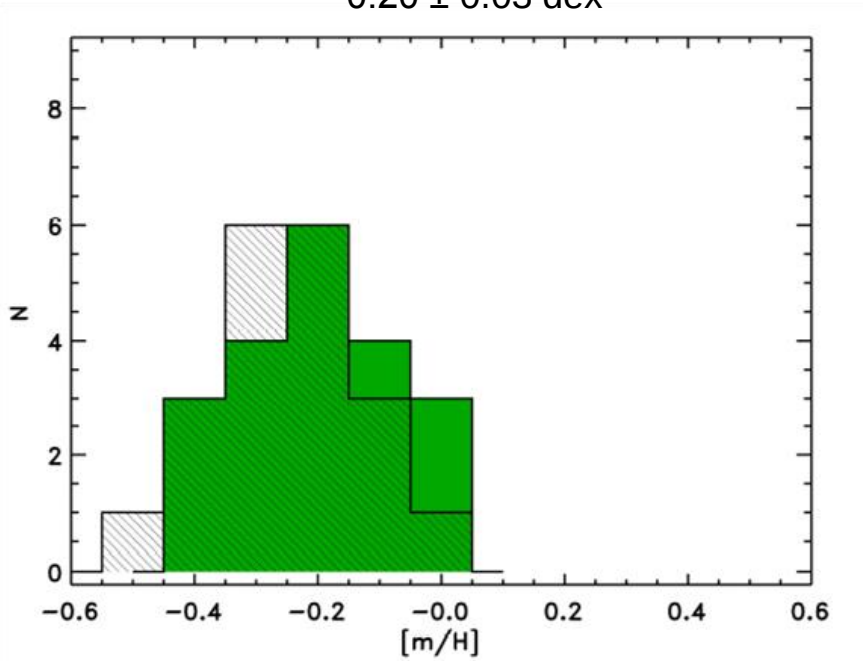
−0.15 ± 0.03 dex



(Niemczura, Daszyńska-Daszkiewicz, 2005)

SPB

−0.20 ± 0.03 dex



(Niemczura, 2003)

Chemical composition and pulsations of B-type stars

The main scientific goal of the project:

- Is the study **of atmospheres of β Cephei and SPB** (Slowly Pulsating B stars) stars in the young open clusters and Galactic field.
- We will obtain **stellar atmosphere parameters and chemical abundances**.
- This will allow to determine the **relationships between chemical abundances and pulsational parameters of β Cephei and SPB stars**.
- Furthermore, the atmospheric parameters are necessary constraints for future **asteroseismology, an independent method of studying stellar interiors and evolution.**
- **Comparison of pulsating and non-pulsating stars in the cluster.**
- **Searching for interesting β Cephei stars**

NATIONAL SCIENCE CENTRE
POLAND

NCN is a government agency, supervised by the Ministry of Science and Higher Education, to support basic research in Poland.

Chemical composition and pulsations of B-type stars

Our main purpose is to analyse high- and medium-resolution spectra of pulsating **β Cephei** and **SPB** stars in young open clusters.

The main goal of such analysis is the determination of the important stellar parameters of these objects, like:

- effective temperatures,
- surface gravities,
- chemical abundances,
- Microturbulence,
- rotational velocities.

Spectroscopic Study of Delta Scuti Stars

F. Kahraman-Aliçavuş, E. Niemczura, M. Polińska, K. Hełminiak, J. Molenda Żakowicz

2015

- HIDES (Okayama observatory, Japan)
- ARCES (Apache Point Observatory, USA)

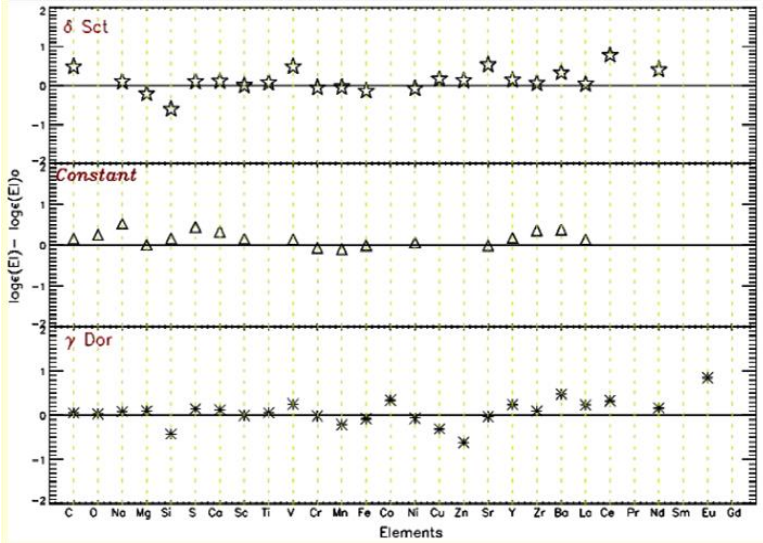
✔ They are located in the lower part of the classical Cepheid instability strip.

✔ Scuti stars have spectral types from **A to early F** with luminosity classes V to III.

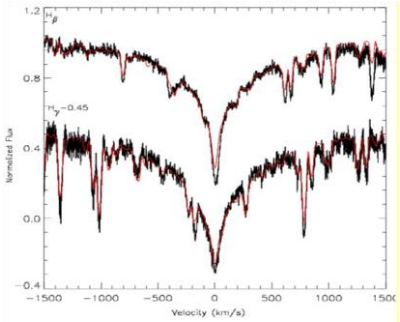
✔ These variables pulsate in both **radial and nonradial pressure modes driven by the kappa mechanism.**

✔ Sct stars typically exhibit pulsations with the periods ranging from **0.02 to 0.25** days with amplitudes lower than **0.5 mag**

(Chang et al. 2013)



Average abundances of Delta Sct, Gamma Dor and constant F-type stars.



Global Astrophysical Telescope System

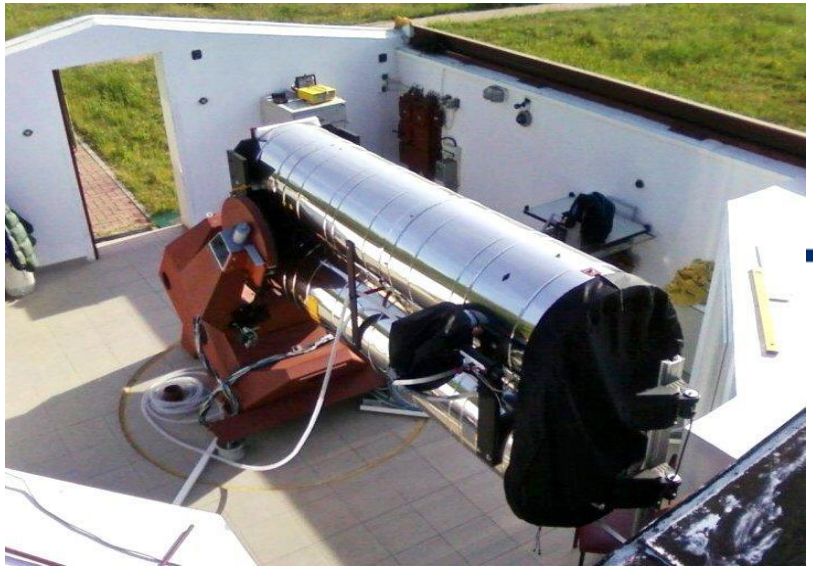
http://www.astro.amu.edu.pl/GATS/

PST1 (Poznań Spectroscopic Telescope)

in operation since summer 2007 at Borowiec Astrogeodynamic Observatory near Poznań in **Poland**

PST2 - RBT (Roman Baranowski Telescope)

has started regular observations at the end of 2013 in Winer Observatory (Arizona), **USA**



PST 1

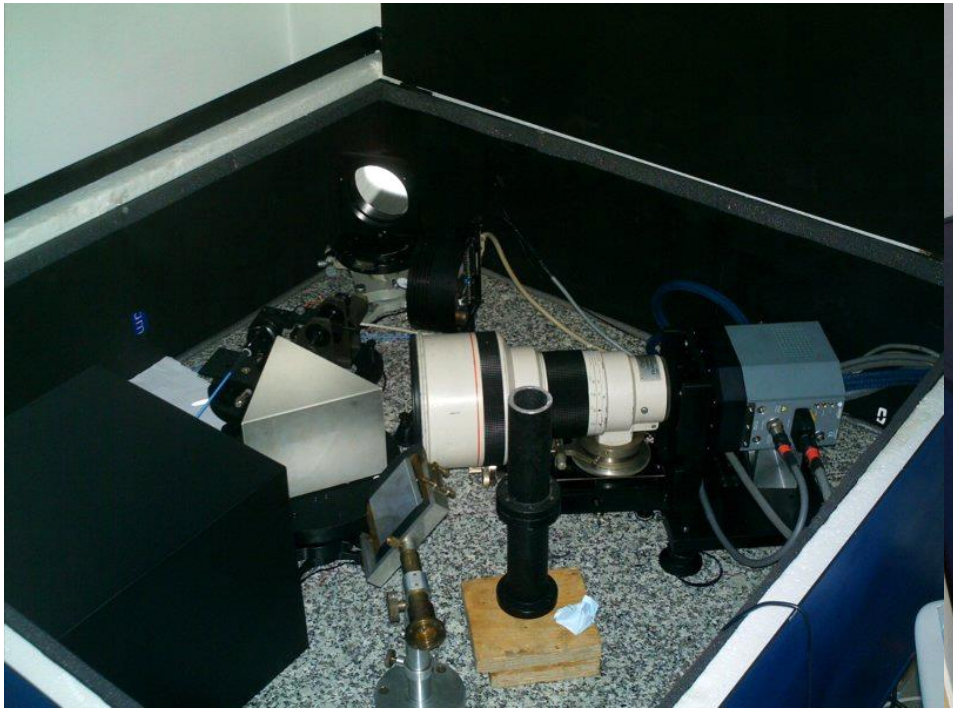
The PST 1 composed of:

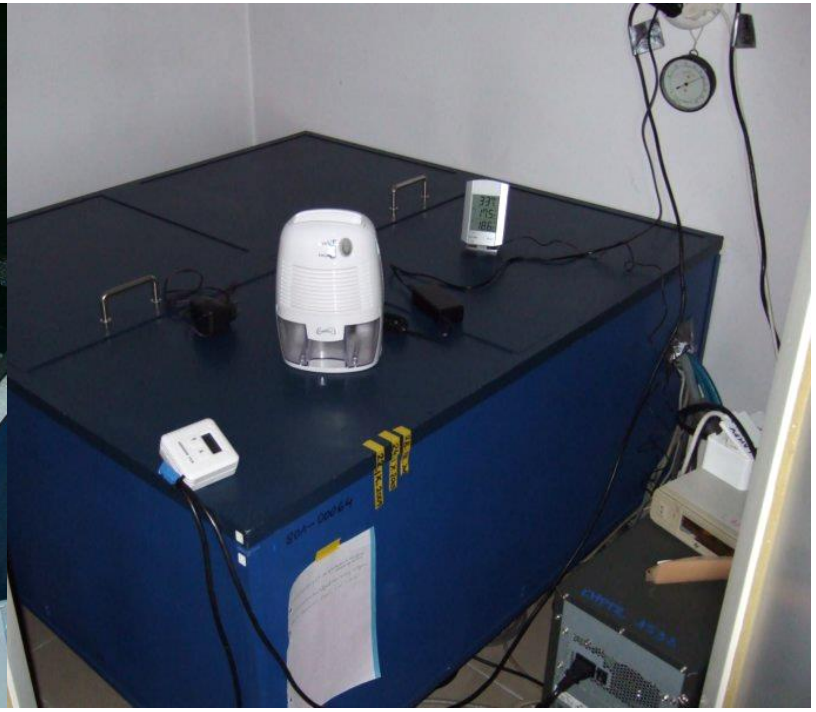
- binary **2 x 0.5 m** Newtonian telescope,
- fibre-fed echelle spectrograph of resolution **R~35000,**
- low noise back-illuminated 2k x 2k Andor DZ 436 CCD camera,

which may be used in several different modes:

1) In basic mode only single mirror is used for spectroscopy.
2) In second mode both mirrors will be used to produce two simultaneous echelle spectra of the same object.
3) Third mode allows for simultaneous photometric and spectroscopic observations.

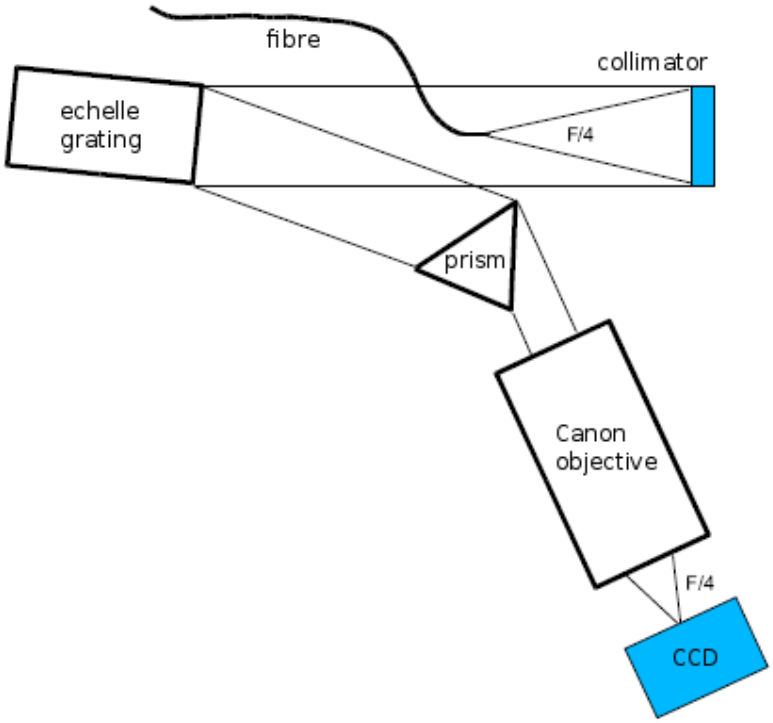
PST1 echelle spectrograph of a resolution of 35000. The spectral range covers 64 echelle orders with wavelength from 4280 Å to 7500 Å.

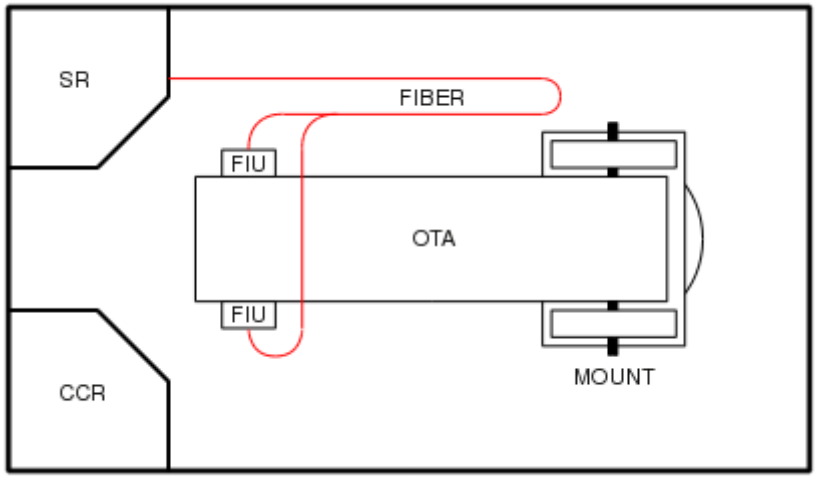




Optical construction is based on a modified MUSICOS (Baudrand and Bohm, 1992)

PST1 echelle spectrograph scheme

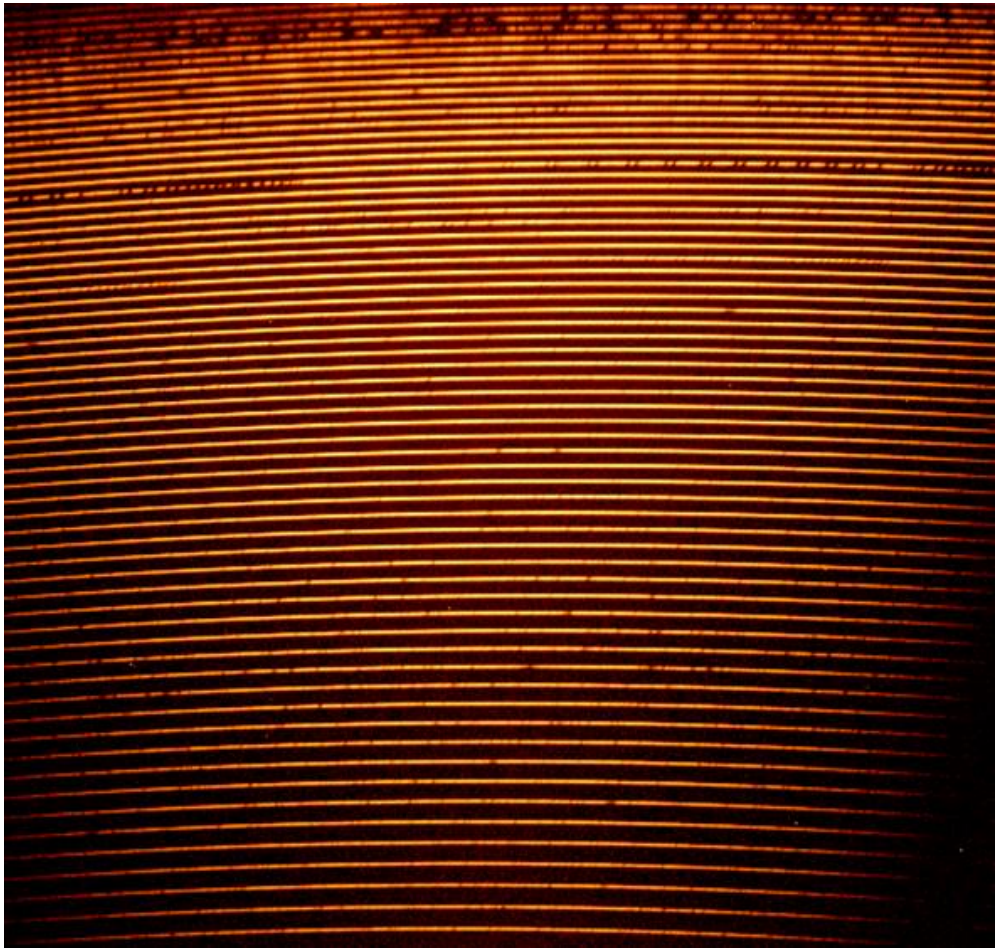




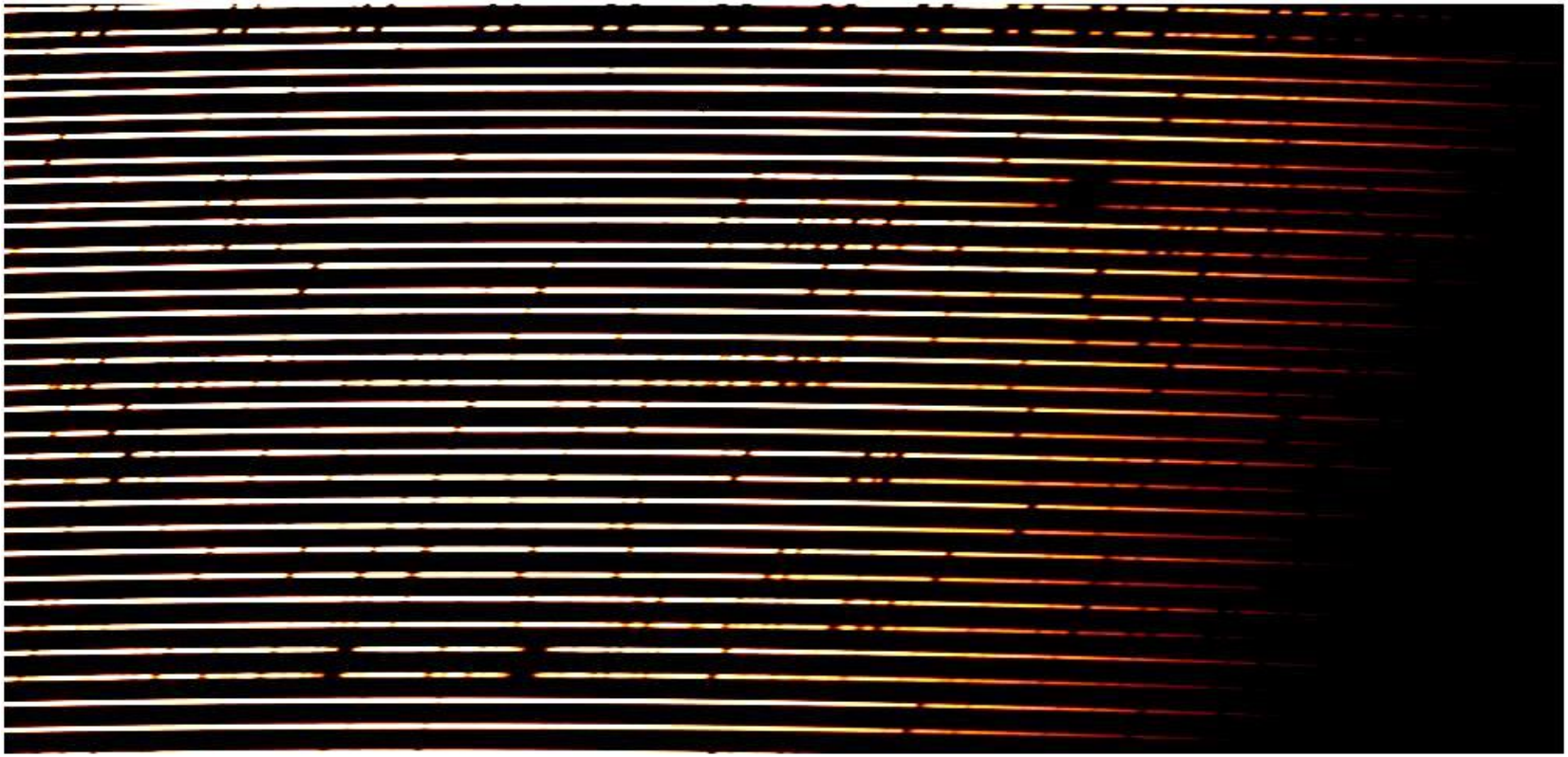
Schematic drawing of PST1 housing:

FIU - fiber injection unit,
CCR - computer control room,
SR - spectrograph room,
OTA - binary Newtonian telescope.

blue range: 1 pix = 0.04 A order lenght = 80 A
middle: 1 pix = 0.05 A order lenght = 100 A
red range: 1 pix = 0.08 A order length = 160 A



Two mirror observing mode



Rough estimate of exposure times and S/N ratios for objects with different magnitudes brightness which were observed by PST1

V mag	Exp. Time [s]	S/N	σ RV [m/s]
1	350	200	40
3	600	100	40
7	600	50	100
11	1800	5	200

We are able to achieve S/N~100 for V=7 stars with 60 min. exposure time. This means that we can precisely measure radial velocities for late type stars up to about 11.5 mag.

PST 2 - RBT

- upgraded version of first spectroscope PST1
- It is placed in better astro-climate in USA (Winer Observatory)
- placed at 126 degrees in longitude from the PST1

PST 2 - RBT

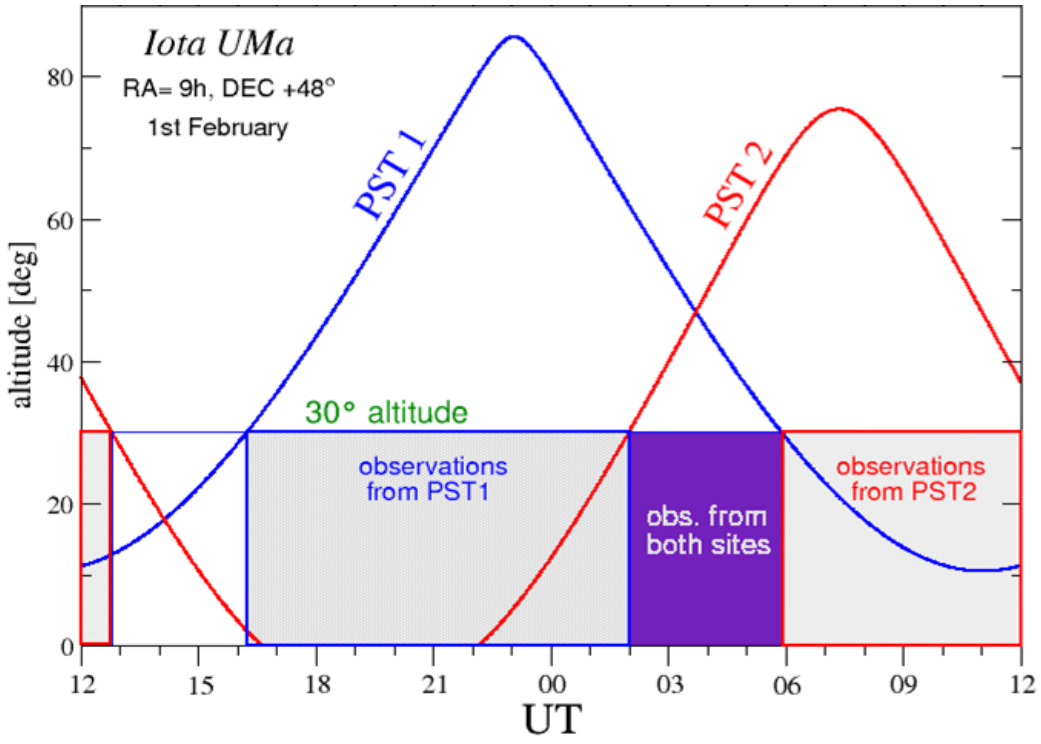
PST 2 - RBT

The metal mesh installed on PST2

The PST 2 consists of:

- Planewave CDK700 0.7 m f/6.6 robotic telescope (Corrected Dall-Kirkham, dual Nasmyth focus)
- fibre-fed echelle spectrograph of resolution **R~40000**, with exposimeter capable of making measurements during spectroscopic exposure,
- Spectroscopic CCD camera Andor iKon-L 936 back-illuminated,
- Photometric CCD camera Andor iXon3 Back-illuminated,
- 0.1 m, f/5 guide telescope (on top of the 0.7 m telescope) with photometric camera and **objective wire mesh** with pitch 1.5 x 1.5 mm.

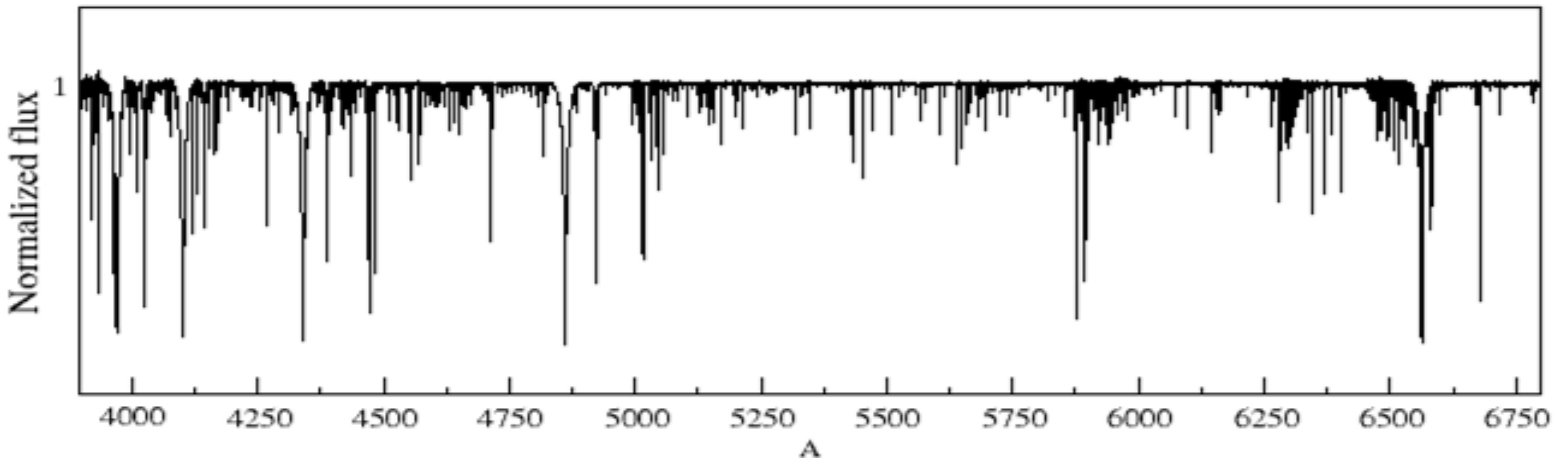
Global Astrophysical Telescope System - GATS



Example of simulation of GATS duty-cycle observations with changes of altitude of Iota UMa from PST1 and PST2 site in 1st February.

Sample data of ι Her obtained with GATS

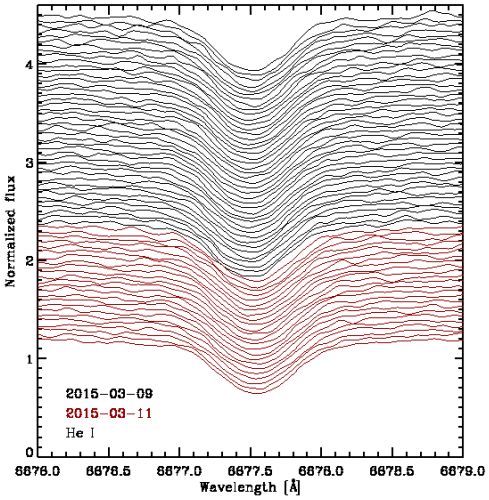
Spectroscopy from PST2



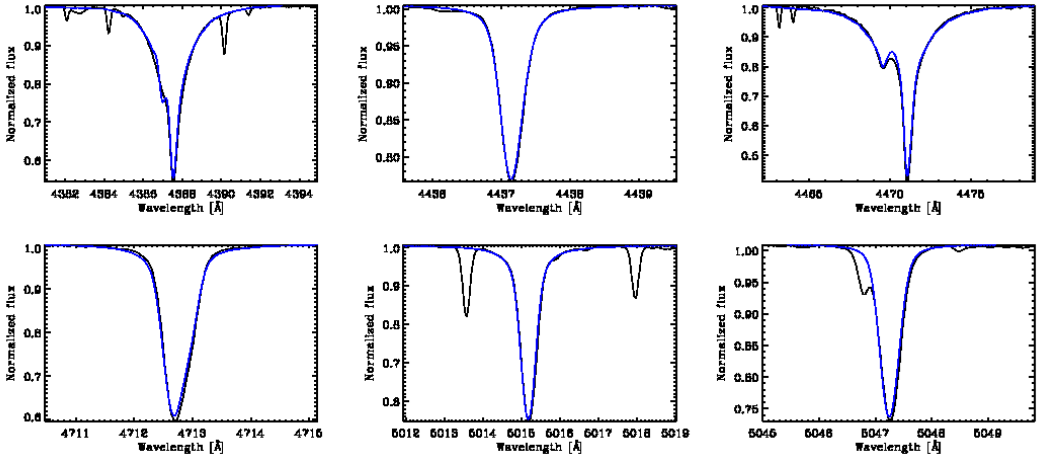
Average spectrum of ι Her (from 393 spectra)

S/N ~ 600

Sample data of ι Her obtained with GATS with



Profile line of He I, dates 2015-03-09 and 2015-03-11

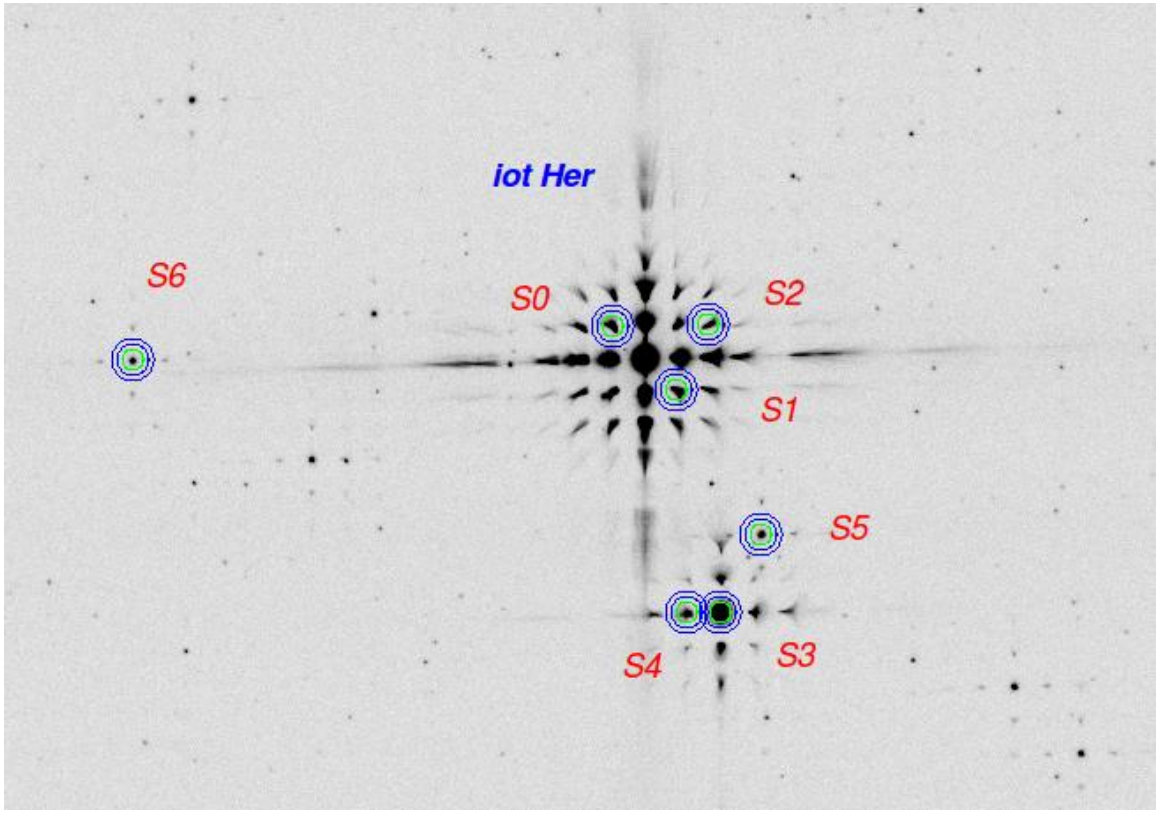


Fit of the model (blue lines) to profile line of He

Sample data of ι Her obtained with GATS

Photometry from PST2 2015 - 03 - 10

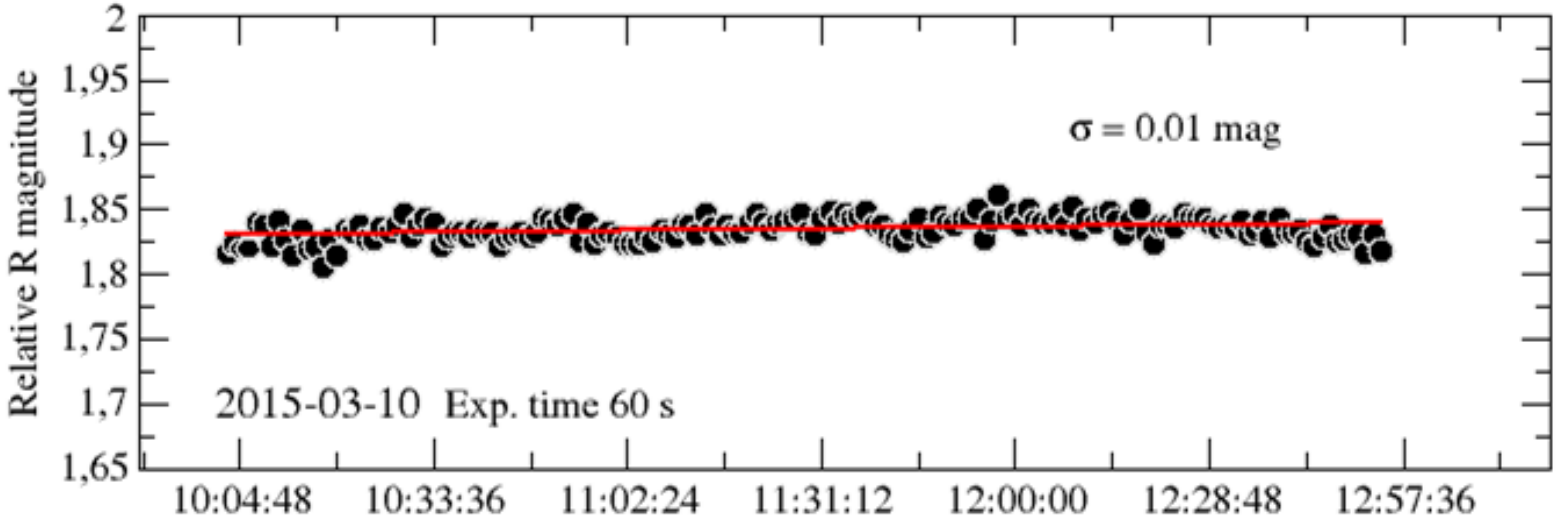
Photometric observation of ι Her, V ≈ 3.8 mag. Apertures are marked with circles, respectively *S 0-1* star ι Her and *S 3-6* stars taken to relative photometry.



Exposure time = 60 s, Filter R

Sample data of ι Her obtained with GATS

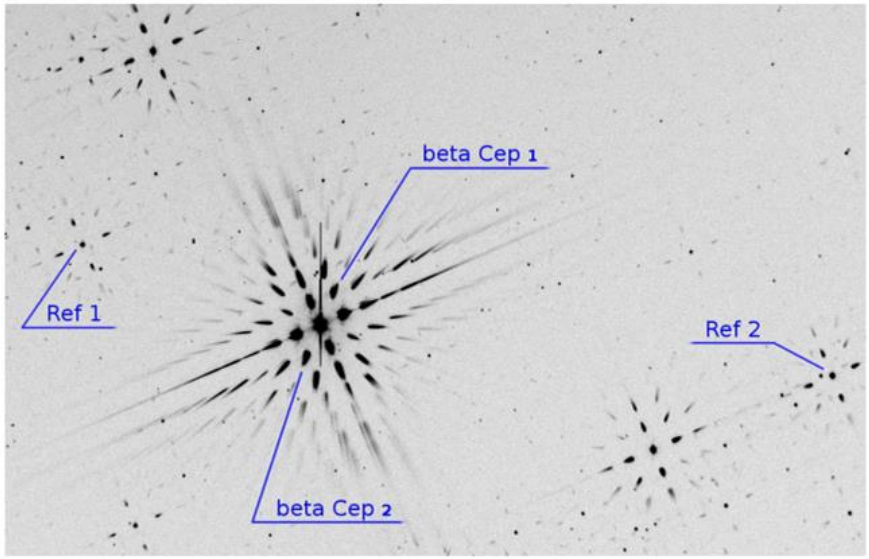
Photometry from PST2 2015 - 03 - 10

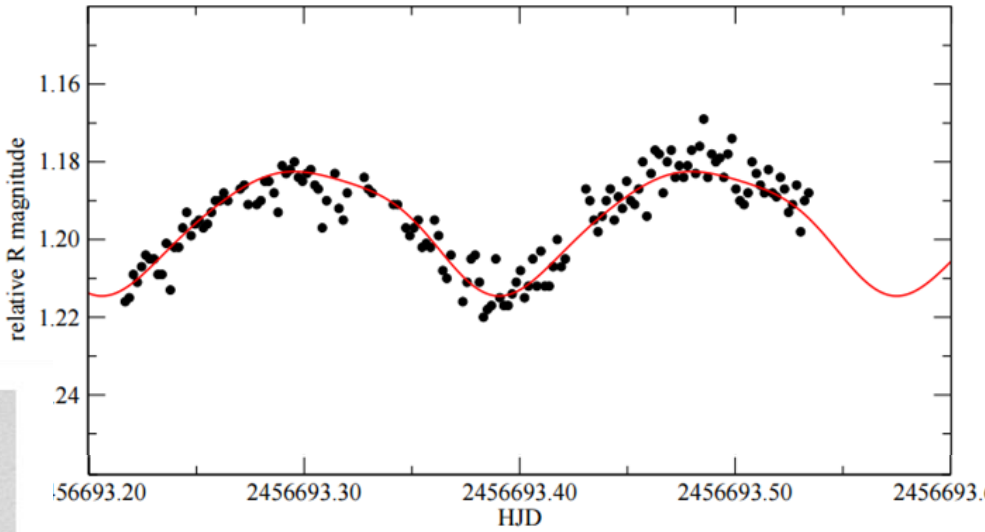


Relative photometry between *S0* ι Her and *S3* relative star apertures. The red line shows a last-square linear fit with precision is one hundredth magnitude.

β Cephei

Image of β Cephei, V≈3.2 mag, taken through the wire mesh. Two measured diffraction images of the target star and the reference stars are marked. Ref 2 V=8.2, Ref 1 V=9.0 - as a check star.





Differential light curve of the first order diffraction image of β Cephei with respect to 0-order image of the reference star (Ref 2).
150s exposure.
Smooth curve marks the least-square fit of 3 harmonic Fourier series.

(Kamiński et al. 2014)

GATS project main research topics:

- eclipsing binary stars,
- asteroseismology of hybrid pulsating stars,
- stellar rotation and dynamical evolution in binary eclipsing stars,
- stellar activity cycles.

Additionally:

- photometric observations of asteroids from Main Belt and Near Earth Objects, satellites and space debris.

- GATS project is also intended to cooperate with BRITE satellites constellation and supplement its photometry with radial velocity measurements and spectroscopic observations.
- Lem and Hevelius - Polish satellites

これまでご清聴ありがとうございました。

Dziękuję za uwagę