

Voyager 1: "Pale Blue Dot"

O CEFEIDAMA TIPA II.

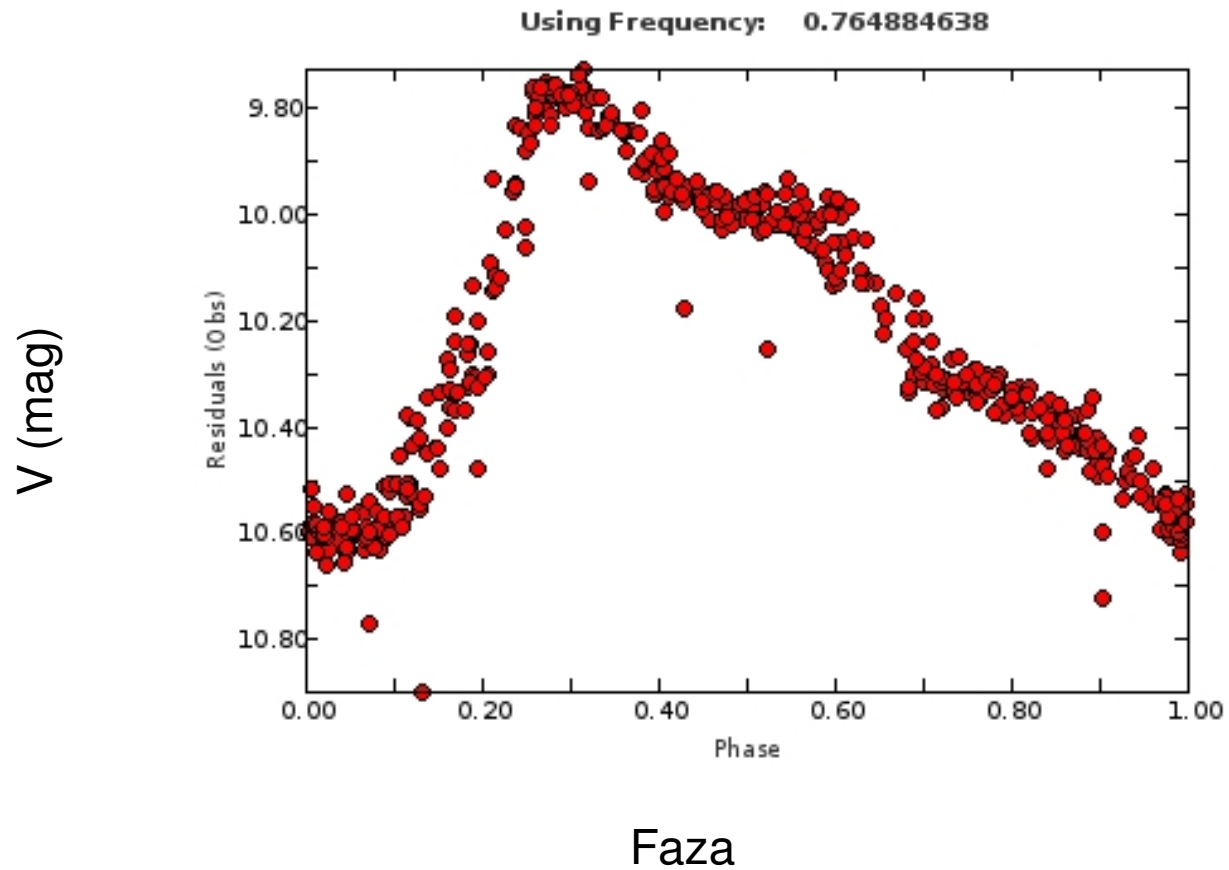
Jurković Monika
Istraživač saradnik
Astronomska opservatorija Beograd

16. decembar 2014.

Šta su cefeide tipa II.?

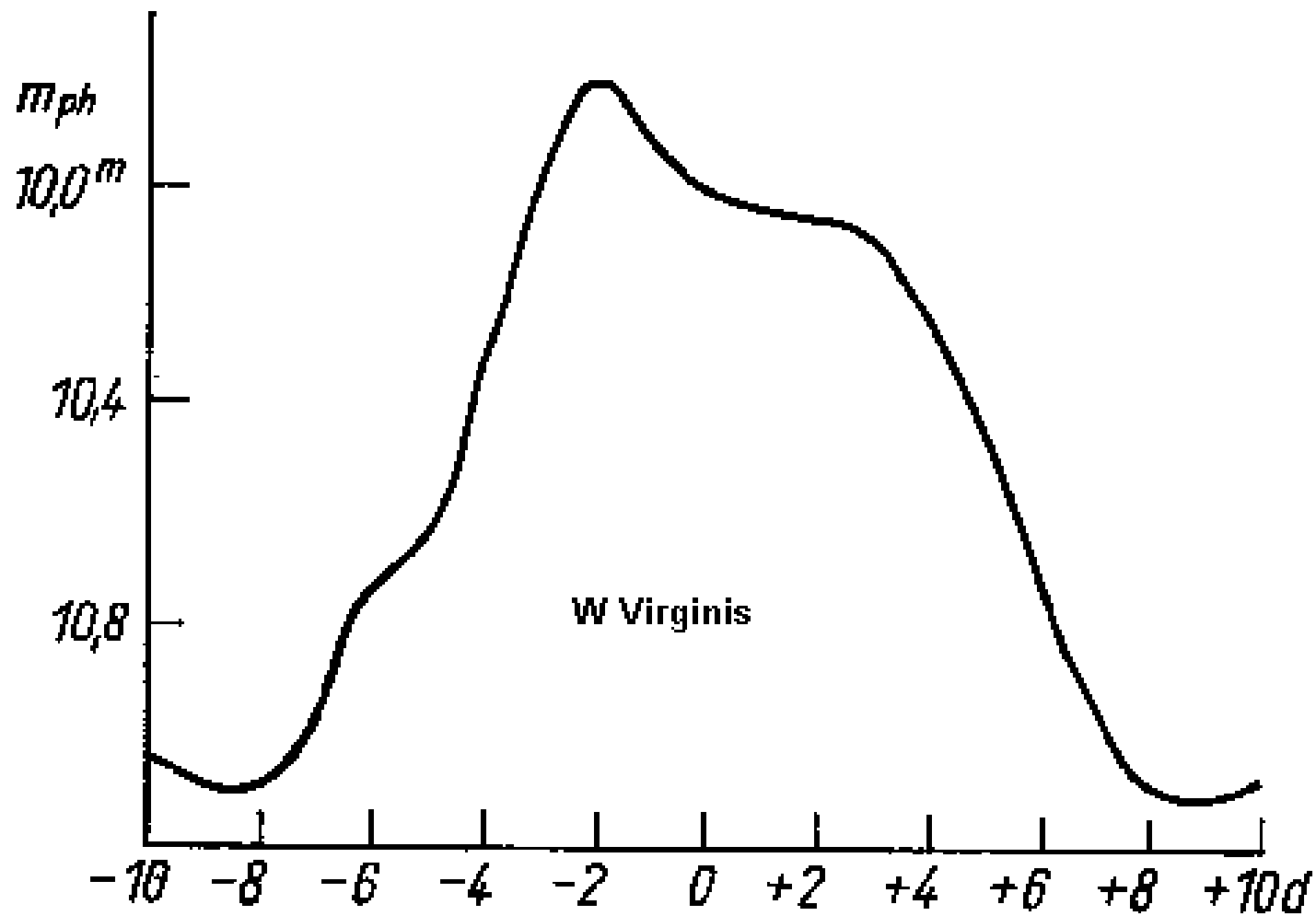
- Zvezde malih masa ($0.5 - 0.9 M_{\odot}$) (?)
- Niske metaličnosti (?)
- Pulsacioni period im je između 1 – 50 dana:
 - 1 – 8 dana: BL Her podtip (CWA)

BL Her, ASAS

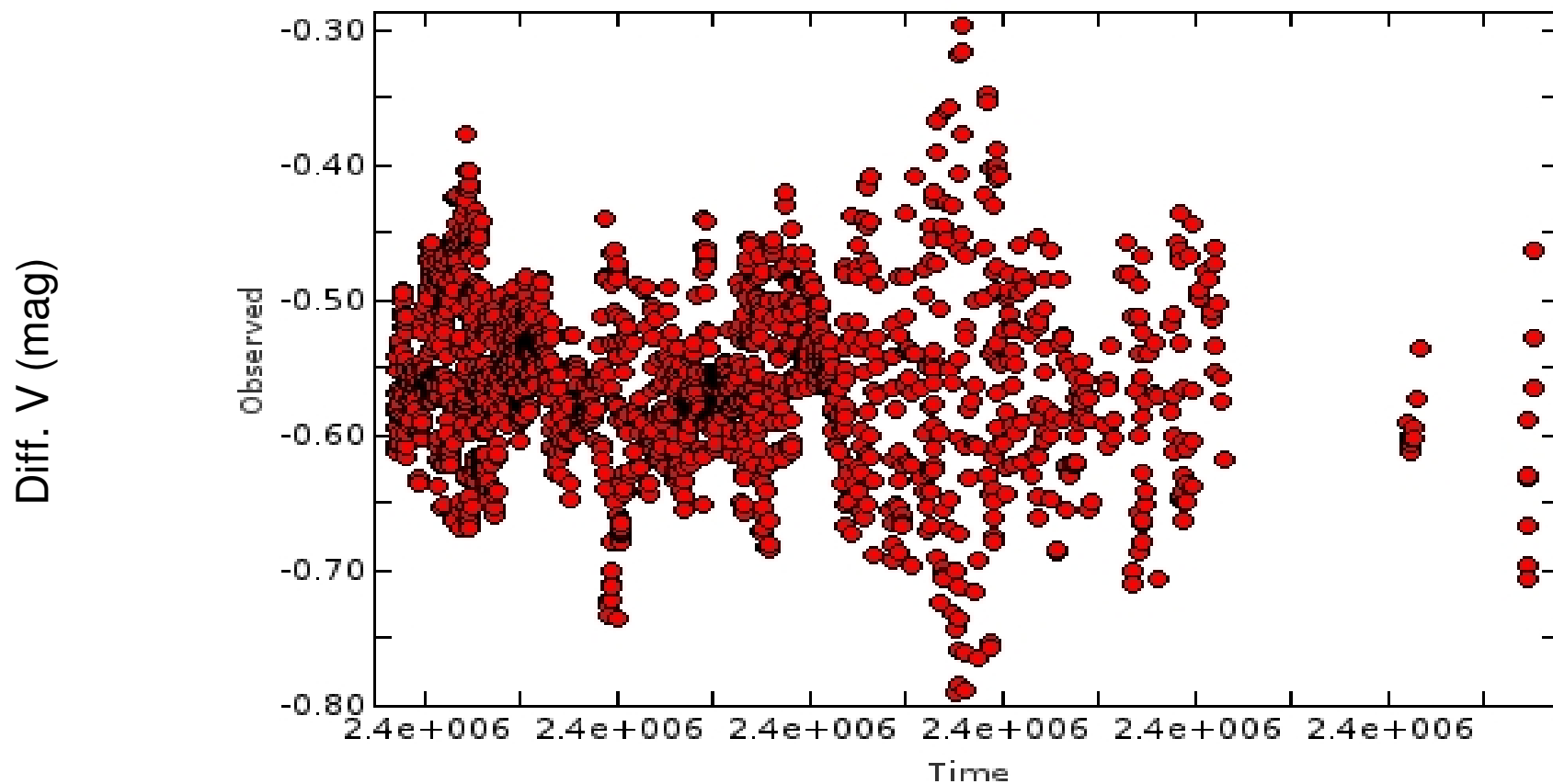


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 - 10 – 20 dana: W Vir podtip (CWB)



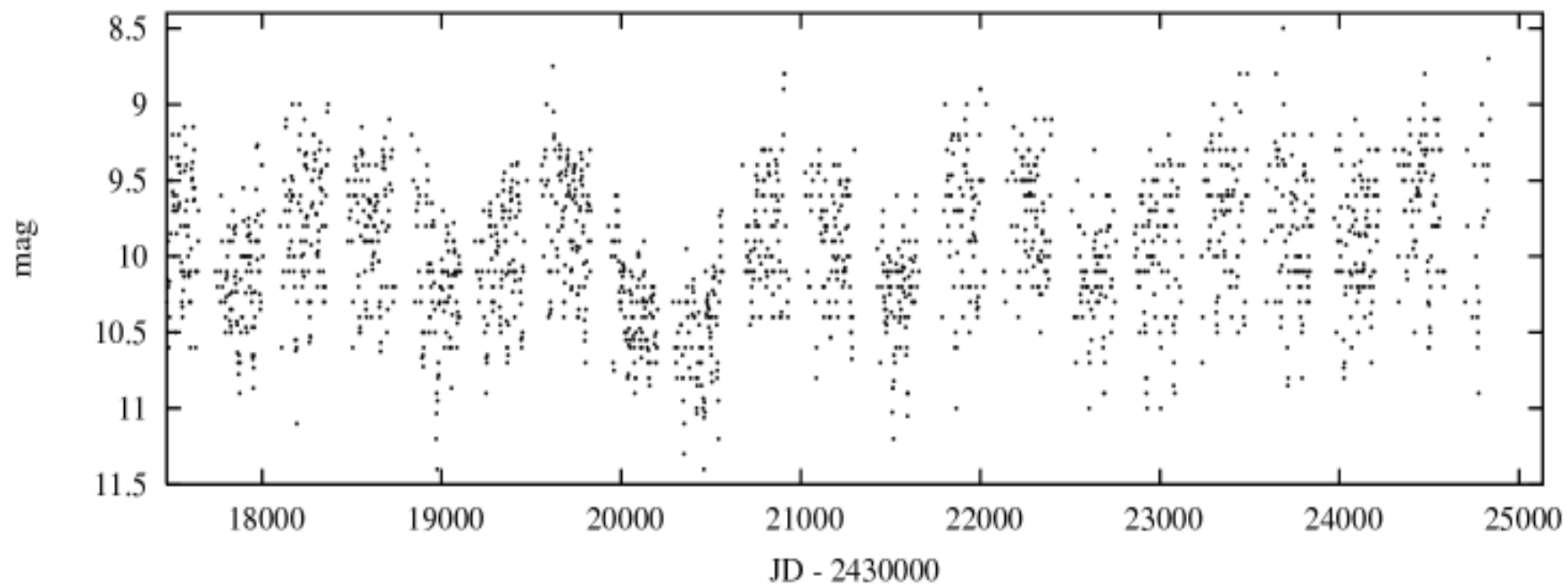
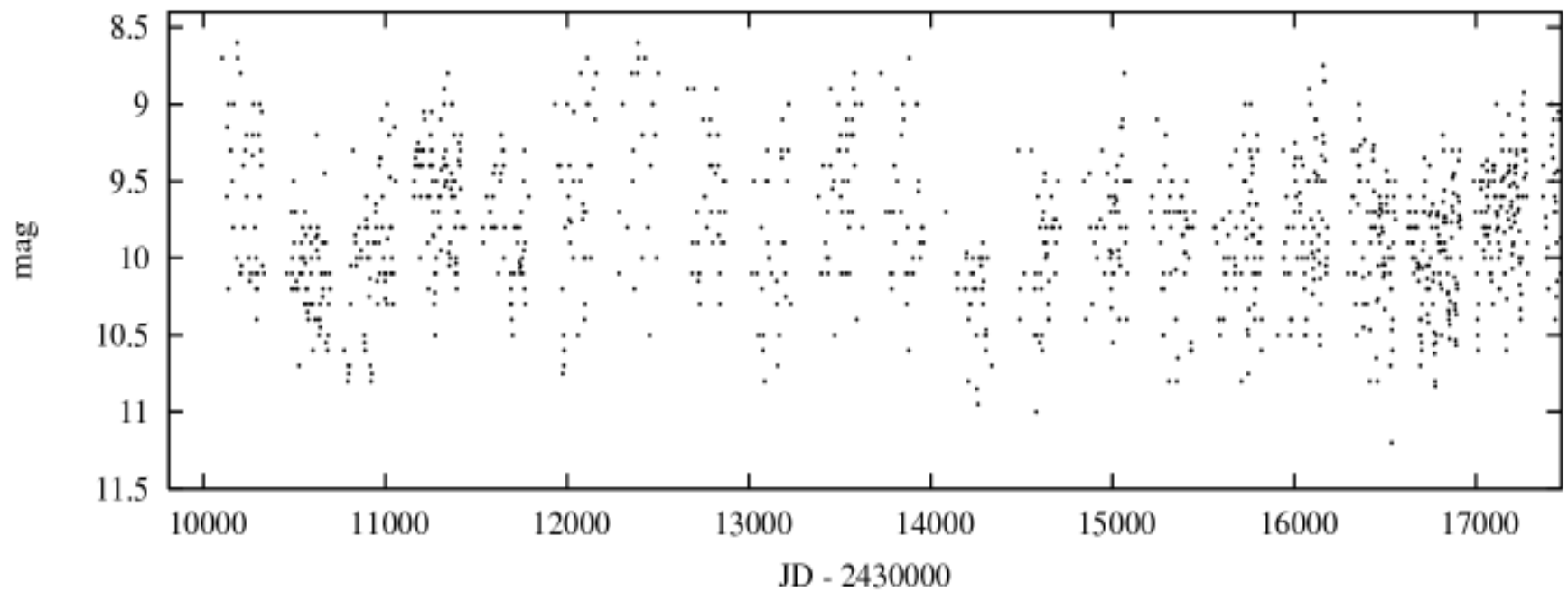
RU Cam: merenja sa Konkoj opservatorije u Budimpešti



JD

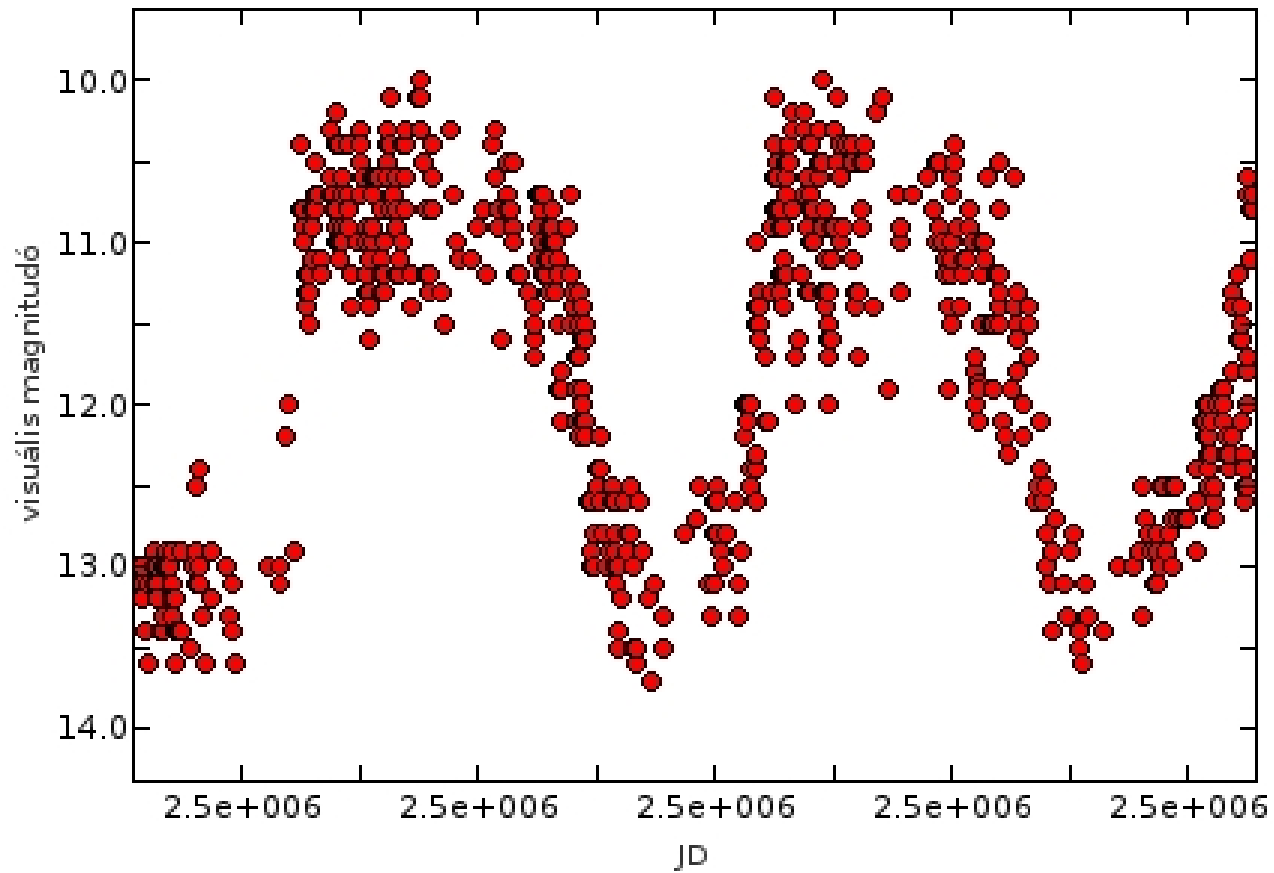
Šta su cefeide tipa II.?

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- Niske metaličnosti (?)
- Pulsacioni period im je između 1 – 50 dana:
 - 1 – 8 dana: BL Her podtip (CWA)
 - 10 – 20 dana: W Vir podtip (CWB)
 - 20 – 1500 dana: RV Tau podtip (RV: RVA, RVB)

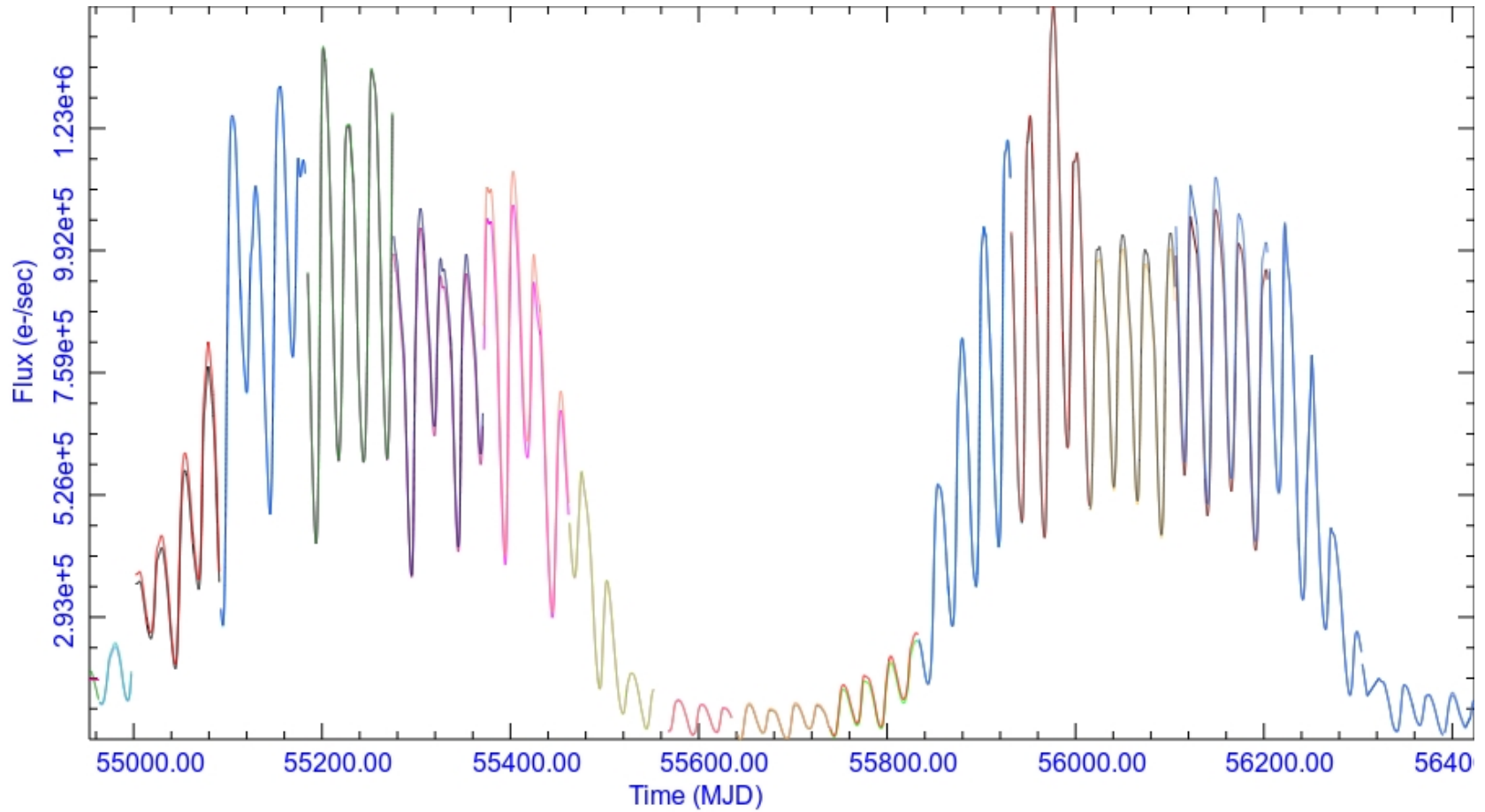


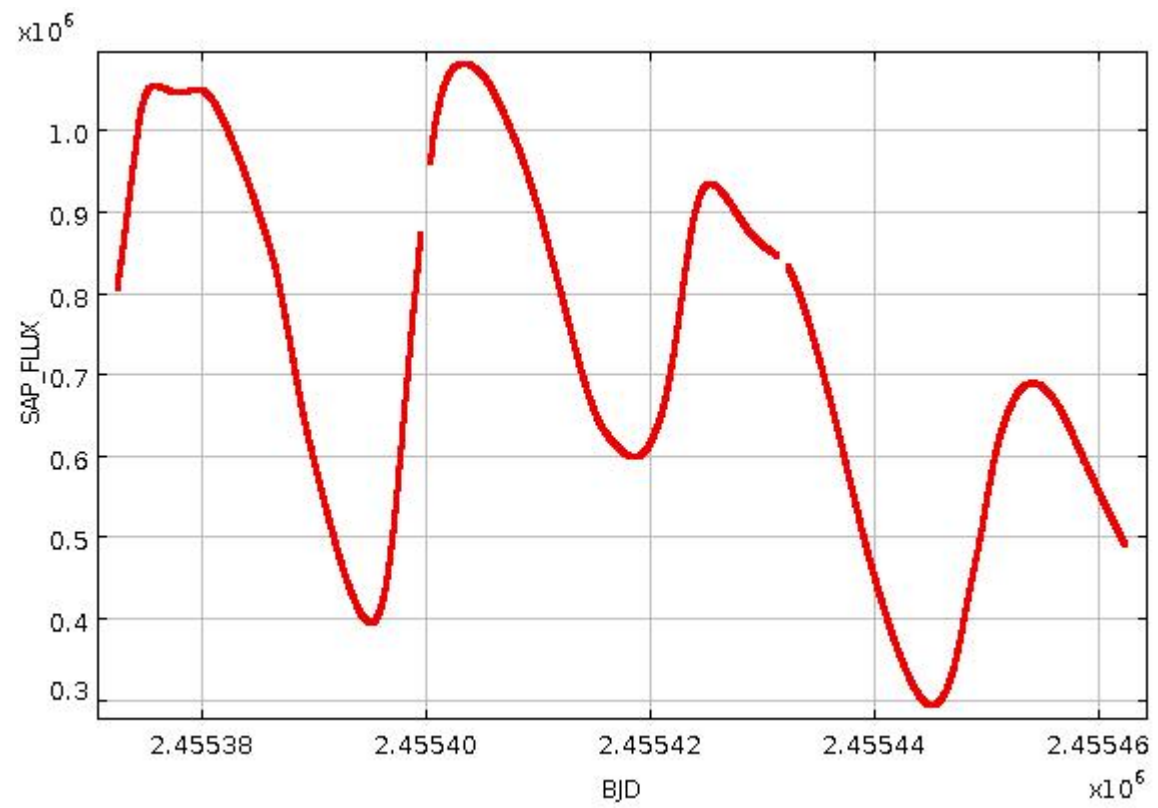
RV Tauri kriva sjaja iz AAVSO baze

DF Cyg, AAVSO



DF Cyg, Kepler





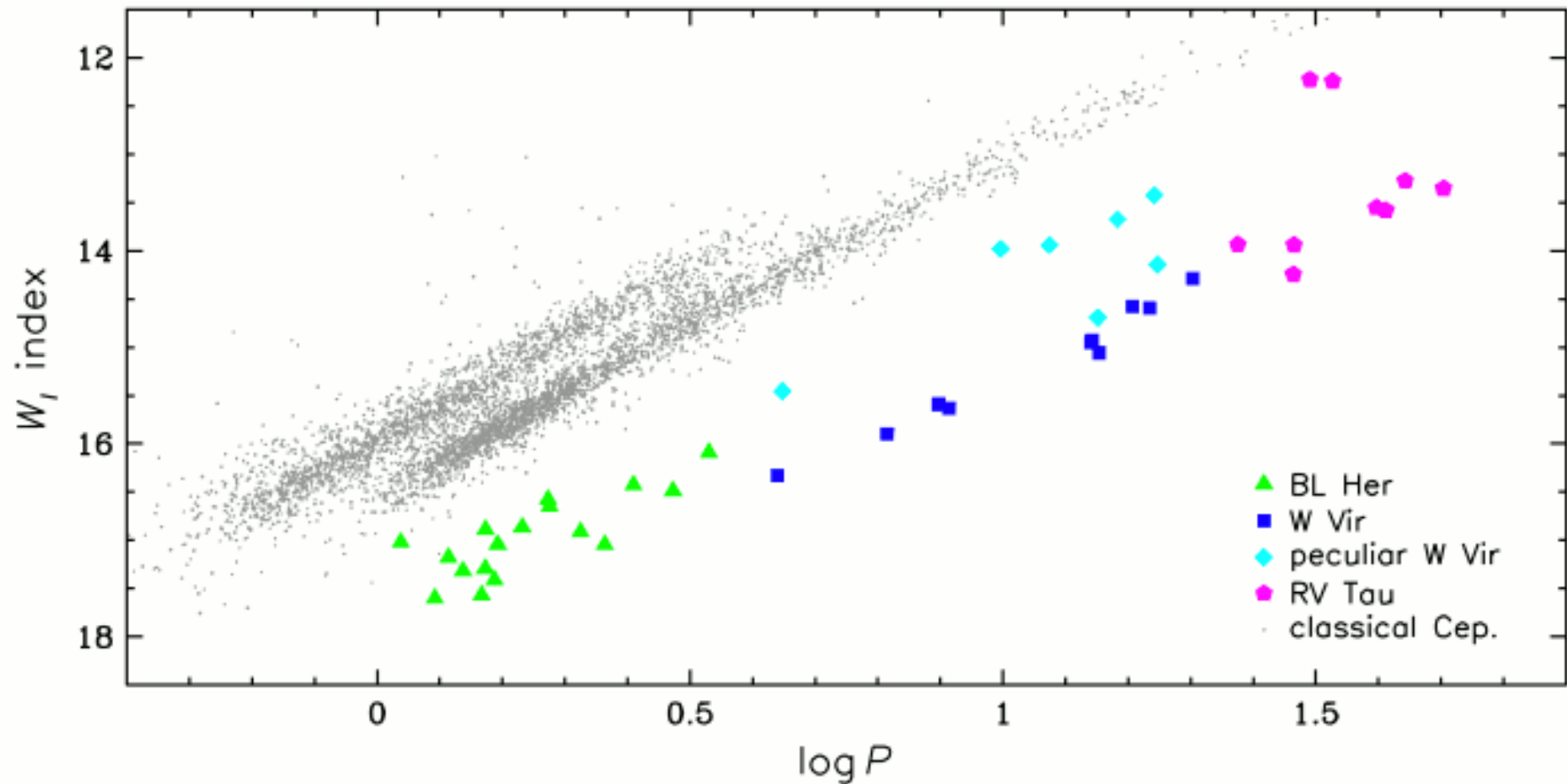
„In summary, the Type II Cepheids are low-mass variables whose luminosities lie below those of the classical Cepheids and above those of the RR Lyrae stars.“

Wallerstein, 2002, PASP, 114:689–699

Relacija perioda i luminoznosti za cefeide tipa II.

OGLE SMC W_i vs $\log P$

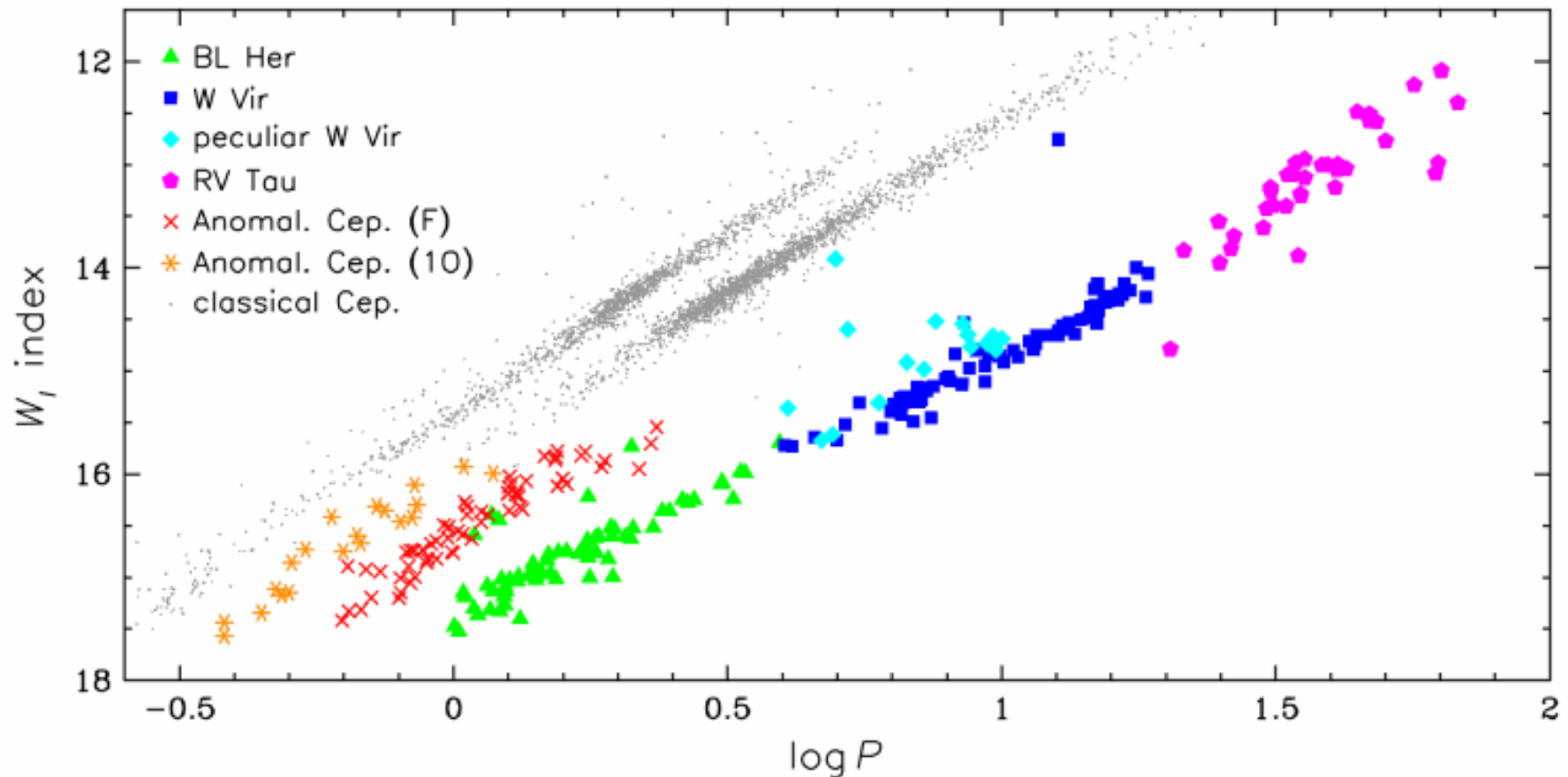
[Fe/H] = -1.07, Leaman, 2012, AJ, 144, 183



Soszyński et al., 2010, Acta Astron., 60, 91 (arXiv:1005.3544)

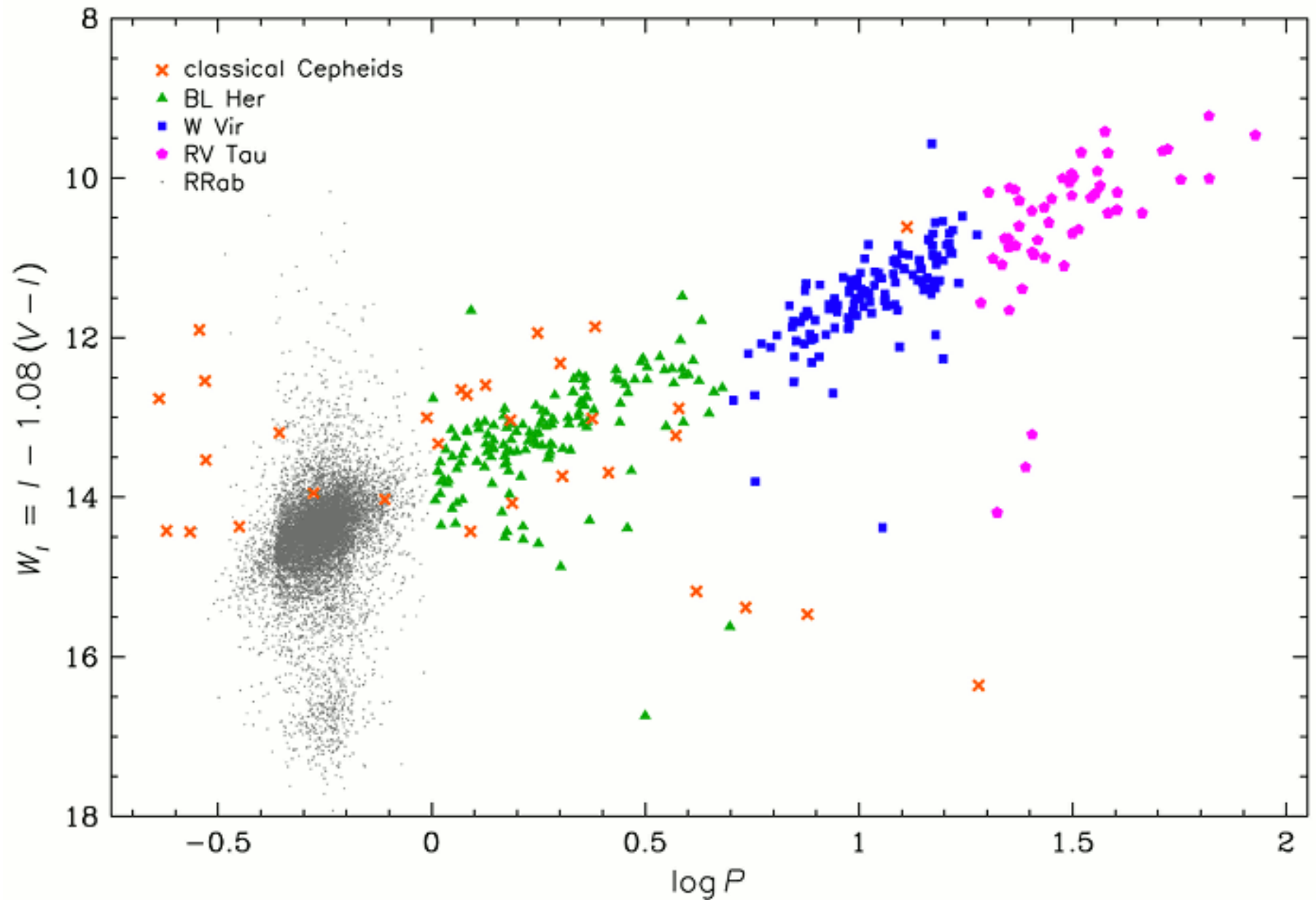
OGLE LMC W_i vs $\log P$

[Fe/H] = -0.55, Leaman, 2012, AJ, 144, 183

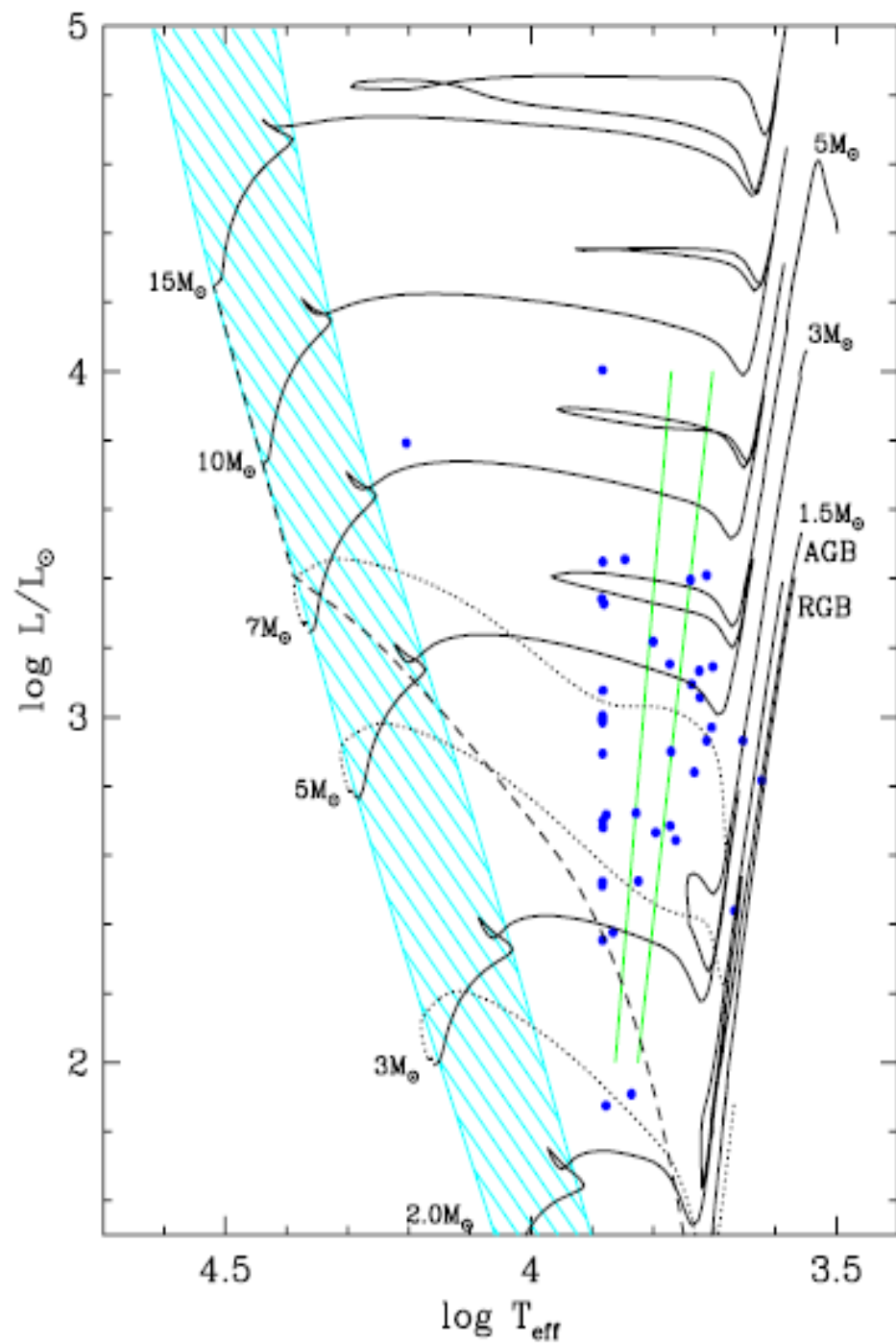
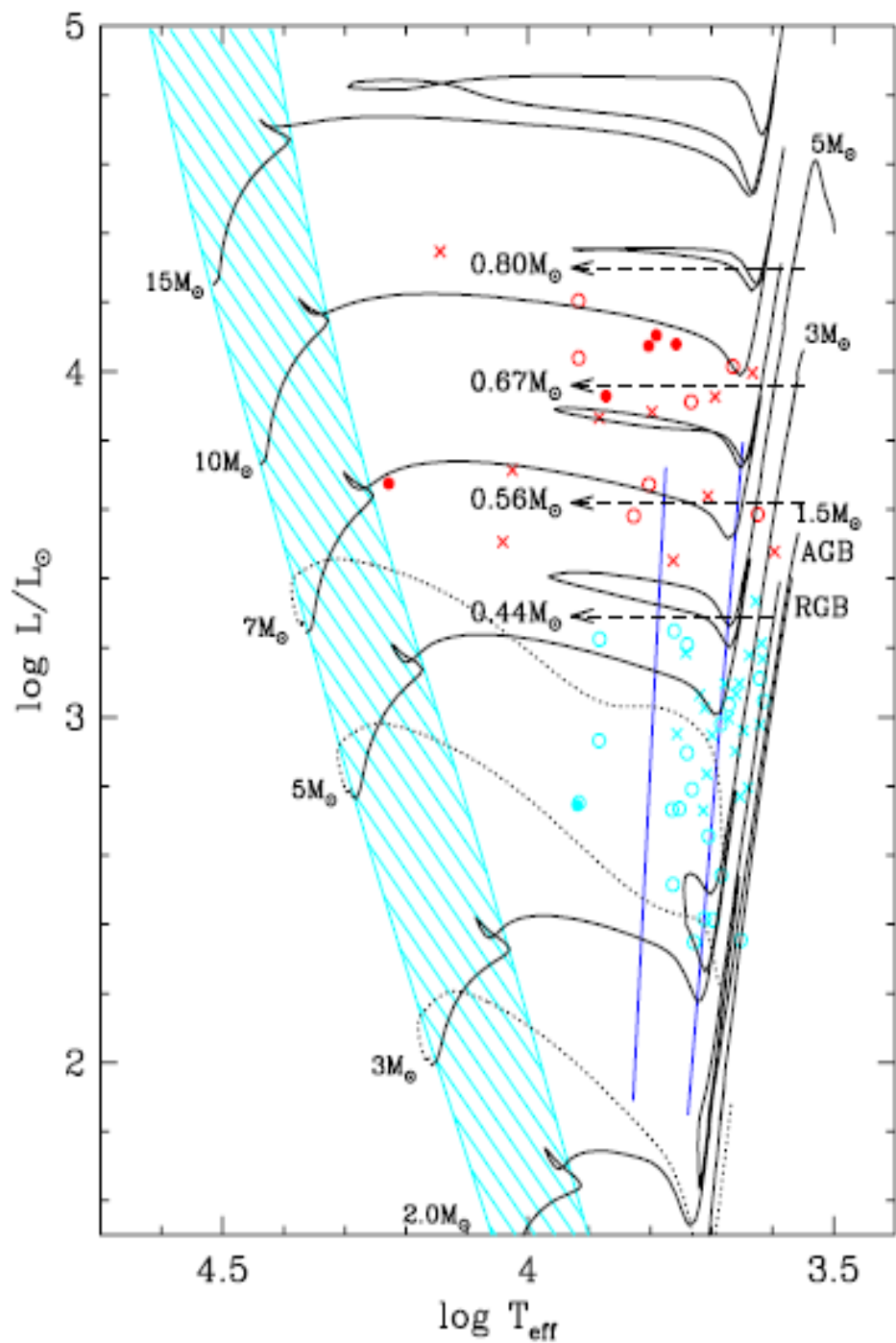


Soszyński et al., 2008, Acta Astron., 58, 293 (astro-ph/0811.3636)

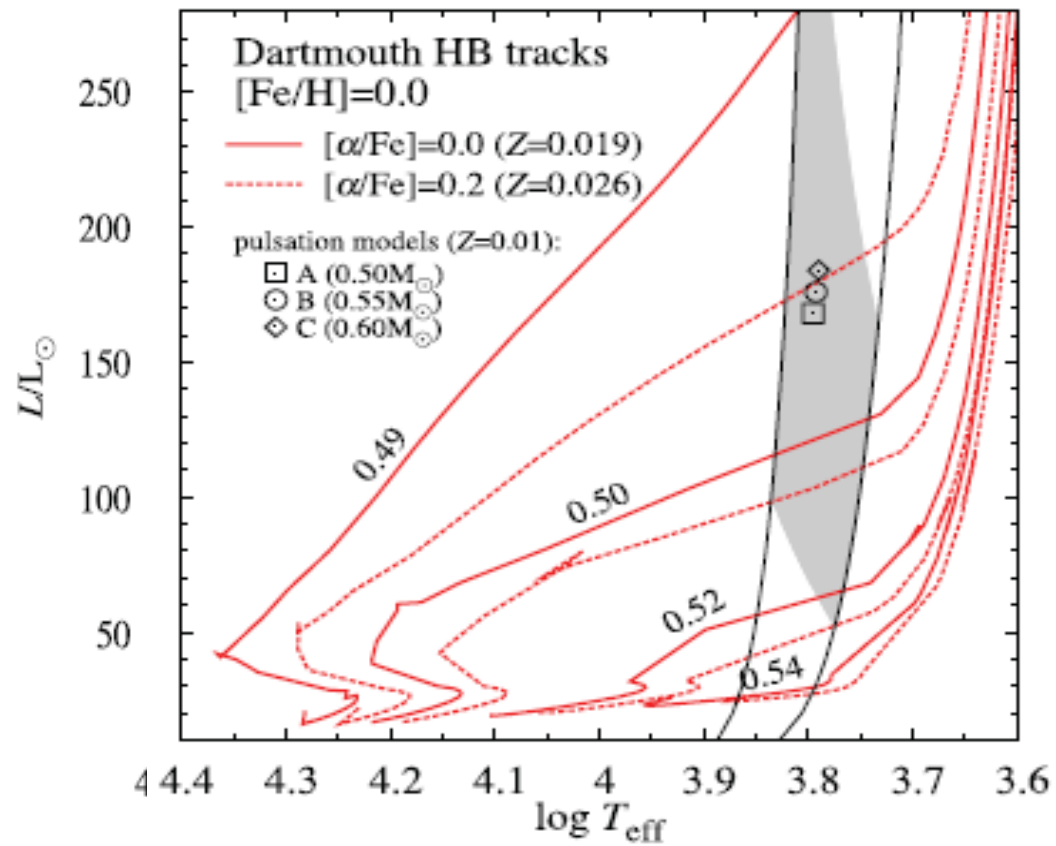
OGLE BULGE W_i vs $\log P$



Cefeide tipa II na HRD-u i modeli



Kamath et al., MNRAS, 2014



Ciljevi istraživanja

- Upoznavanje nisko metalične, stare, zvezdane populacije velike luminoznosti u Mlečnom putu:
 - Istraživanje različitosti i sličnosti u obliku krive sjaja objekata u sva tri podtipa
 - Izračunavanje kolor indexa i proučavanje infracrvenog viška
 - Traženje promene perioda pulsacije, ustanovljivanje procenta dvojnih sistema u celom uzorku, izračunavanje gubitka mase ako je to moguće

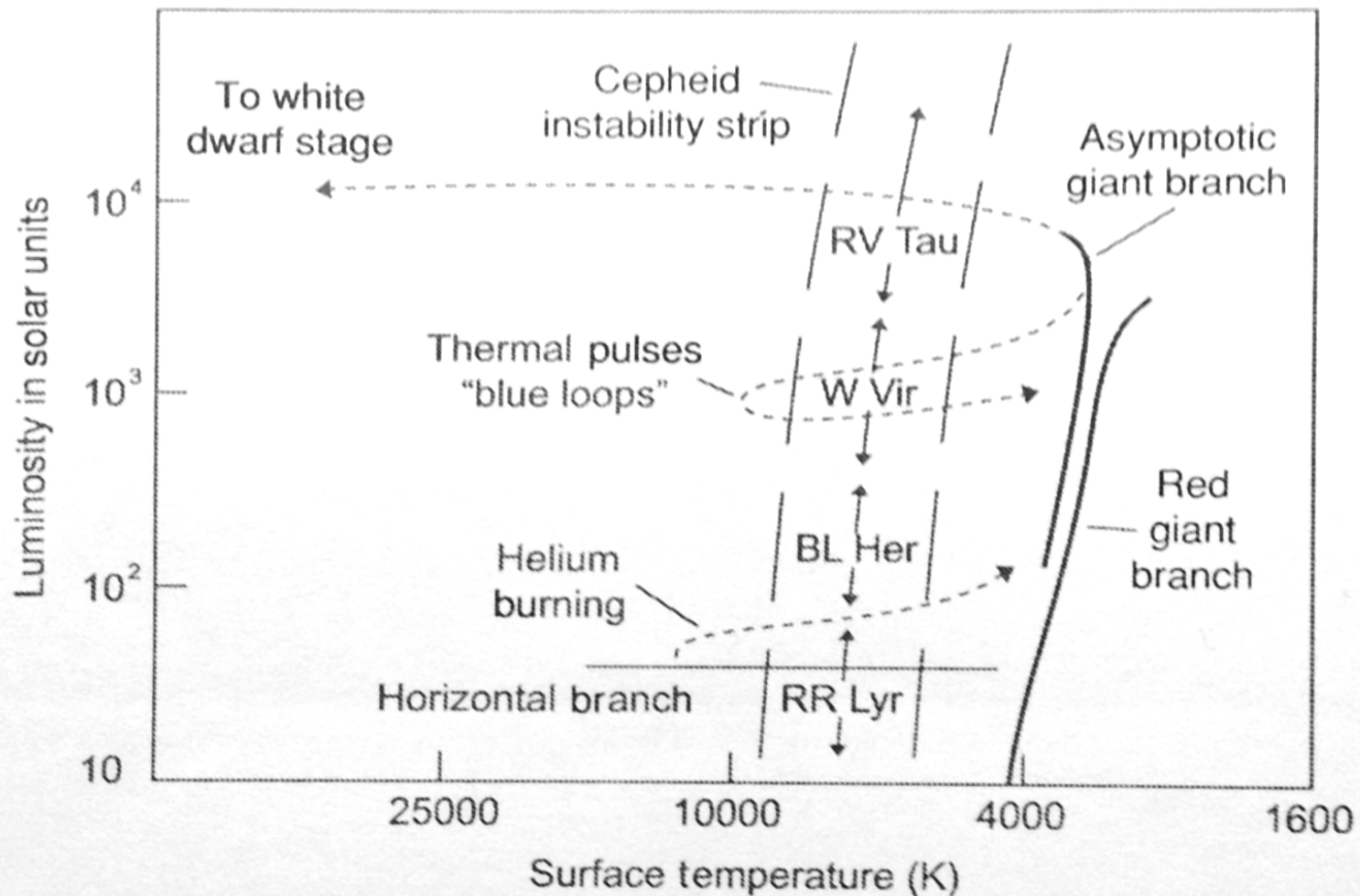


Figure 6.13 The position of Population II Cepheids, including BL Herculis, W Virginis, and RV Tauri variables, on the H-R diagram. As shown by the dashed evolution tracks, low-mass stars may reach these positions by helium-burning evolution from the horizontal branch, by thermal pulses (flashes) from the AGB, or by evolution from the AGB towards the white dwarf stage. (Jeff Dixon Graphics.)

- Radi ostvarivanja prethodno navedenih ciljeva potrebno je imati dobro definisan uzorak cefeida tipa II., ali pronalaženje takvog uzorka nije jednoznačno

Prikupljanje podataka

- Prikupljanje podataka je vršeno iz baza podataka sa fotometrijskim merenjima, koji su javno dostupni i sadrže dovoljno duga i precizna posmatranja da bi se mogli iskoristiti u prethodno navedene svrhe

- ASAS
- CATALINA Sky Survey
- LINEAR
- SuperWASP
- AAVSO
- NSVS
- INTEGRAL OMC

Metoda: Furije analiza

- Za analizu podataka sam koristila program Period04:

$$A_0 + \sum A_i \cos 2\pi [i f_i (t - t_0) + \Phi_i]$$

where A_i is the amplitude, f_i is the frequency, Φ_i is the phase.

■ ■ ■

Realnost je ...

- Veliki projekti koji skeniraju nebo (npr. ASAS, OGLE) koriste automatizovane klasifikacione programe. Oni kreiraju grafikone raznih Furije parametara promenljivih objekata i na osnovu mesta koji objekti zauzimaju na tim grafikonima dodeljuju verovatnoću pripadnosti podtipu promenljivosti za svaki objekat. Granice između objekata su određene na osnovu već poznatih objekata, kao i uz pomoć testova.

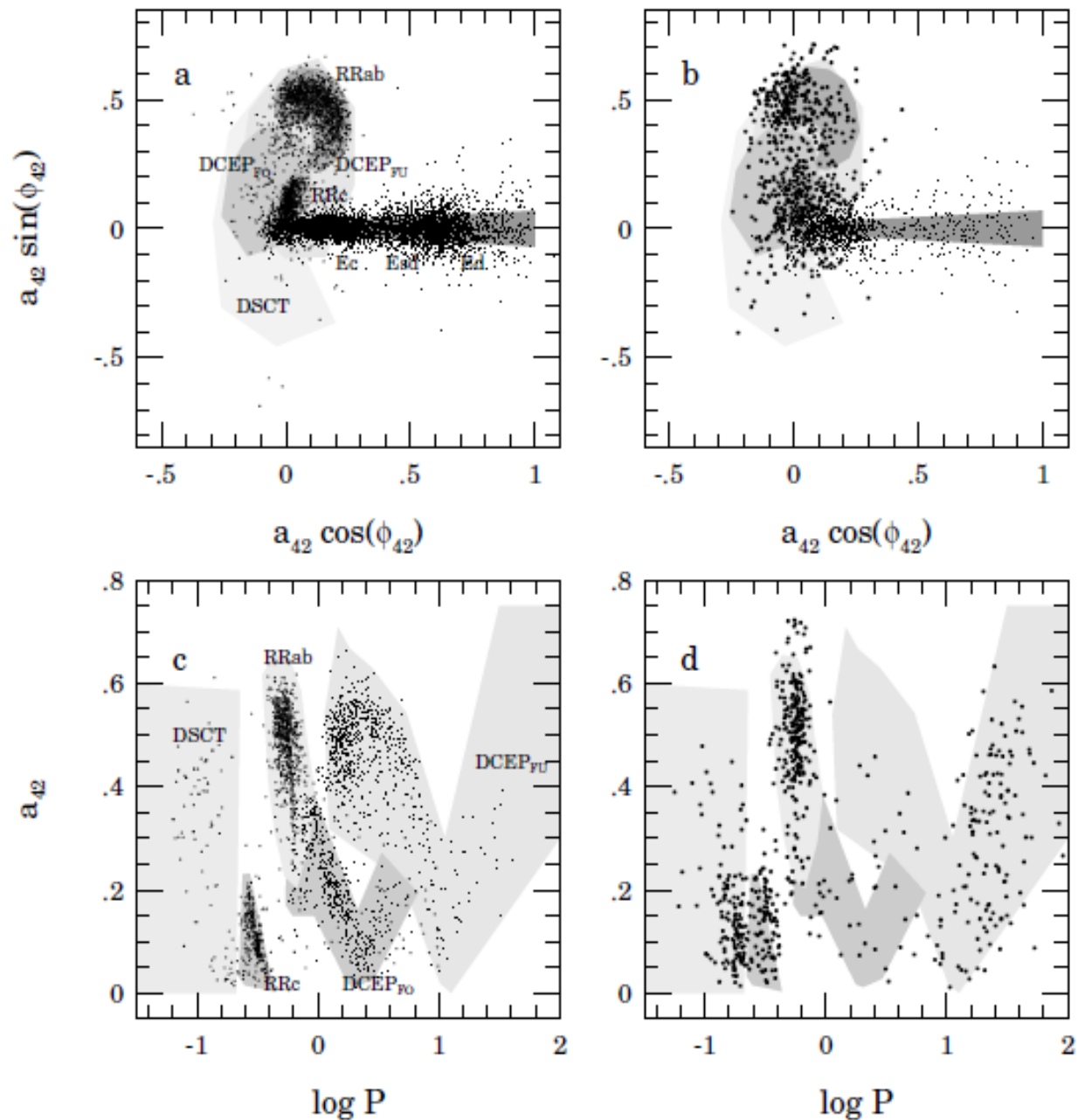


Fig. 6. Distribution of light curve parameters in the $a_{42} - \phi_{42}$ and $\log P - a_{42}$ planes for OGLE (a,c) and ASAS (b,d) variables. Tiny dots in the upper panel are eclipsing binaries, while larger ones - pulsating.

■ ■ ■

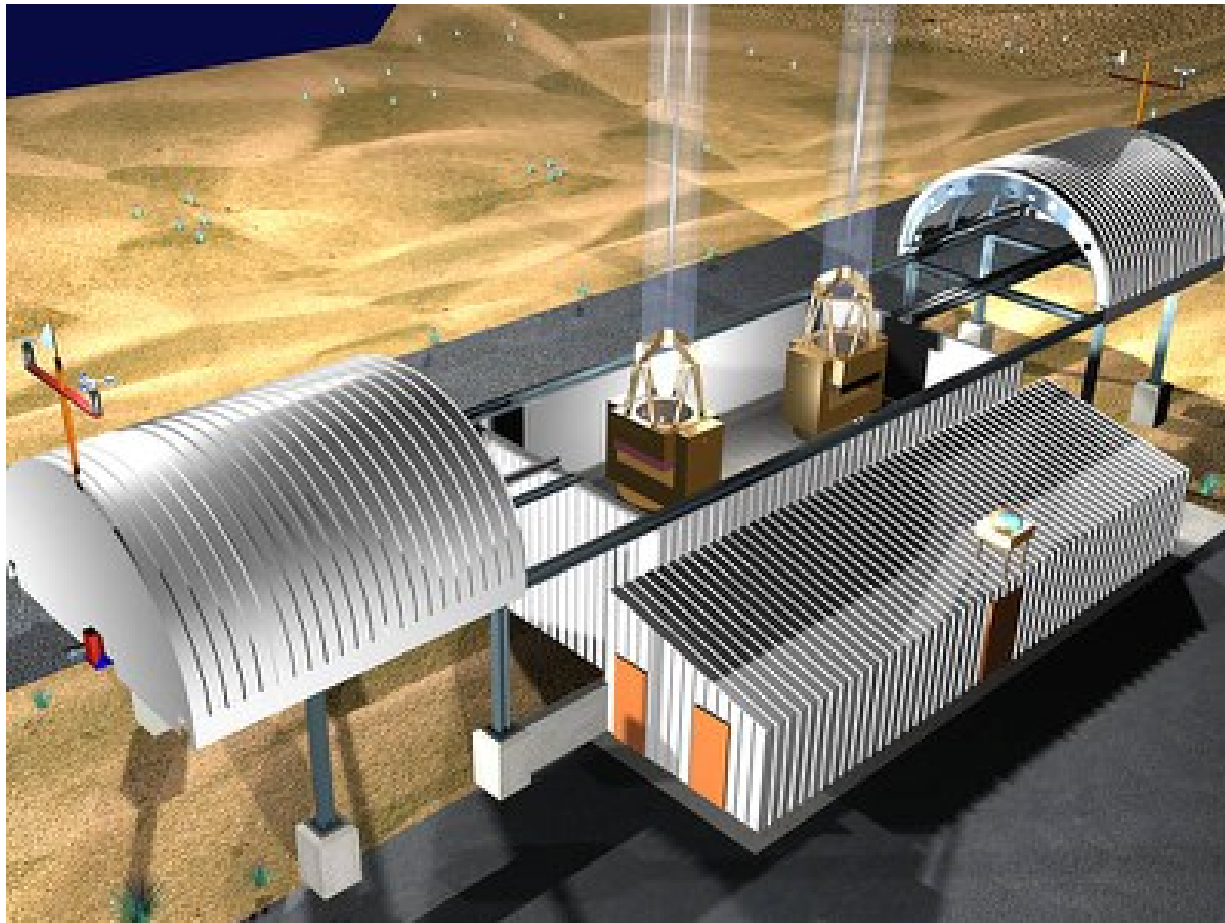
I sve ostalo ...

- Pretraživanje publikovanih članaka za svaki objekat pojedinačno, tražeći spektroskopski izmerene zvezdane parametre: T_{eff} , $\log g$, $[\text{Fe}/\text{H}]$...

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- Dalja merenja:
STELLA (RU Cam) i HERMES (SW Tau, BL Her, V351 Cep, TX Del (dvojni sistem)) spektri

STELLA



HERMES

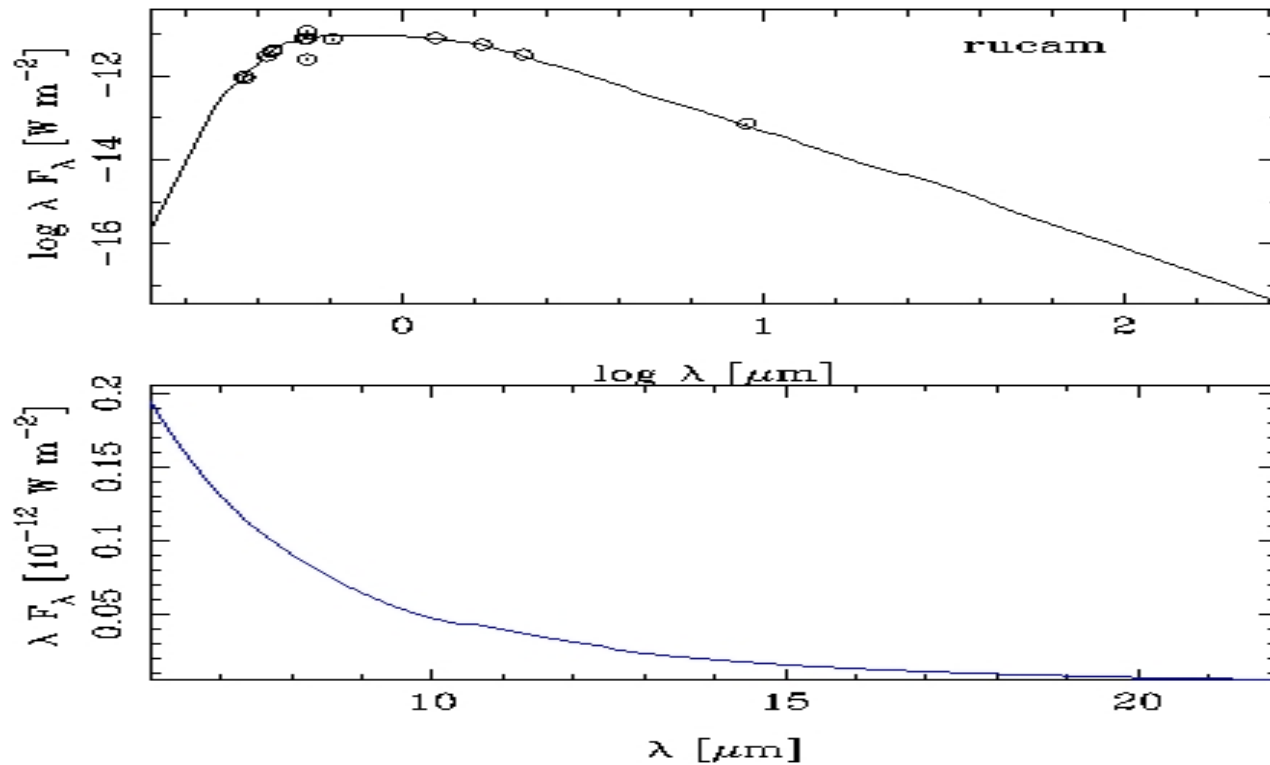


I sve ostalo ...

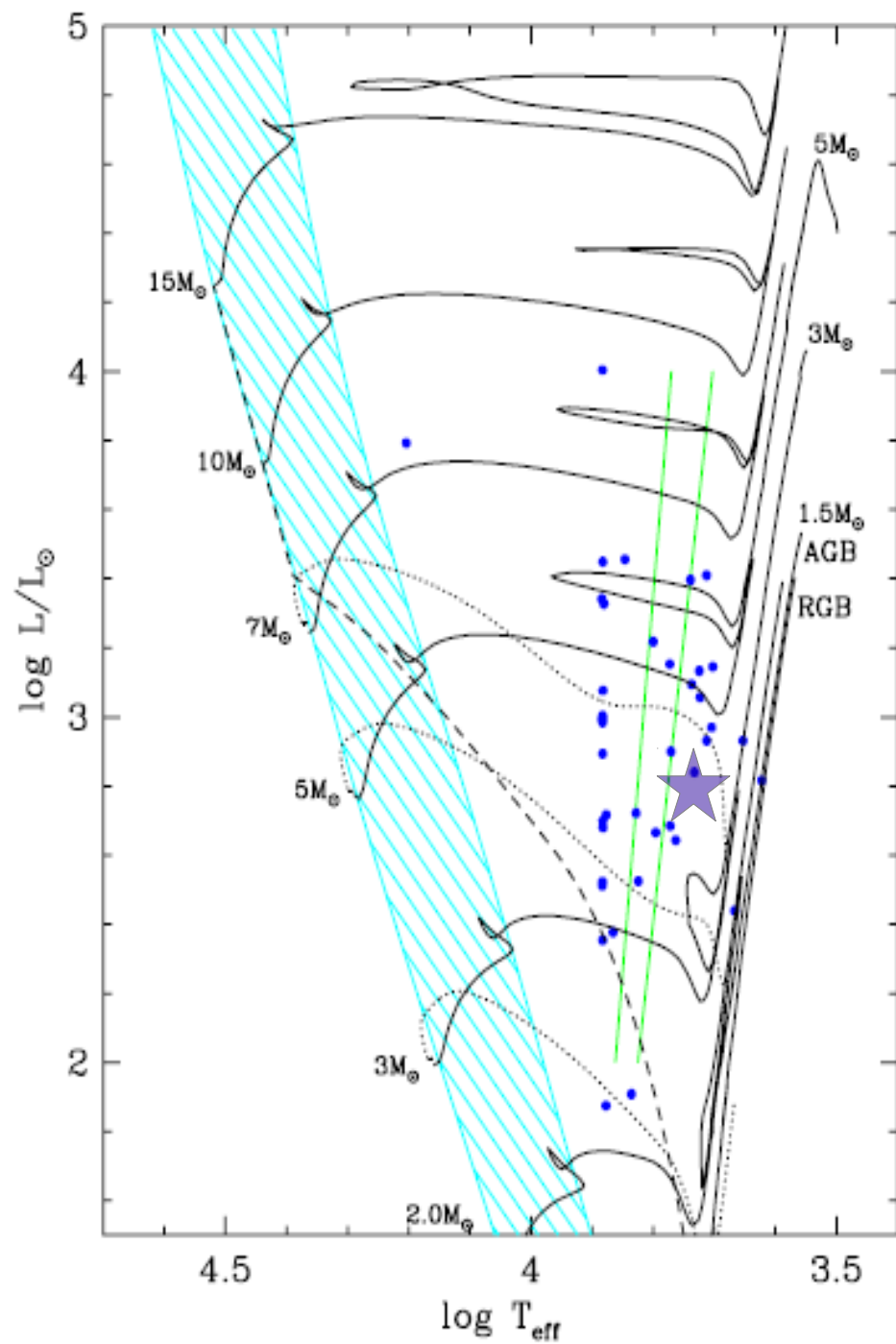
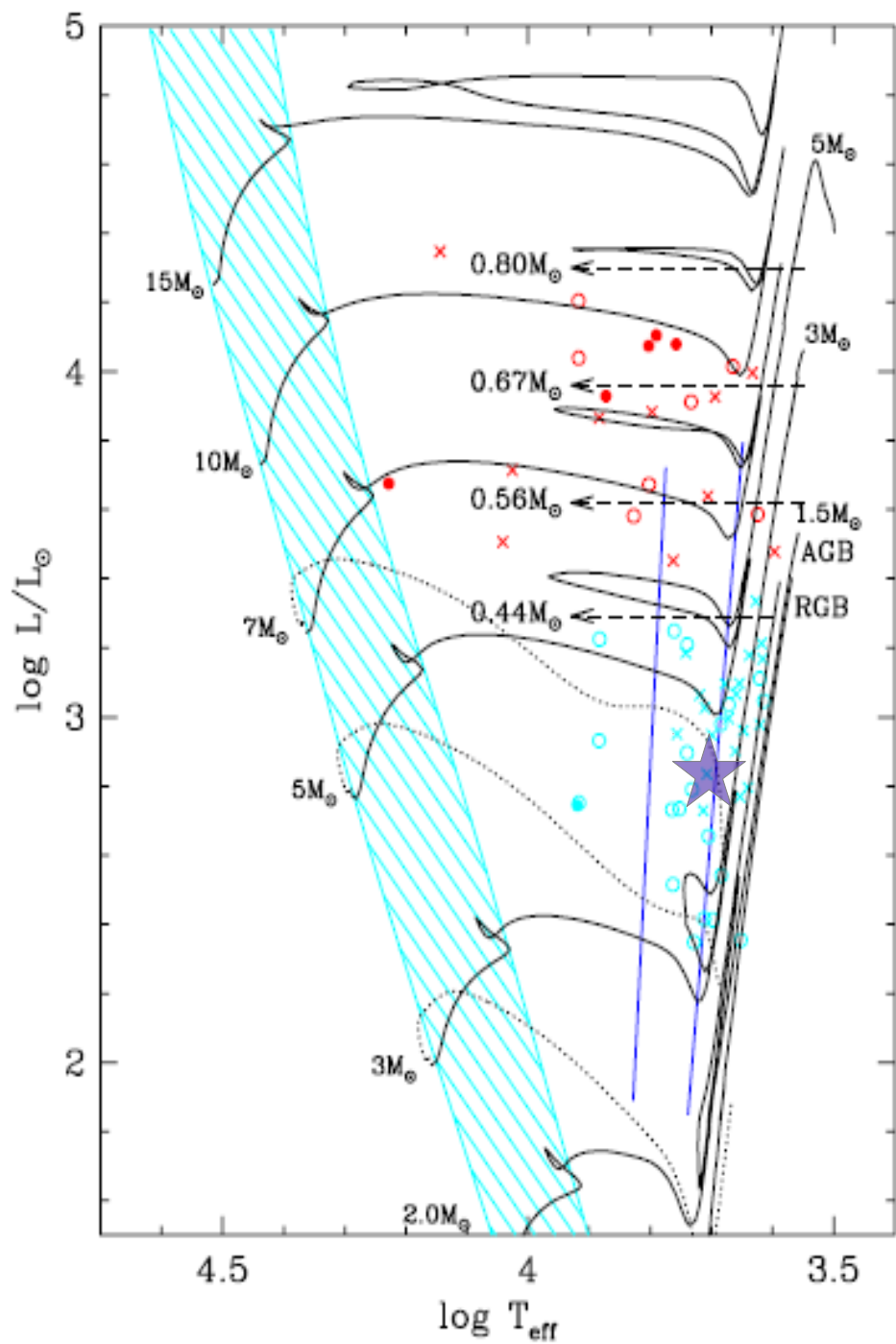
- Pretraživanje publikovanih članaka za svaki objekat pojedinačno, tražeći spektroskopski izmerene zvezdane parametre: T_{eff} , $\log g$, $[\text{Fe}/\text{H}]$...
- Dalja merenja:
STELLA (RU Cam) i HERMES (SW Tau, BL Her, V351 Cep, TX Del (dvojni sistem)) spektri
- Modeliranje dostupnih podataka iz spektralne distribucije energije (Spectral Energy Distribution - SED)

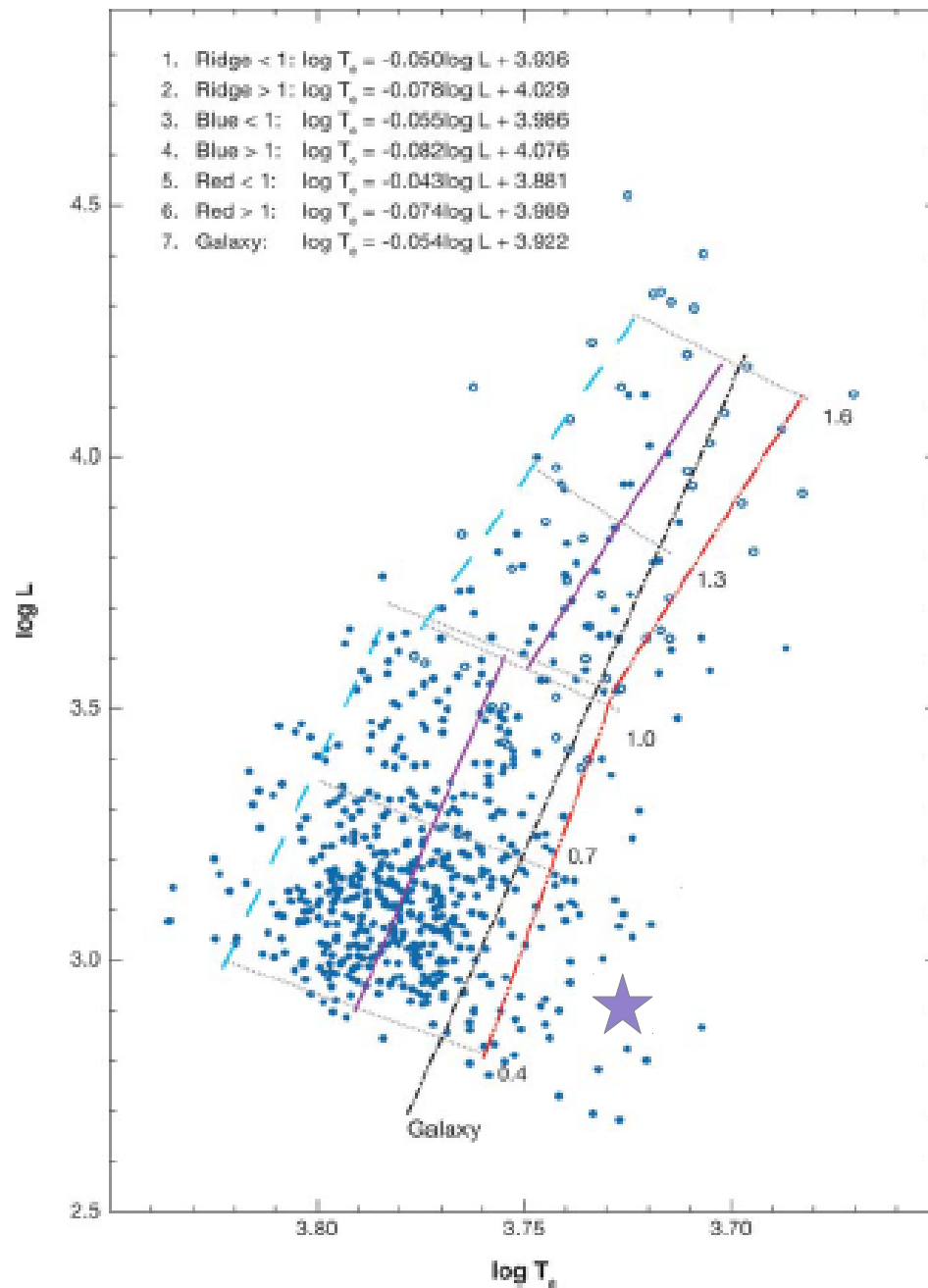
<http://vizier.u-strasbg.fr/vizier/sed/>

Model za RU Cam



M. A. T. Groenewegen:
Model atmosphere of 5250 K,
and the luminosity is 780 L_{sol} for a distance of 1.2 kpc





Sandage & Tammann,
 Annu. Rev. Astron.
 Astrophys., 2006

Figure 6

The instability strip in $\log L$, $\log T_e$ for the LMC compared with the ridge-line relation for the Galaxy, shown as the black, dashed-dot line. Five lines of constant period ($\log P$ of 1.6, 1.3, 1.0, 0.7, and 0.4) are shown. The hot and cold boundary lines to the strip are the same lines as in Figure 5 transformed to temperature. Diagram is from figure 20 of Sandage, Tammann & Reindl (2004).

Moji najbolji „drugovi” su postali:

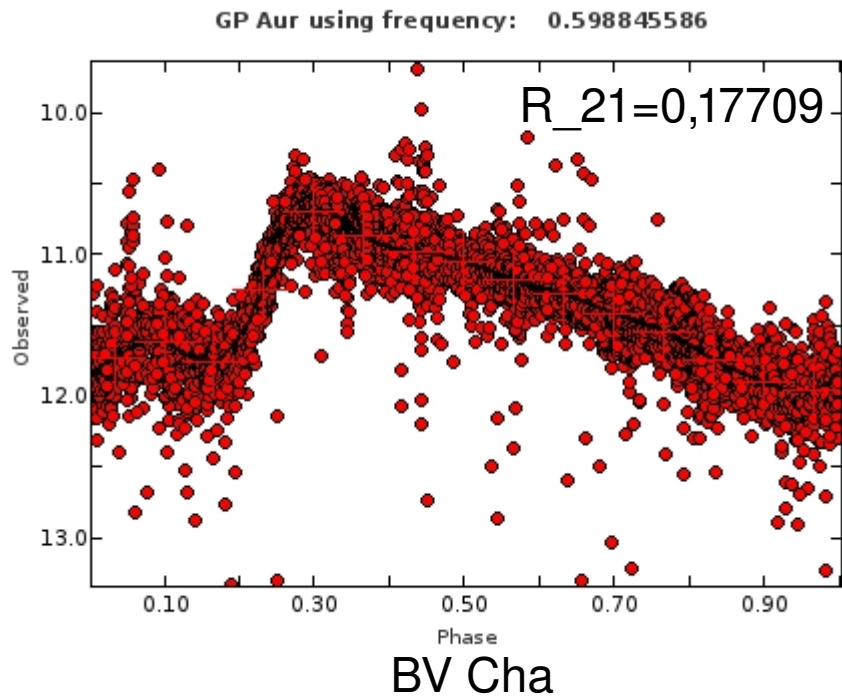


Period04

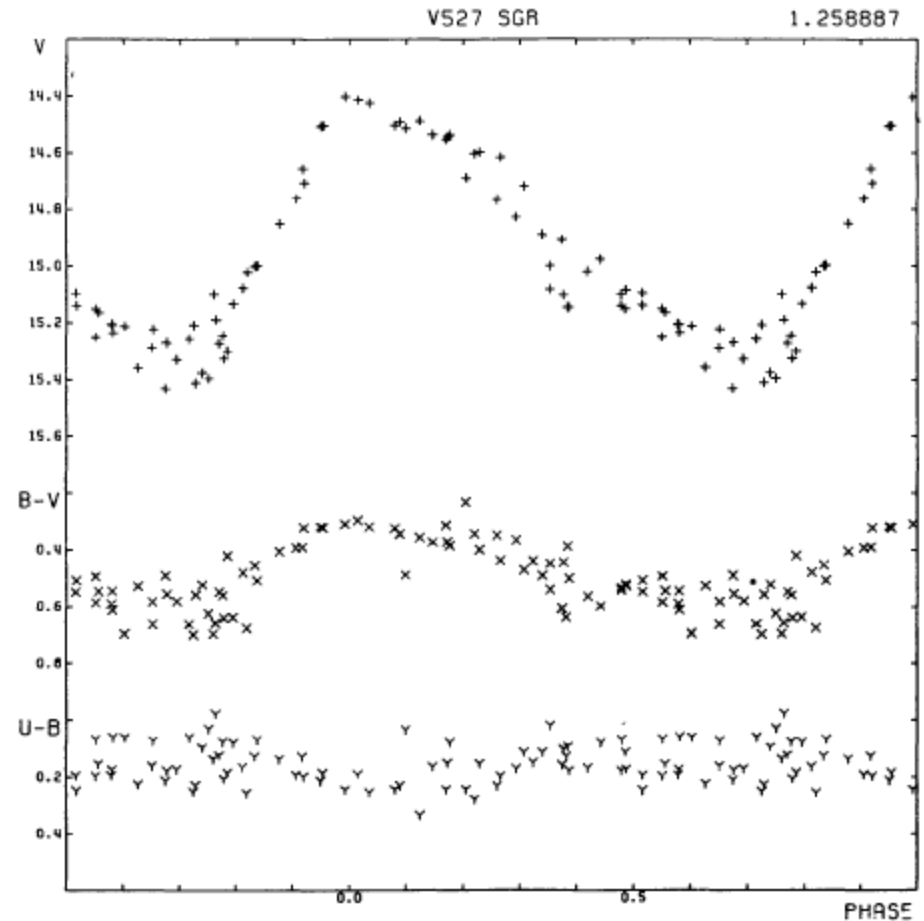
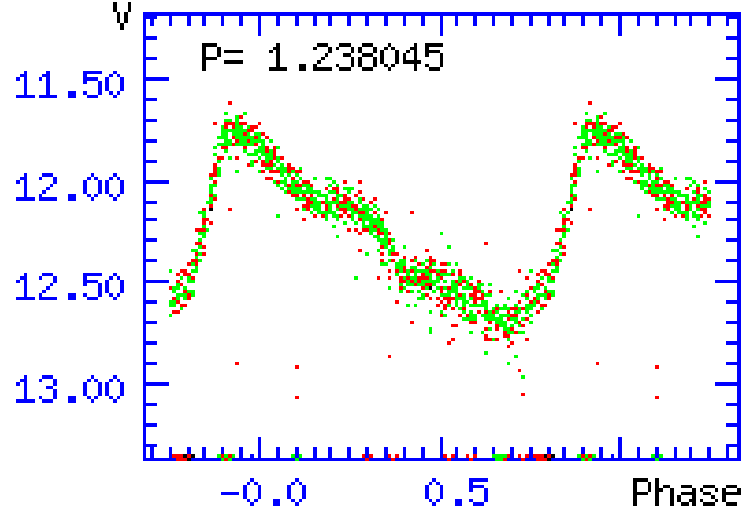
CWA i CWA: objekti iz GCVS-a

- 2012 sam počela obrađivati uzorak od 71 objekata cefeida tipa II, podtipa BL Her (CWA) iz GCVS-a (2014-te ih je 128)
- Za 16 objekata nisam našla krive sjaja u navedenim bazama
- Za 7 objekata se već znalo iz publikacija da nisu cefeide tipa II. (iako se u SIMBAD-u još uvek vode tako)
- Između preostalih objekata verovatno ima RR Lira i klasičnih cefeida
- Ako se pulsacija pojavi u bliskom dvojnog sistema onda se priroda pulsiranja u odnosu na pojedinačne zvezde menja zbog transefa mase (vidi G. Pietrzyński et al., *Nature*, 484, 75–77, 05 April 2012)

Dobri



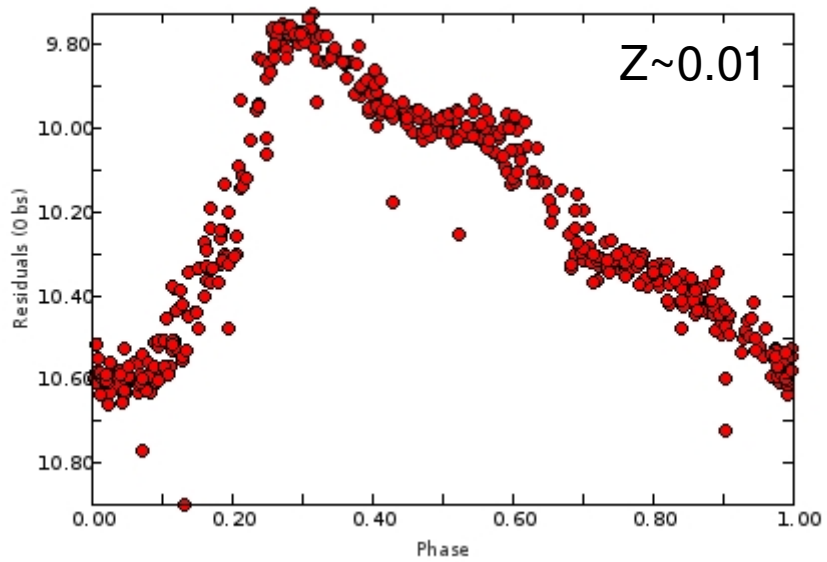
4 130214-7945.6 130227-7945.6 13022



Kwee & Diethelm, A & A Suppl. Ser,
55, 77-86, 1984

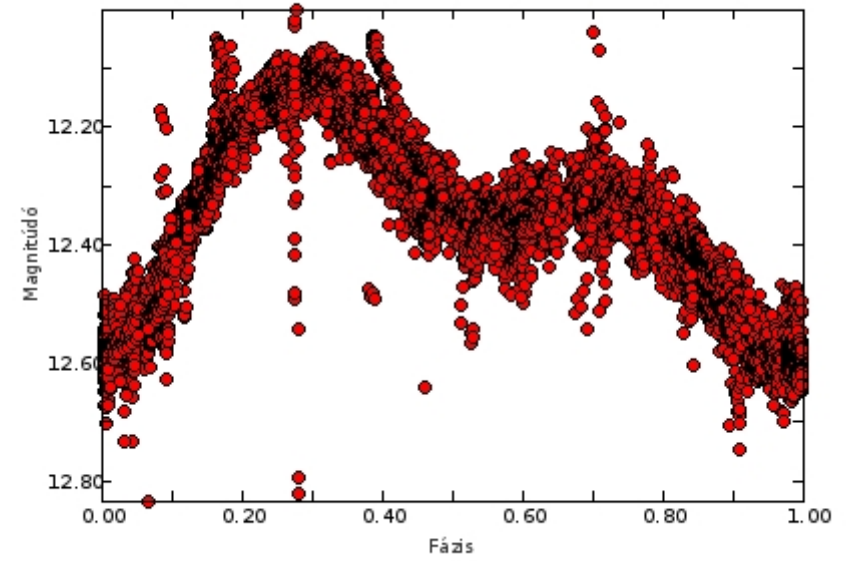
BL Her

Using Frequency: 0.764884638

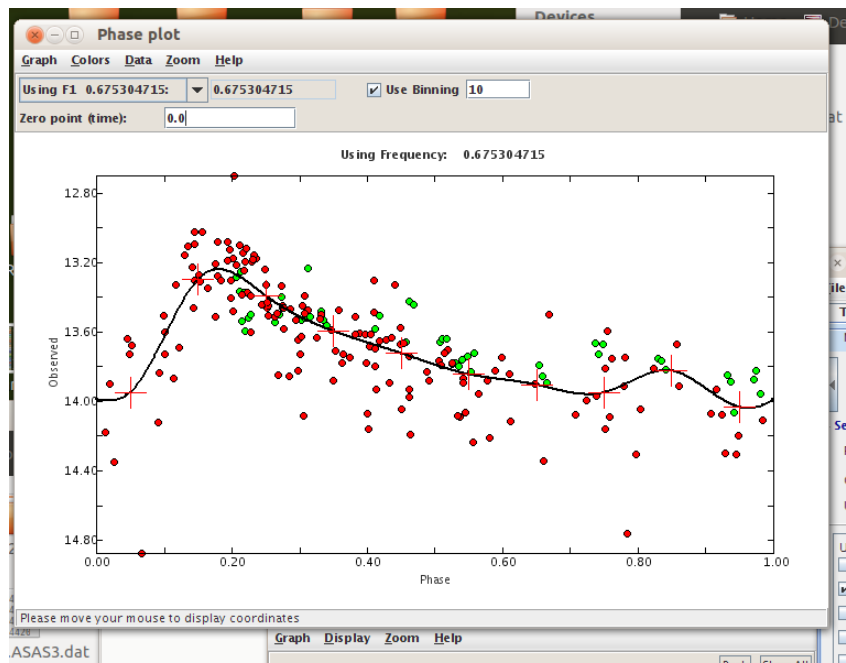


DI And

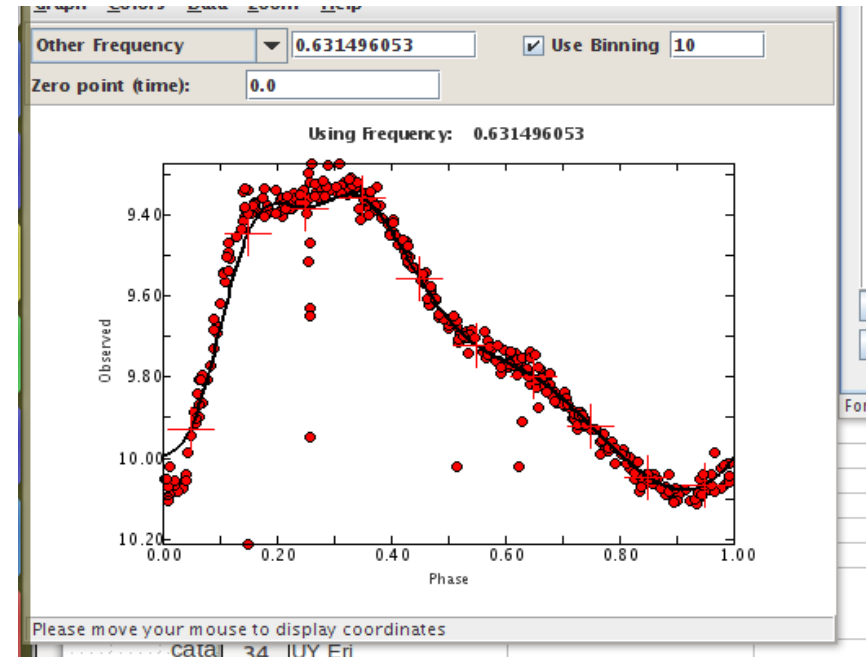
DI And f_0=0.295369939



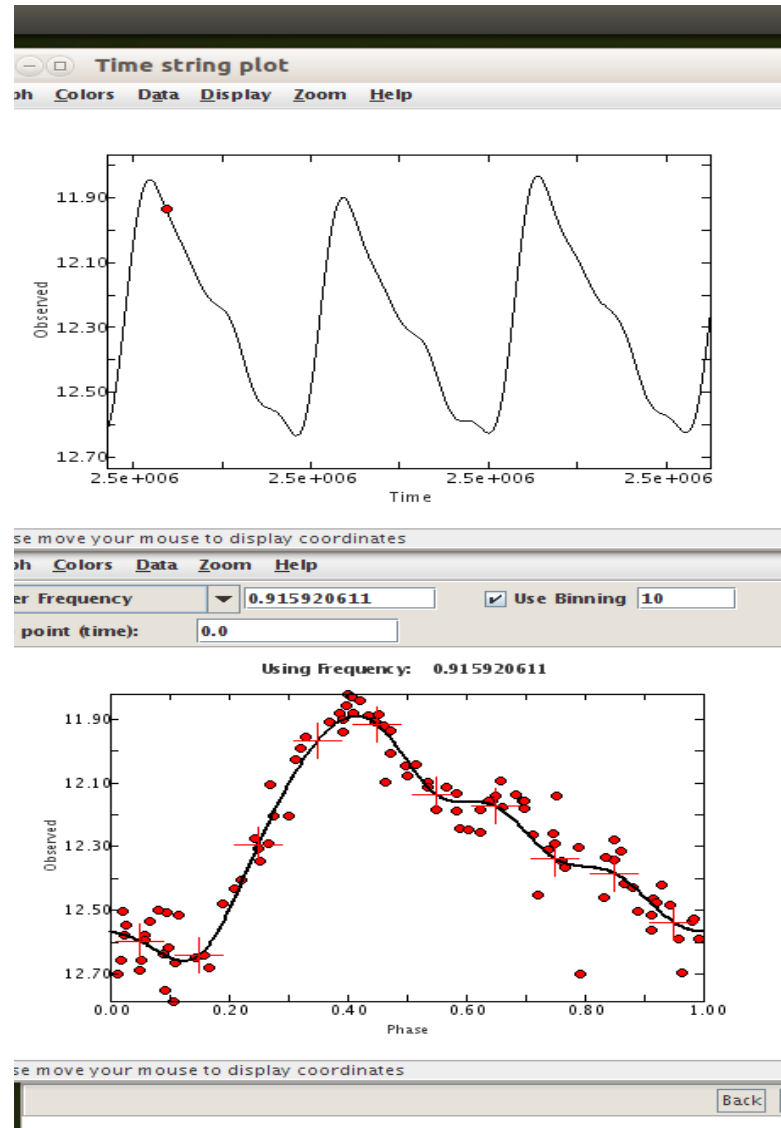
MQ Aql



SW Tau

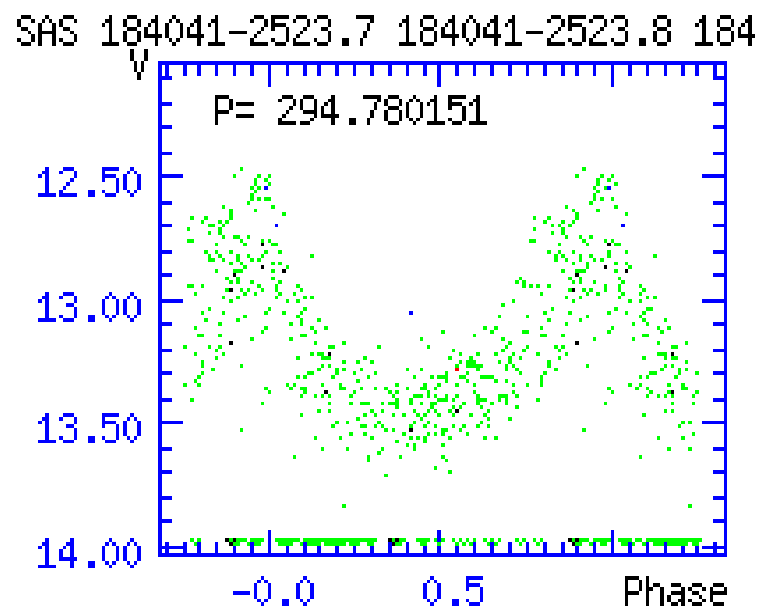
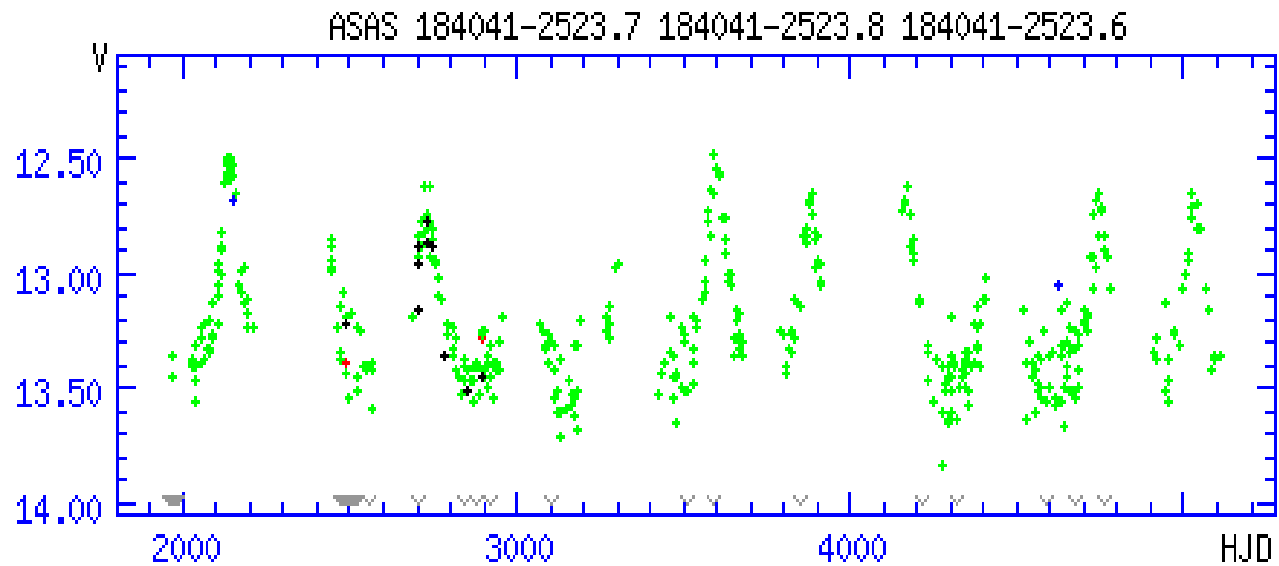


BX Del



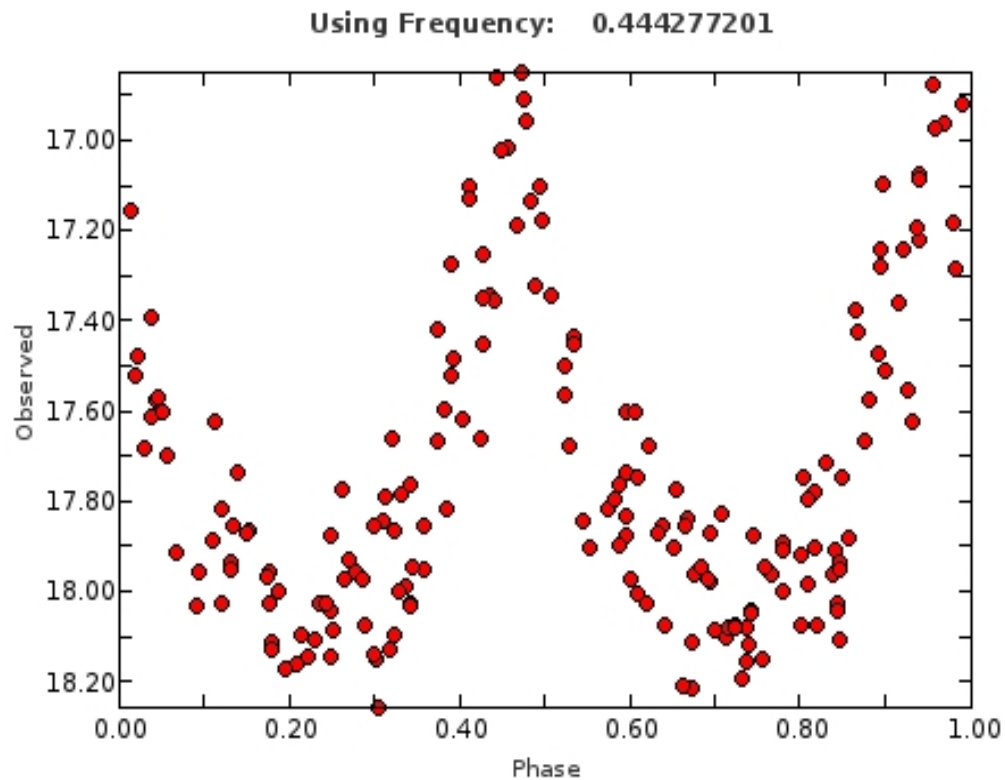
Loši

V2022 Sgr

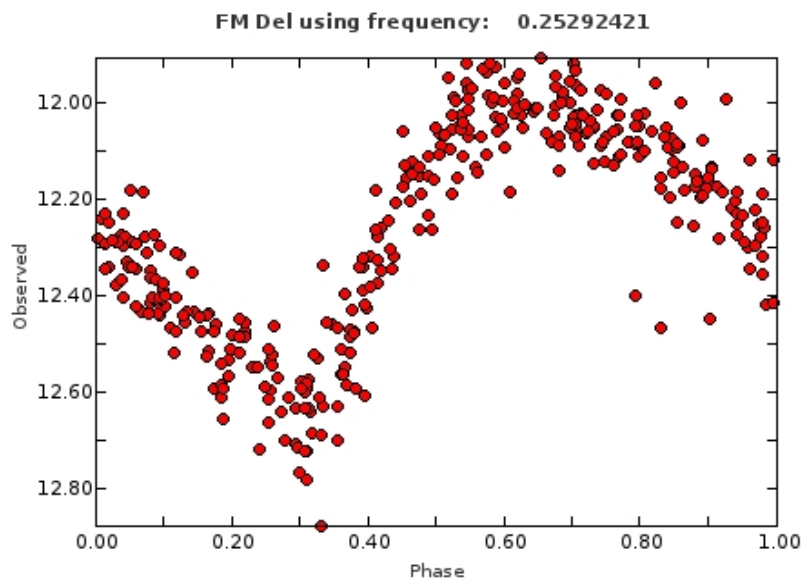


V4110 Sgr ($P=2,250847$ dana):

BY Dra tip promenljivog objekta/tesni
dvojni sistem?



FM Del



ASAS

Klasična cefeida

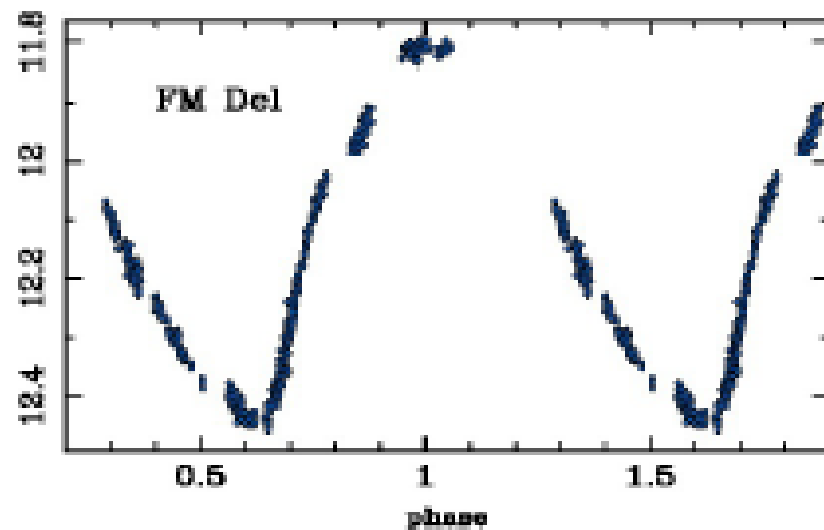
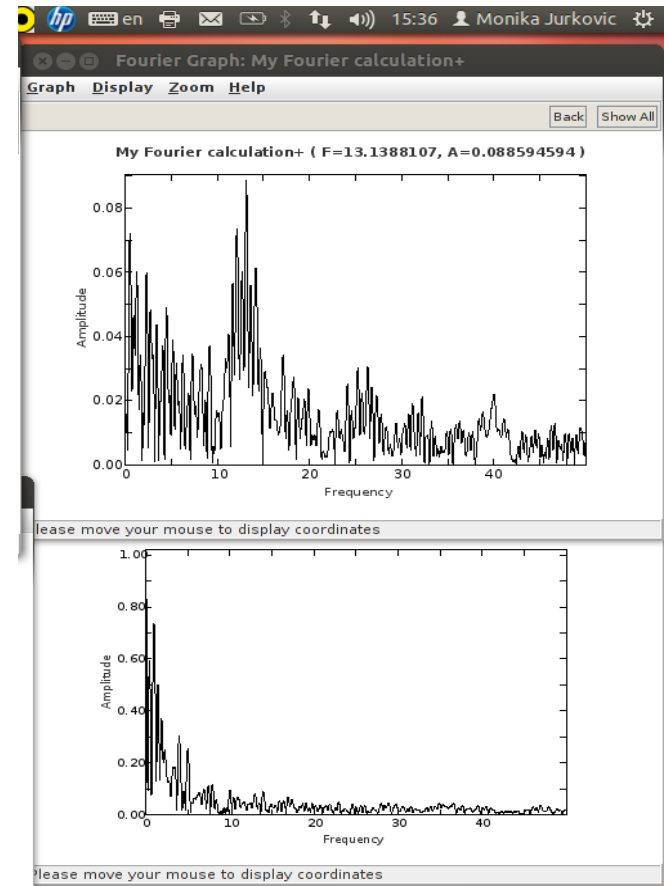
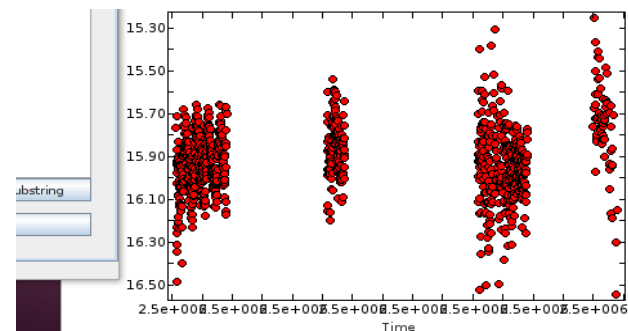
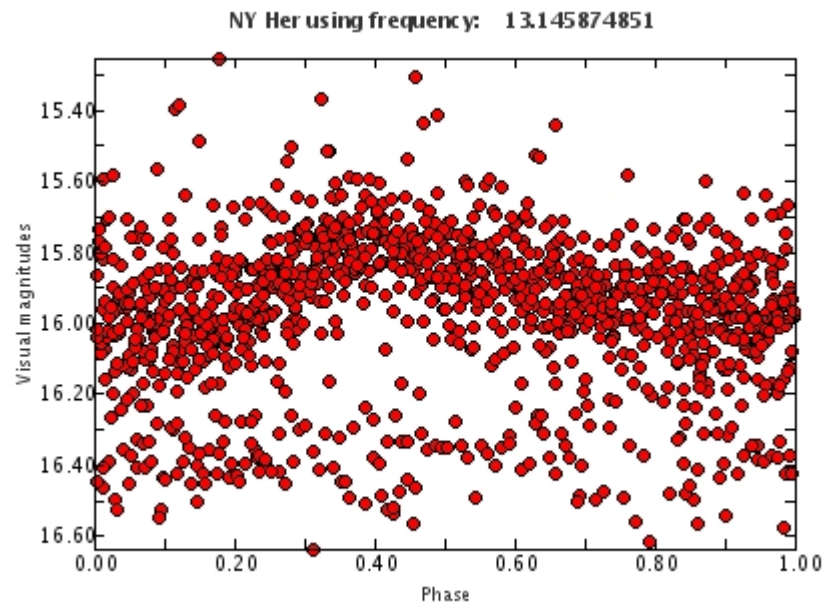


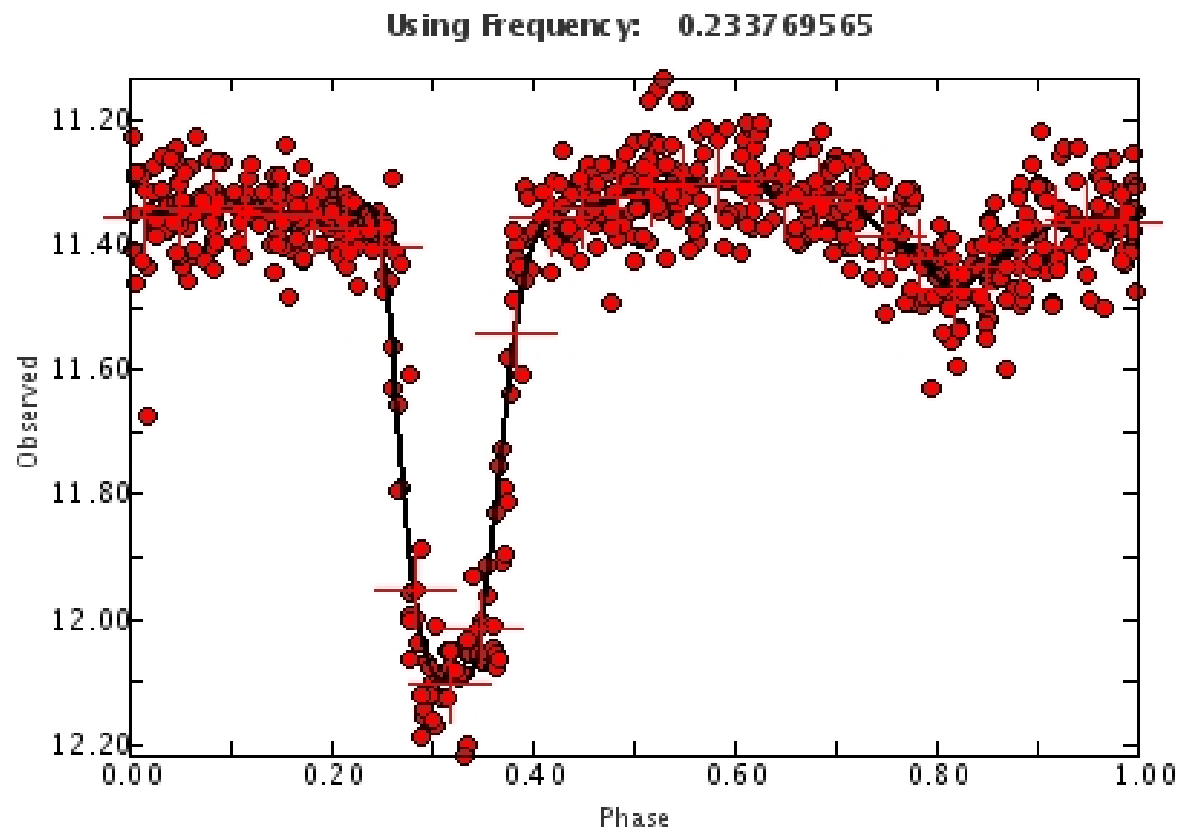
Figure 1: Folded light curve of FM Del (TAROT) using elements (1).

Le Borgne & Klotz, arXiv:1407.4961, 2014

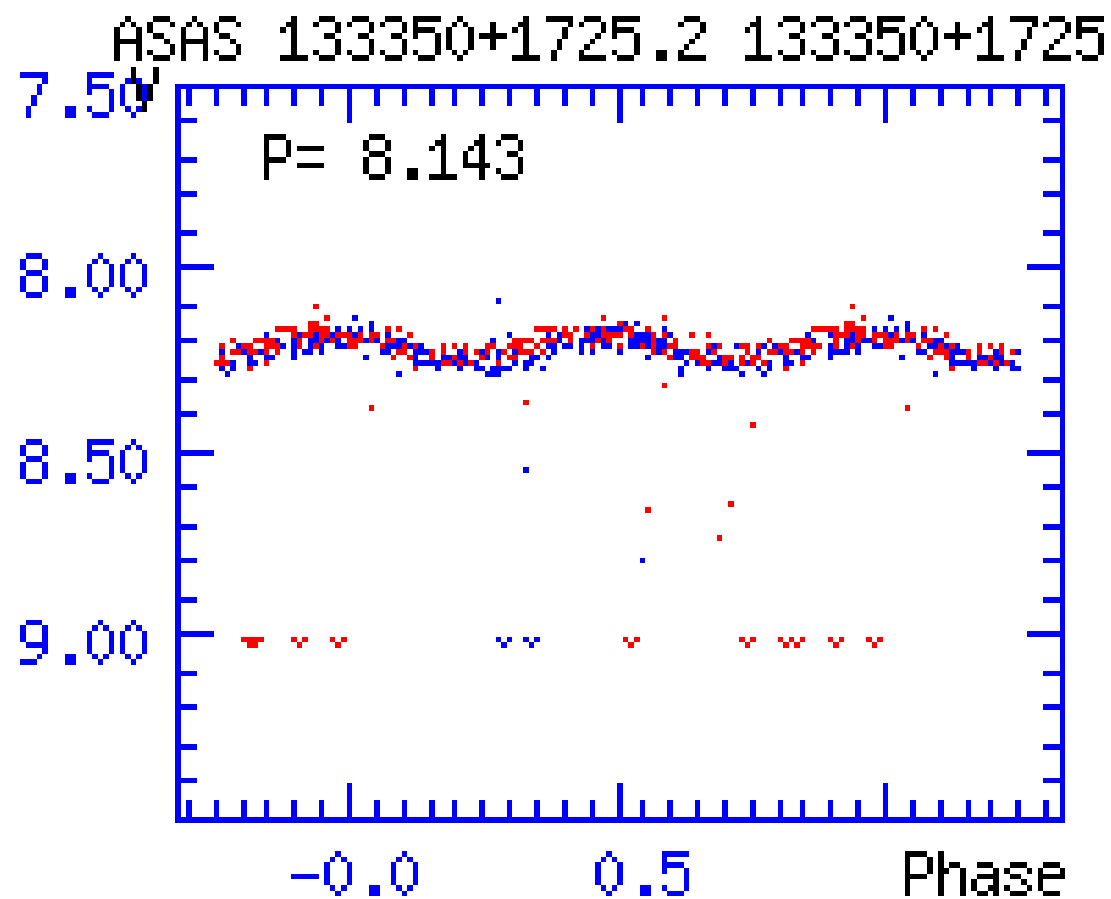
- NY Her: SU UMa podtip patuljastih nova
(Kato et al, 2013)



- UW For: eklipsni dvojni sistem ($P = 4,277$ dana)



- KT Com: dvojni sistem? Cefeida?



KO Lyr

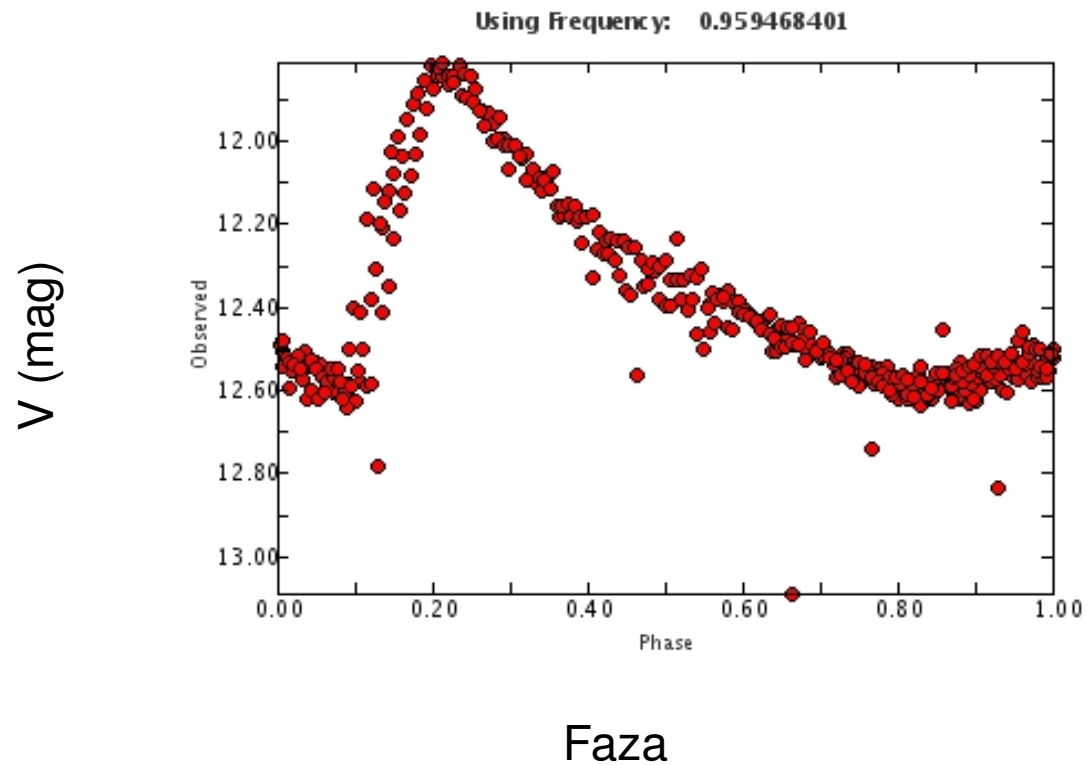
- $[\text{Fe}/\text{H}] = +1.85$?, Ammons et al., 2005
- Harris et al., AJ, 90, 756, 1985 je ovu zvezdu na osnovu galaktičke pozicije uvrstio u podtip cefeide tipa II.

- V403 Cyg, V742 Cyg, WY CMa, V1153 Sgr, V553 Sco, AT Tel, HQ CrA, YZ CMa, V839 Sgr, V714 Cyg, VX CMa, BE Pup, V351 Cep, BE CrA, LN Pav, QY Cyg – nema dovoljno podataka da se kreira kriva sjaja

Mogu se naći u McMaster katalogu.

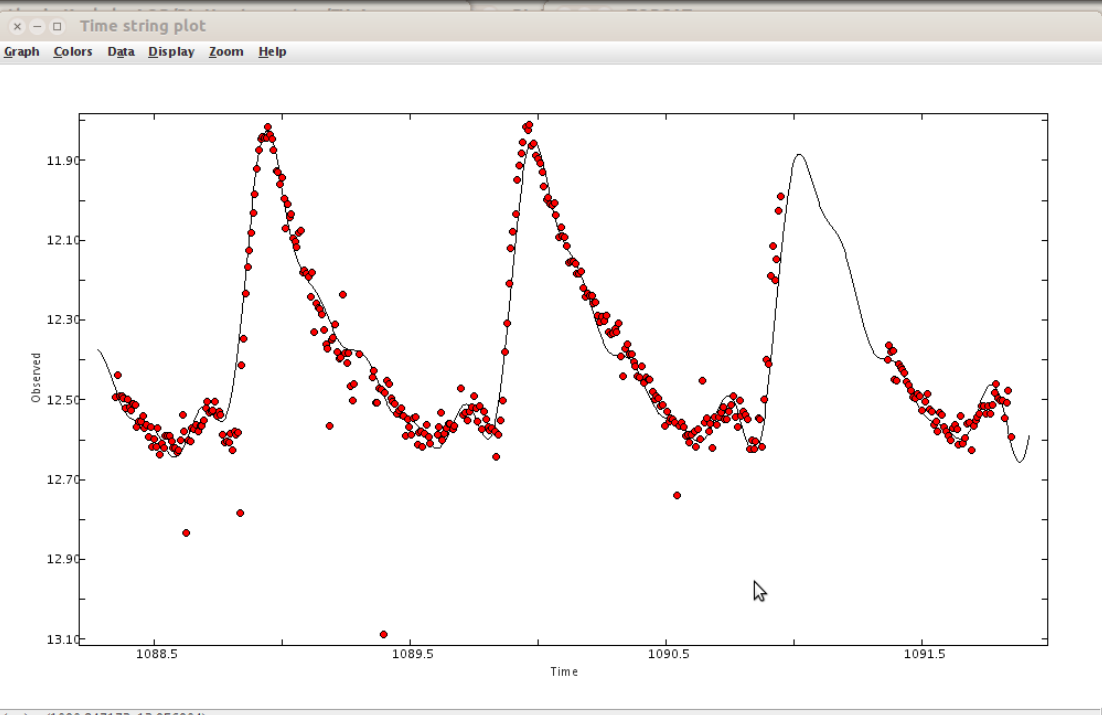
I zli

- FY Aqr: RR Lyrae?/T2C?
P = 1,0422 dana



```

INFO: Creating default XmlRpcIns
04-Feb-2014 18:23:30 org.astrogr
INFO: Default XmlRpcInstance is
04-Feb-2014 18:23:30 org.astrogr
INFO: Server http://127.0.0.1:45
04-Feb-2014 18:23:30 org.astrogr
y
INFO: Performing queued message
04-Feb-2014 18:23:30 org.astrogr
INFO: SAMP autoconnection attempt
  
```



Period04: FY_Aqr_INTEGRAL_period04.p04

File Special Configuration Help

Time String Fit Fourier Log

Fourier Calculation Settings

Title: My Fourier calculation+++++

From: 0 Step rate: High 0.0143204239

To: 5 Nyquist: 58.5497

Use Weights: none Edit weight settings

Calculations based on:

Original data Residuals at original Spectral window

Adjusted data Residuals at adjusted Freq folded w SW

Compact mode: Peaks only All

Highest Peak at: Frequency = 4.84854952 Amplitude = 0.0416947425

Calculate

My Fourier calculation (F=0.936558249, A=0.224017918)

My Fourier calculation+ (F=0.959468401, A=0.256549245)

My Fourier calculation++ (F=1.89029595, A=0.105251541)

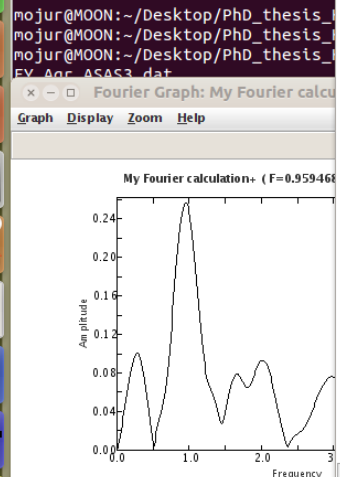
My Fourier calculation+++ (F=2.87233102, A=0.0806424001)

My Fourier calculation++++ (F=3.88908112, A=0.05112485)

My Fourier calculation+++++ (F=4.84854952, A=0.0416947425)

Rename spectrum Export spectrum Delete spectrum

Display table Display graph

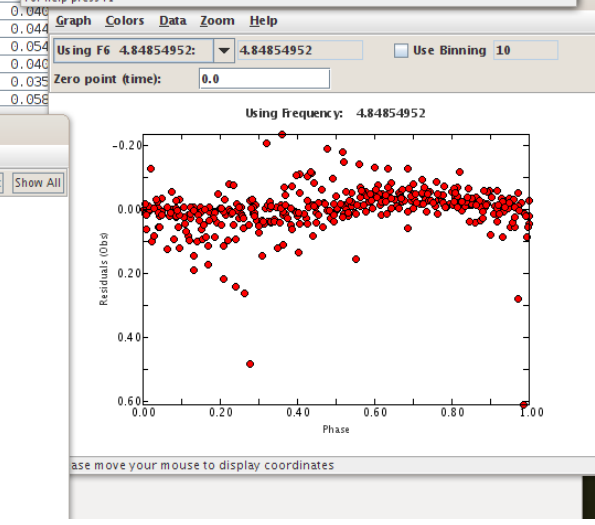
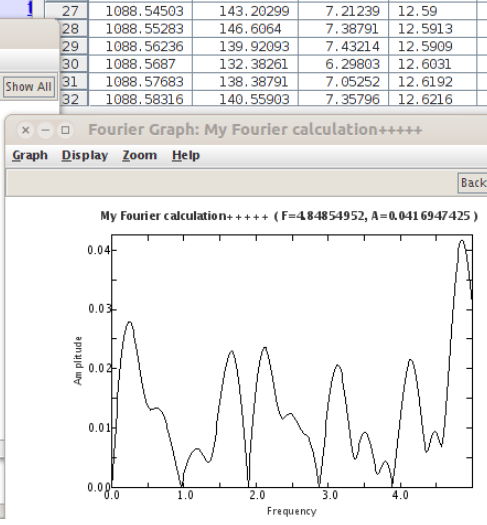
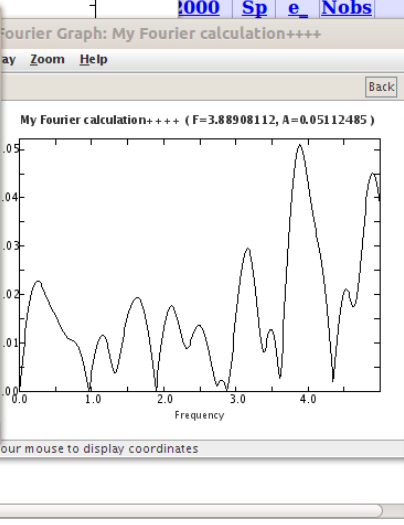
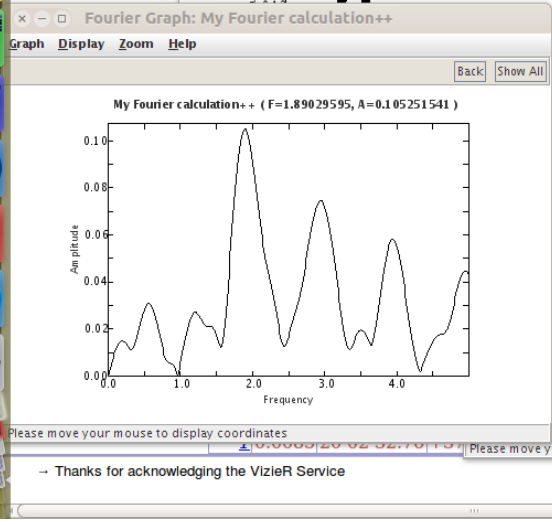


Please move your mouse to display coordinates

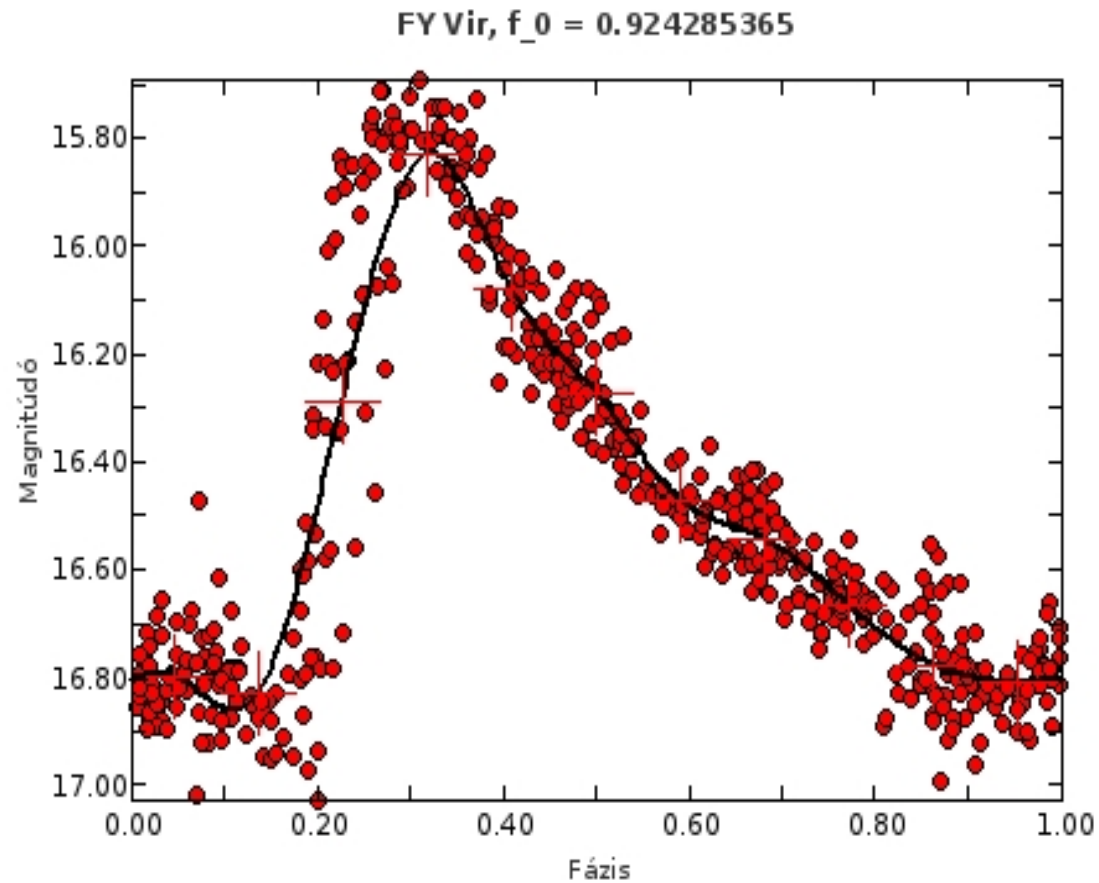
1773484 rows

1000 Sp e Nobs

24	1088.52424	128.68102	6.20498	12.6367	0
25	1088.53057	141.16139	6.85602	12.6098	0
26	1088.5387	143.12528	7.23934	12.6199	0
27	1088.54503	143.20299	7.21239	12.59	0.044
28	1088.55283	146.6064	7.38791	12.5913	0.044
29	1088.56236	139.92093	7.43214	12.5909	0.054
30	1088.5687	132.38261	6.29803	12.6031	0.040
31	1088.57683	138.38791	7.05252	12.6192	0.035
32	1088.58316	140.55903	7.35796	12.6216	0.058

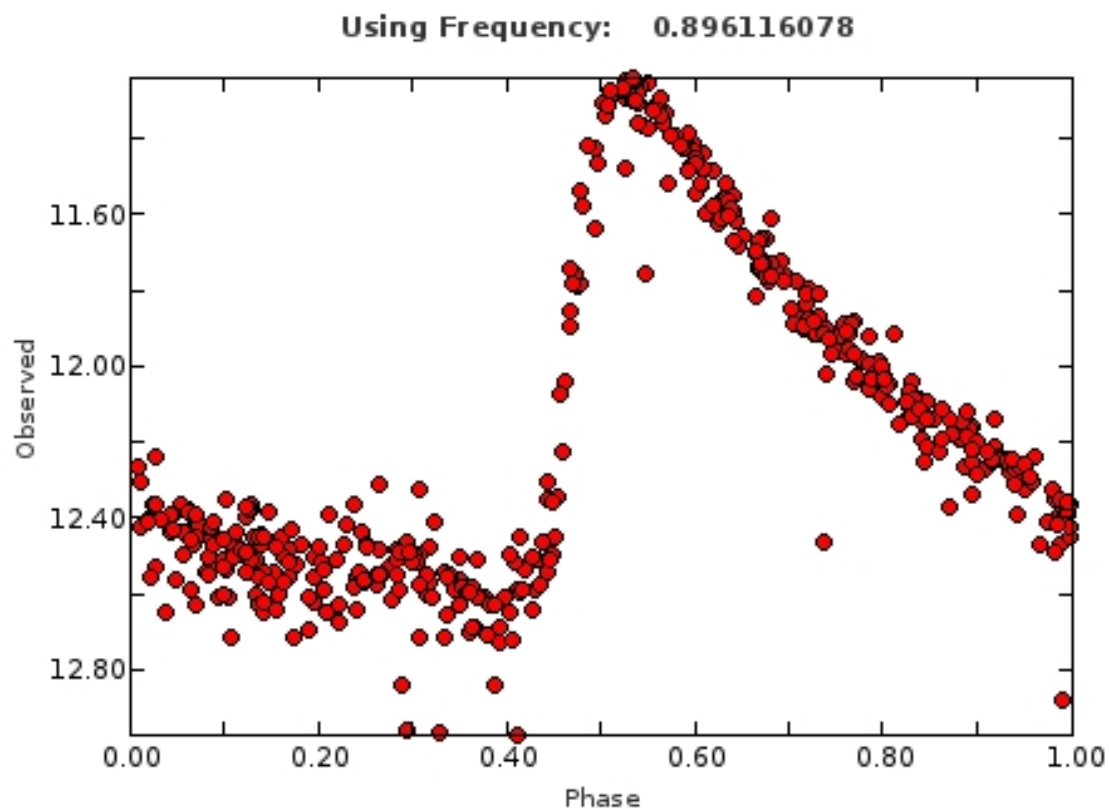


- FY Vir: T2C? / RR Lira? + ima li modulacije?

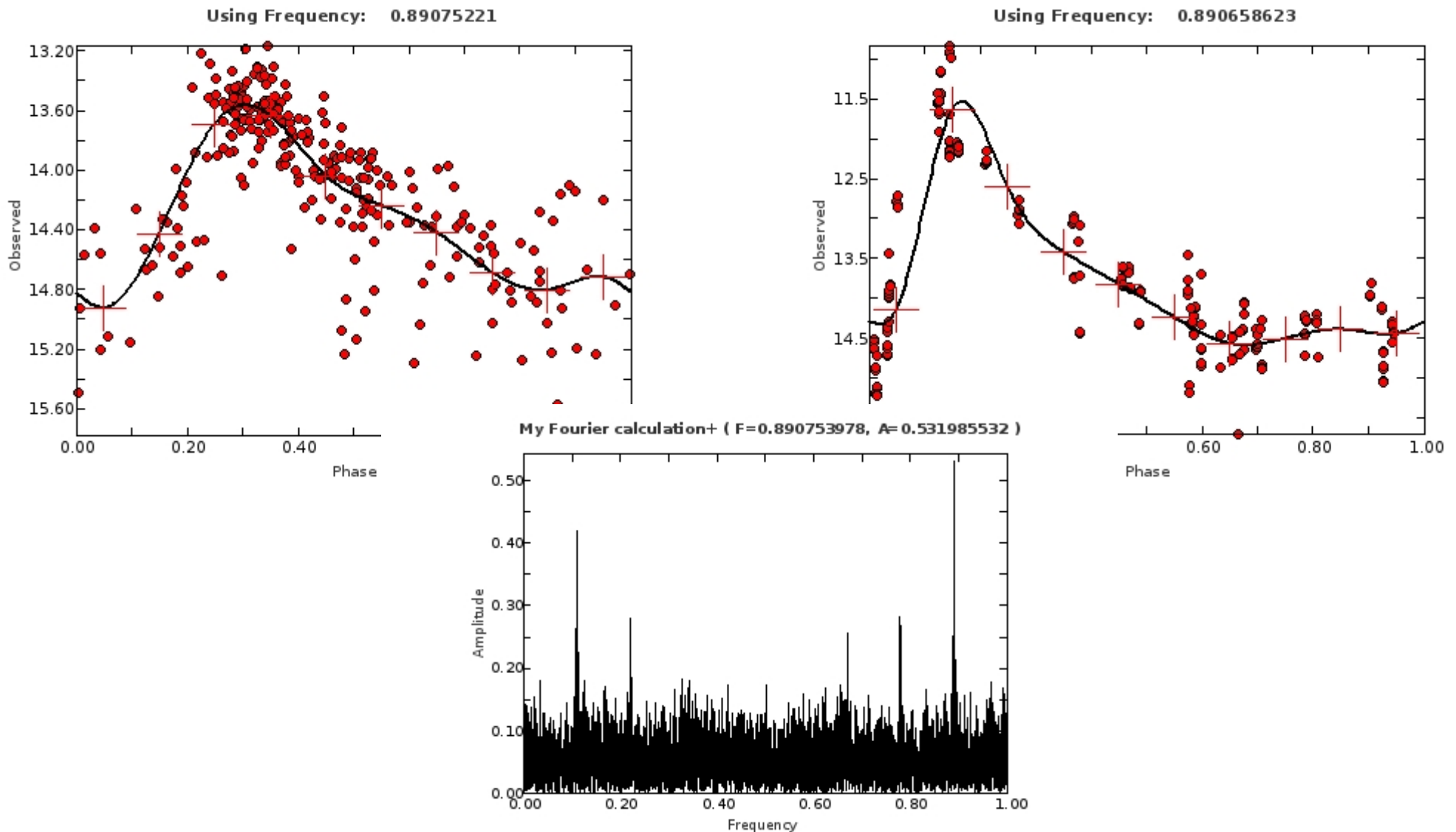


- V716 Oph: $[Fe/H] = -1,1$

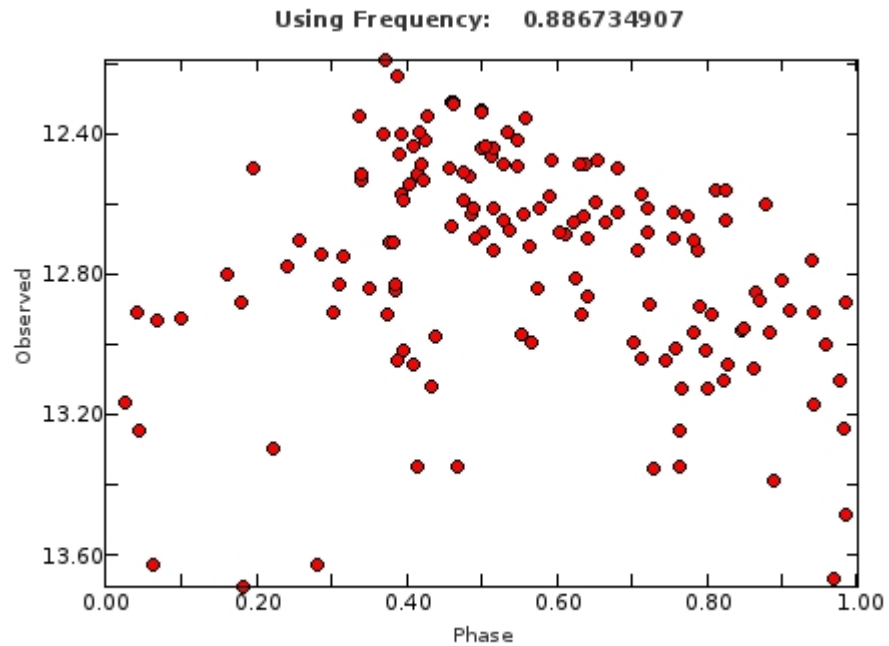
ASAS: DCEP (klasična cefeida)?/ RR Lira?



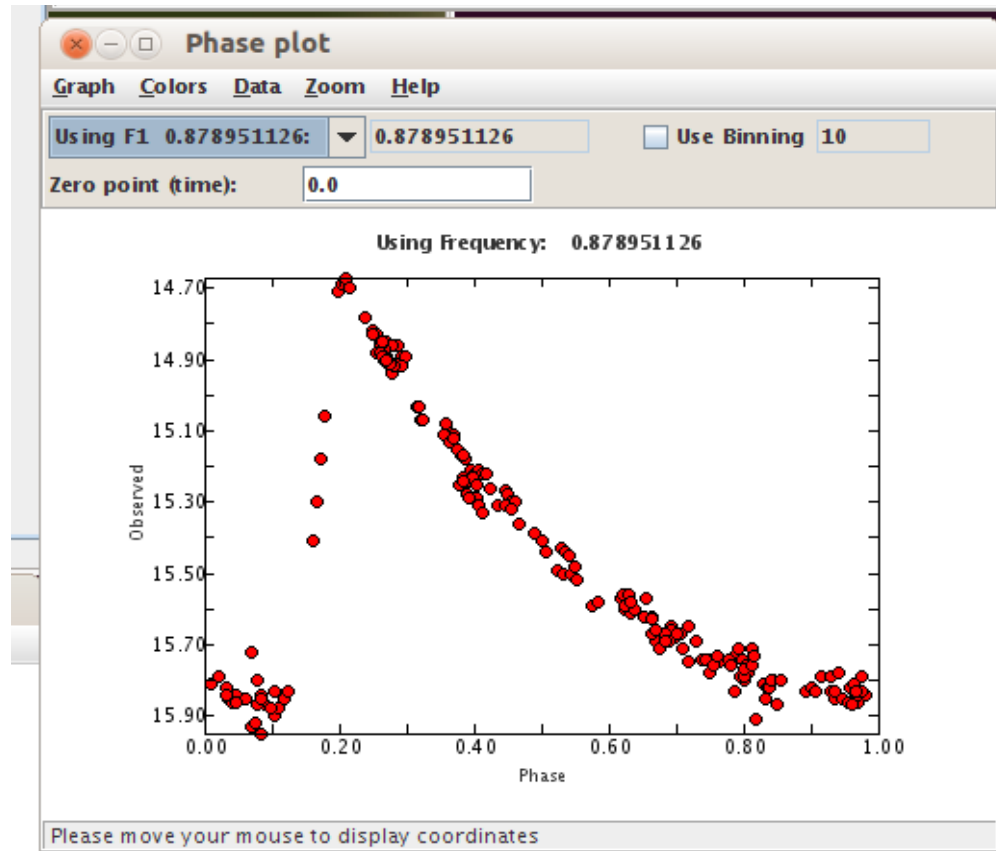
- DF Hyi: i ASAS i SuperWASP krive sjaja su veoma nepravilne, ali Furije spektar daje vrlo jasne pikove



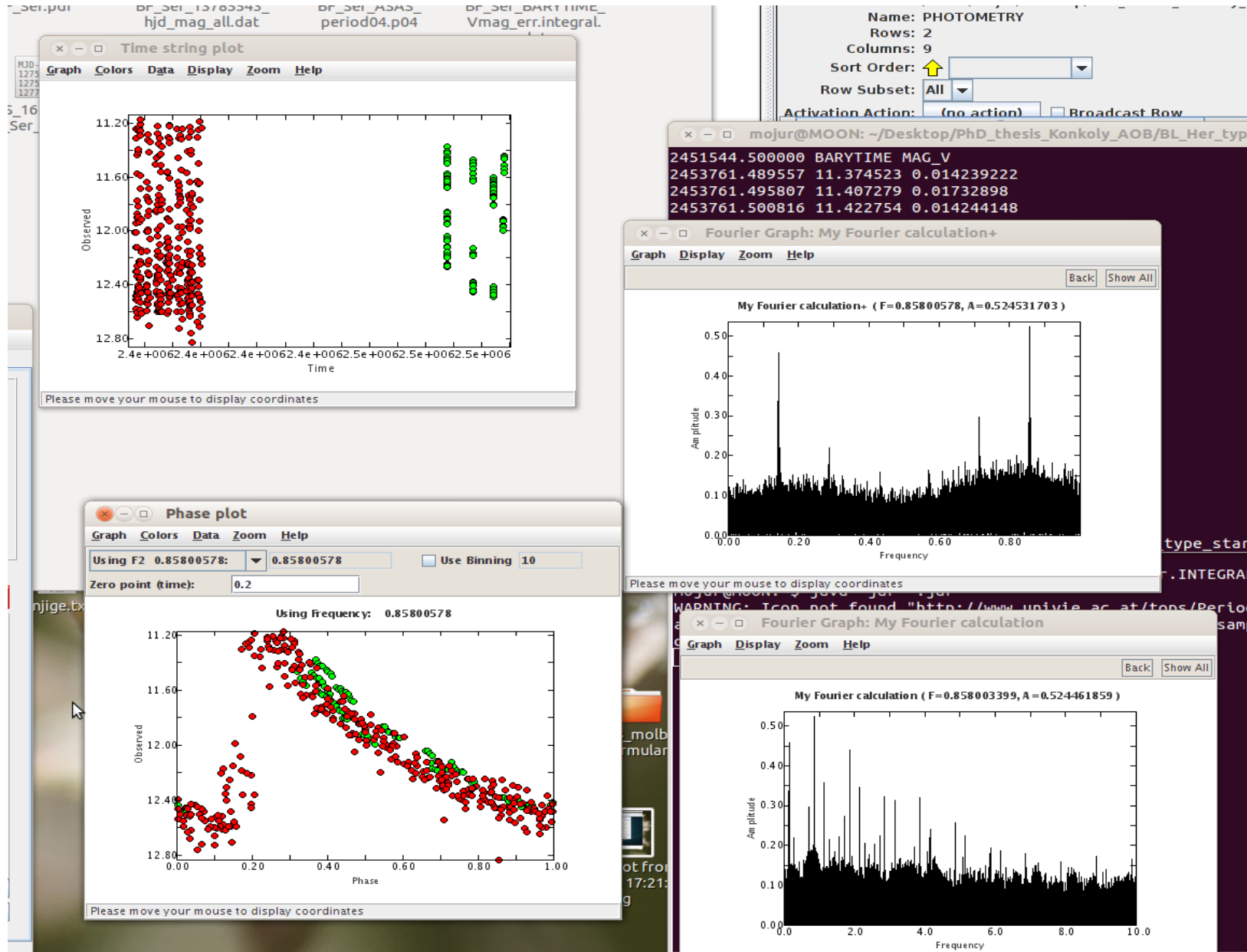
- BQ CrA: ?
[Fe/H] = -2,3 (Sandage et al., 1994, A&A, 283, 111)



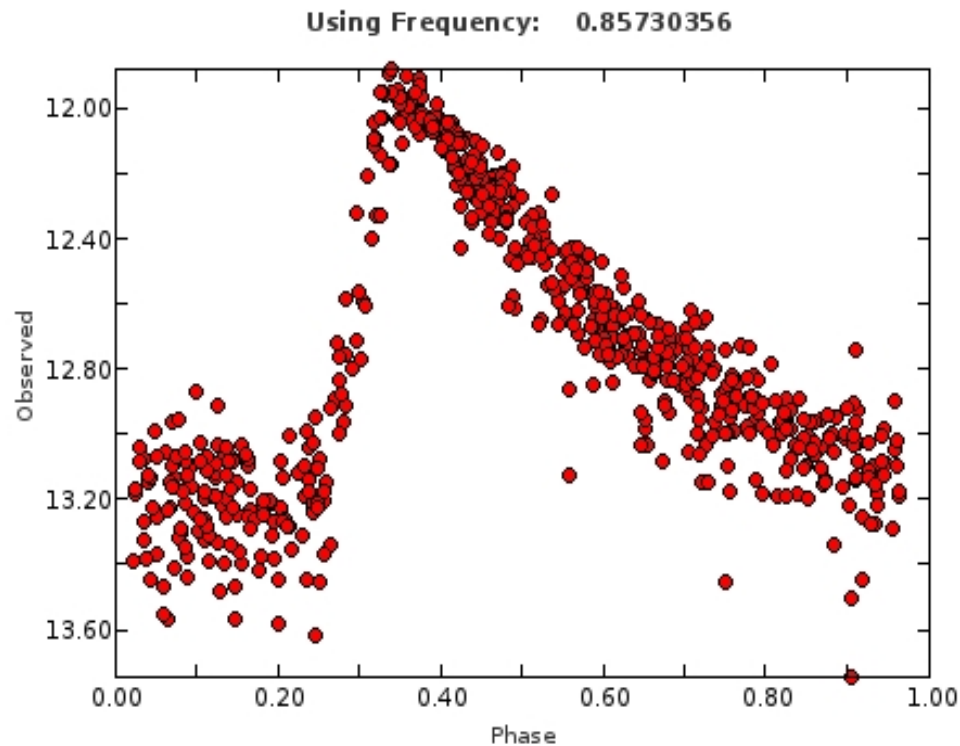
- BH Cet: RR Lira?
[Fe/H] = -1.3 (Sandage et al., 1994, A&A, 283, 111)



- BF Ser: ? - Spektralni tip: A 9,5 / A7 – F3
[Fe/H] = -2,5 (Schmidt et al., 126, AJ, 2003)



- BI Tel: RR Lira? + modulacija?
[Fe/H] = -1,9 (GCVS)



- VY Pyx, XX Vir, KZ Cen, V745 Oph, V1437 Sgr, RT TrA ($A_{21}=0,104$, ugljenična zvezda), V1287 Sco, V553 Cen, UY Eri, UX Nor, V617 Ara, CN Cma, BE CrA, BD Cas, V572 Aql, V675 Cen...

Metoda: Furije analiza

- Za analizu podataka sam koristila program Period04:

$$A_0 + \sum A_i \cos 2\pi [i f_i (t - t_0) + \Phi_i]$$

where A_i is the amplitude, f_i is the frequency, Φ_i is the phase.

Furije parametri

$$\phi_{n1} = \phi_n - n\phi_1 ,$$

$$R_{n1} = A_n/A_1 .$$

R_21 vs logP

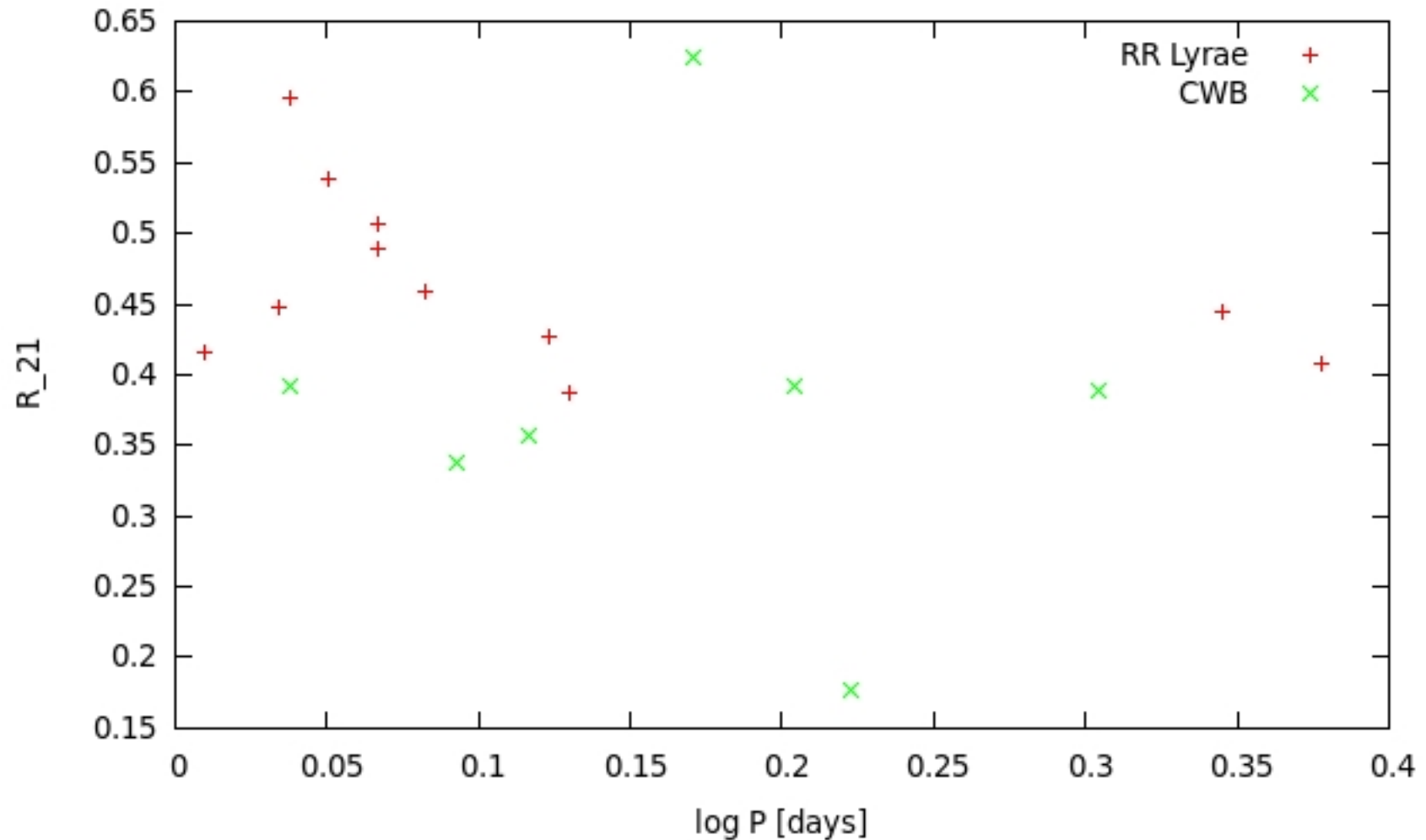


Figure 1.: RR Lyrae (log P, R_21): FY Aqr (0.00984, 0.415), FY Vir (0.03419, 0.4472), PP Tel (0.03769, 0.5962), DF Hyi (0.05023, 0.5378), BF Ser (0.06649, 0.4889), BI Tel (0.06685, 0.5071), CE Her (0.08257, 0.4595), VX Cap (0.12305, 0.4273), XX Vir (0.12976, 0.3867), CWB (log P, R_21): BX Del (0.038142, 0.3926), GP Aur (0.22268, 0.1771), BV Cha (0.09273, 0.3373), BL Her (0.11642, 0.3570), MQ Aql (0.170464, 0.6253), SW Tau (0.19962, 0.3181), V477 Oph (0.30442, 0.3891)

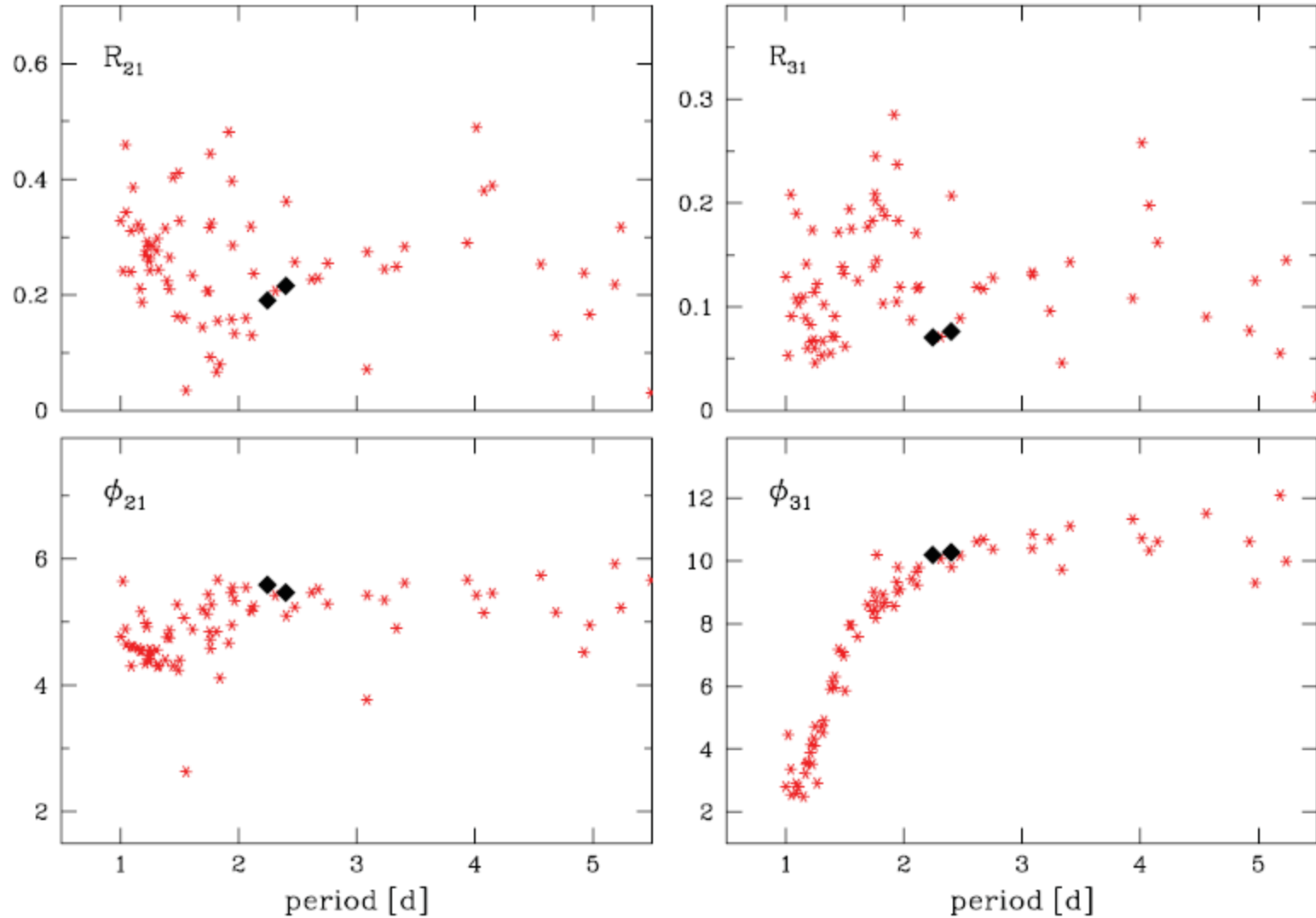
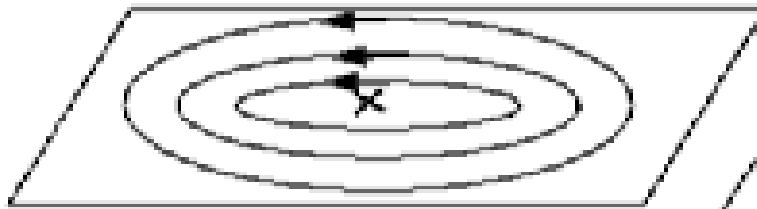


Figure 8. *I*-band Fourier parameter progressions for the Type II Cepheids. Asterisks represent Type II Cepheids of the LMC (Soszyński et al. 2008). BLG184.7133264 and BLG189.6137529 are plotted with diamonds. Their ϕ_{31} values are shifted up by 2π .

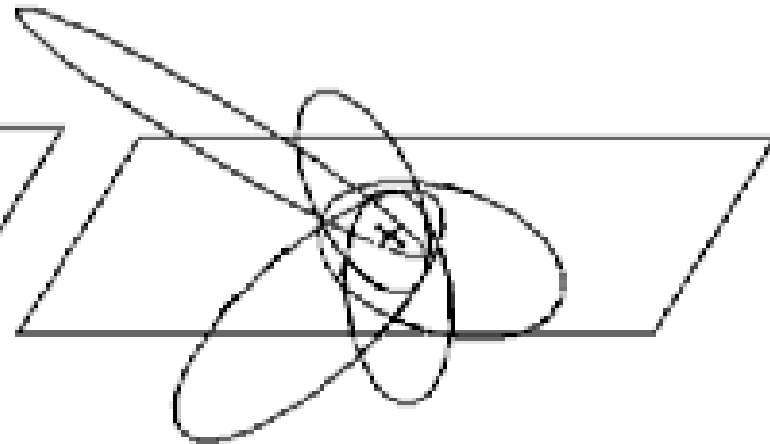
Buduća istraživanja

- Proširiti ovde predstavljenu analizu na W Vir i RV Tau podtipove
- Na novom uzorku Galaktičkih cefeida tipa II. fitovati novu PL relaciju
- Istražiti pojedinačne objekte koji se izdvajaju iz uzorka i otkriti šta su ti objekti zapravo

Istraživanje pripadnosti cefeida tipa II. Galaktičkim populacijama



Population I stars: ordered motion.
Circular orbits in the disk plane;
younger, more metal rich.



Population II stars: random motion.
Eccentric orbits passing through disk
plane; older, more metal-poor.

@Nick Strobel

Ime	RA	DEC	proper motion [mas/yr]	rad.vel. [km/s]	parallax [mas]
<i>BD Cas</i>	00 09 51.39	+61 30 50.54	-1.1 -0.9	-49.30	2.13
<i>V383 Cyg</i>	20 28 58.15	+34 08 06.36	-1.99 -2.64	-24.4	4.44
<i>V553 Cen</i>	14 46 33.63	-32 10 15.25	5.01 -0.71	-6.00	1.84
<i>DQ And</i>	00 59 34.47	+45 24 24.22	5.16 1.92	-230.91	0.67
<i>TX Del</i>	20 50 12.69	+03 39 08.35	-4.26 -8.18	13.9	0.04
<i>V572 Aql</i>	20 02 32.68	+00 42 50.03	-6.27 -7.96	~	-4.69
SW Tau	04 24 32.97	+04 07 24.05	4.05 -11.17	10.9	2.8
BL Her	18 01 09.22	+19 14 56.68	-2.94 -12.94	18.0	1.27
<i>RT TrA</i>	16 34 30.89	-63 08 00.83	-4.00 -14.25	~	1.26
BF Ser	15 16 28.49	+16 26 39.71	-17.49 -10.53	-175.0	-3.75
<i>UY Eri</i>	03 13 39.13	-10 26 32.40	27.95 -6.55	171	-2.94
<i>KT Com</i>	13 33 50.22	+17 25 30.37	-15.93 -24.76	-13.0	5.50
<i>VY Pyx</i>	08 54 29.63	-23 31 18.57	11.67 29.33	~	5.01

