The catalog of the variable stars from the "Pi of the Sky" data

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Wilga,

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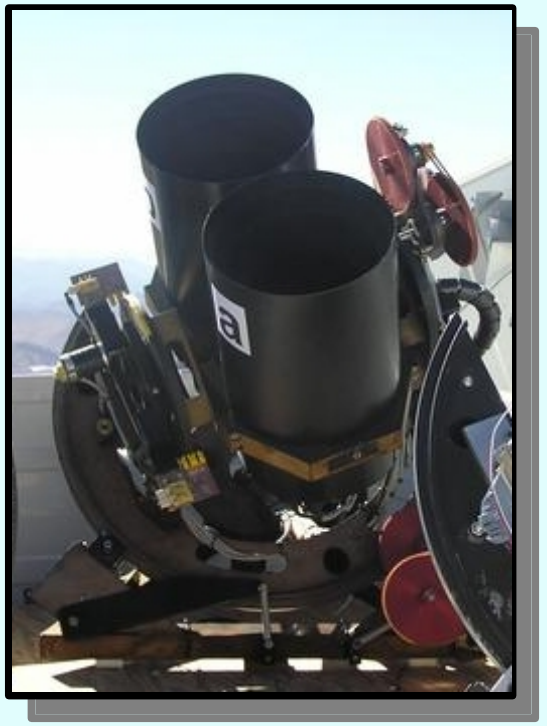
Plan of my talk

1. Basic informations about "the Pi of the Sky" project.
2. Very short introduction to the variable stars subject.
3. Search for variable stars in "Pi of the Sky" data.
4. Determination of the variability type.
5. Summary and future perspective.



Basic informations about "the Pi of the Sky" project

In the first phase of the project, the telescope was equipped with:

1. the 2032 × 2032 CCD camera with 15 × 15 m pixels and 12 e^- readout noise,
2. Carl-Zeiss telephoto lens with f = 50mm and d = f/1.4,
3. camera is mounted on paralactic mount,
4. field of view is large – 33° × 33°,
5. the limiting magnitude for 10 sec exposure is 10–11 mag, and for 200 sec exposure 12–13 mag,
6. we do not use any filter, so during the data reduction procedure instrumental magnitudes are translated to the pseudo V magnitude, based on Tycho-2 catalogue.

Basic informations about variable stars

1. Eclipsing binaries:
   a) Algol type (EA)
   b) beta Lyrae type (EB)
   c) W UMa type (EW)
2. Pulsating stars:
   a) RR Lyrae (RRAB and RRC)
   b) delta Scuti (DSCT)
   c) beta Cephei (BCEP)
   d) delta Cephei (DCEP)
   e) W Virginis (CW)
3. Other types of variability:
   a) Alpha2 Canum Venaticorum (ACV)
   b) Orion variables
      of the T Tauri stars (INT/IT)

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Algol (Beta Persei)-type eclipsing systems. Binaries with spherical or slightly ellipsoidal components. It is possible to specify, for their light curves, the moments of the beginning and end of the eclipses. Between eclipses the light remains almost constant or varies insignificantly because of reflection effects, slight ellipsoidality of components, or physical variations. Secondary minima may be absent. An extremely wide range of periods is observed, from 0.2 to >= 10000 days. Light amplitudes are also quite different and may reach several magnitudes.

taken from http://www.sai.msu.su/groups/cluster/gcvs/gcvs/iii/vartype.txt

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Beta Lyrae-type eclipsing systems. These are eclipsing systems having ellipsoidal components and light curves for which it is impossible to specify the exact times of onset and end of eclipses because of a continuous change of a system's apparent combined brightness between eclipses; secondary minimum is observed in all cases, its depth usually being considerably smaller than that of the primary minimum; periods are mainly longer than 1 day. The components generally belong to early spectral types (B-A). Light amplitudes are usually <2 mag in V.

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W Ursae Majoris-type eclipsing variables. These are eclipsers with periods shorter than 1 days, consisting of ellipsoidal components almost in contact and having light curves for which it is impossible to specify the exact times of onset and end of eclipses. The depths of the primary and secondary minima are almost equal or differ insignificantly. Light amplitudes are usually <0.8 mag in V. The components generally belong to spectral types F-G and later.

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RRAB - RR Lyrae variables with asymmetric light curves (steep ascending branches), periods from 0.3 to 1.2 days, and amplitudes from 0.5 to 2 mag in V.

RRC - RR Lyrae variables with nearly symmetric, sometimes sinusoidal, light curves, periods from 0.2 to 0.5 days, and amplitudes not greater than 0.8 mag in V (SX UMa).

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Variables of the Delta Scuti type. These are pulsating variables of spectral types A0-F5 III-V displaying light amplitudes from 0.003 to 0.9 mag in V (usually several hundredths of a magnitude) and periods from 0.01 to 0.2 days. The shapes of the light curves, periods, and amplitudes usually vary greatly. Radial as well as nonradial pulsations are observed. The variability of some members of this type appears sporadically and sometimes completely ceases, this being a consequence of strong amplitude modulation with the lower value of the amplitude not exceeding 0.001 mag in some cases. The maximum of the surface layer expansion does not lag behind the maximum light for more than 0.1 periods. DSCT stars are representatives of the galactic disk (flat component) and are phenomenologically close to the SX Phe variables.

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Variables of the Beta Cephei type (Beta Cep, Beta CMa), which are pulsating O8-B6 I-V stars with periods of light and radial-velocity variations in the range of 0.1-0.6 days and light amplitudes from 0.01 to 0.3 mag in V. The light curves are similar in shape to average radial velocity curves but lag in phase by a quarter of the period, so that maximum brightness corresponds to maximum contraction, i.e., to minimum stellar radius. The majority of these stars probably show radial pulsations, but some (V649 Per) display nonradial pulsations; multiperiodicity is characteristic of many of these stars.

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These are Delta Cep variables having light amplitudes <0.5 mag in V (<0.7 mag in B) and almost symmetrical light curves (M-m approx. 0.4- 0.5 periods); as a rule, their periods do not exceed 7 days. They are probably first-overtone pulsators and/or are in the first transition across the instability strip after leaving the main sequence (SU Cas).

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Variables of the W Virginis type. These are pulsating variables of the galactic spherical component (old disk) population with periods of approximately 0.8 to 35 days and amplitudes from 0.3 to 1.2 mag in V. They obey a period-luminosity relation different from that for Delta Cep variables (see DCEP). For an equal period value, the W Vir variables are fainter than the Delta Cep stars by 0.7-2 mag. The light curves of W Vir variables for some period intervals differ from those of Delta Cep variables for corresponding periods either by amplitudes or by the presence of humps on their descending branches, sometimes turning into broad flat maxima. W Vir variables are present in globular clusters and at high galactic latitudes.

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Alpha2 Canum Venaticorum variables. These are main-sequence stars with spectral types B8p-A7p and displaying strong magnetic fields. Spectra show abnormally strong lines of Si, Sr, Cr, and rare earths whose intensities vary with rotation. They exhibit magnetic field and brightness changes (periods of 0.5-160 days or more). The amplitudes of the brightness changes are usually withine 0.01-0.1 mag in V.

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Orion variables. Irregular, eruptive variables connected with bright or dark diffuse nebulae or observed in the regions of these nebulae. Some of them may show cyclic light variations caused by axial rotation. In the Spectrum-Luminosity diagram, they are found in the area of the main sequence and subgiants. They are probably young objects that, during the course of further evolution, will become light-constant stars on the zero-age main sequence (ZAMS). The range of brightness variations may reach several magnitudes. In the case of rapid light variations having been observed (up to 1 mag in 1-10 days), the letter "S" is added to the symbol for the type (INS).

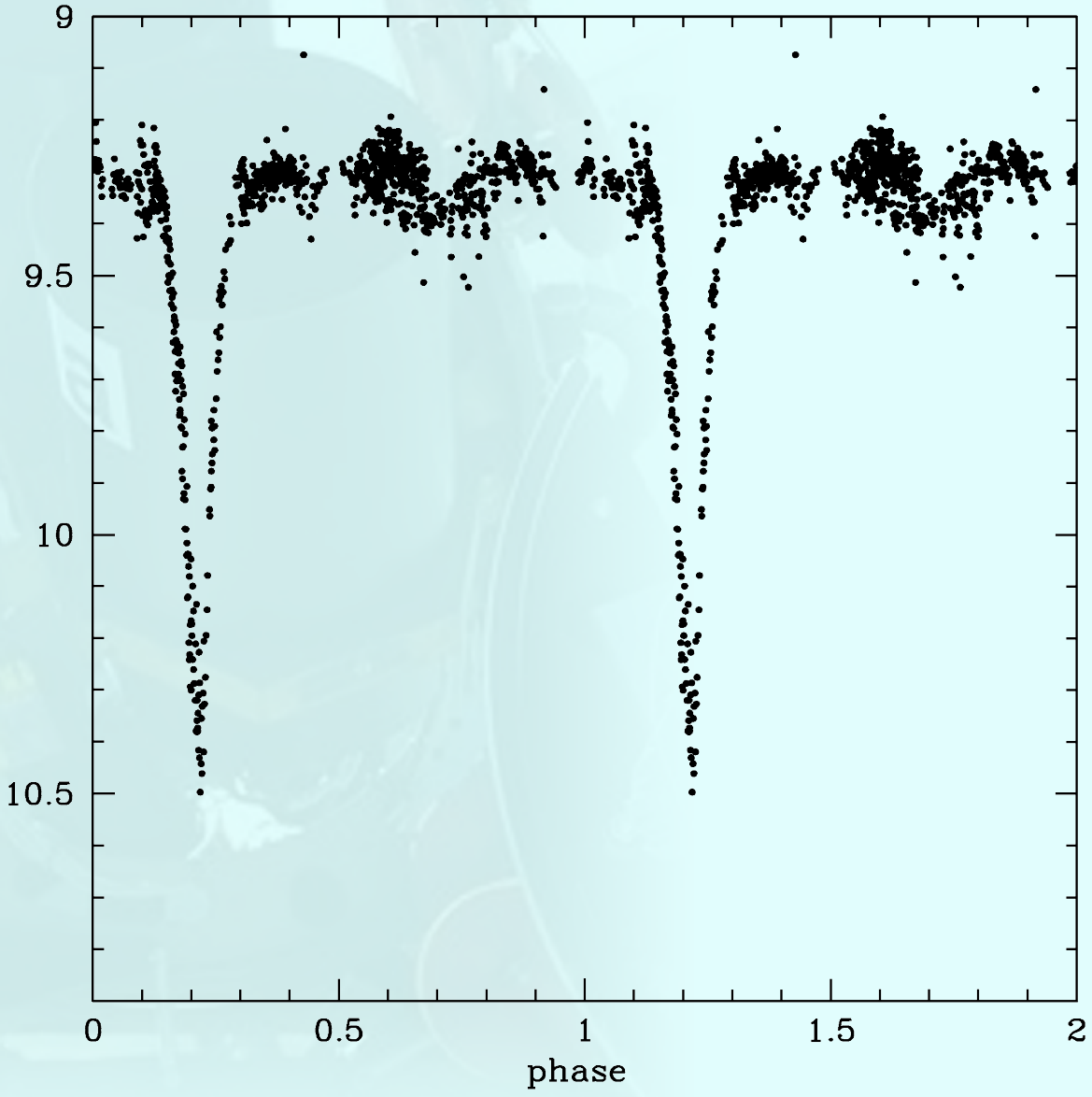
taken from http://www.sai.msu.su/groups/cluster/gcvs/gcvs/iii/vartype.txt

Search for variable stars in "Pi of the Sky" data

1. 92 5201 star was analysed by Marek Biskup and only 1228 was classified as the variable stars.
2. Periods were determined by use the AoV program (Schwarzenberg-Czerny 1989).
3. Stars with statistic value larger than 50 were accepted.
4. The AoV algorithm often find wrong period (2 times larger, or 2/3) so after visual inspection wrong periods were corrected.
5. Finally we classified about 750 stars with different types of variability.

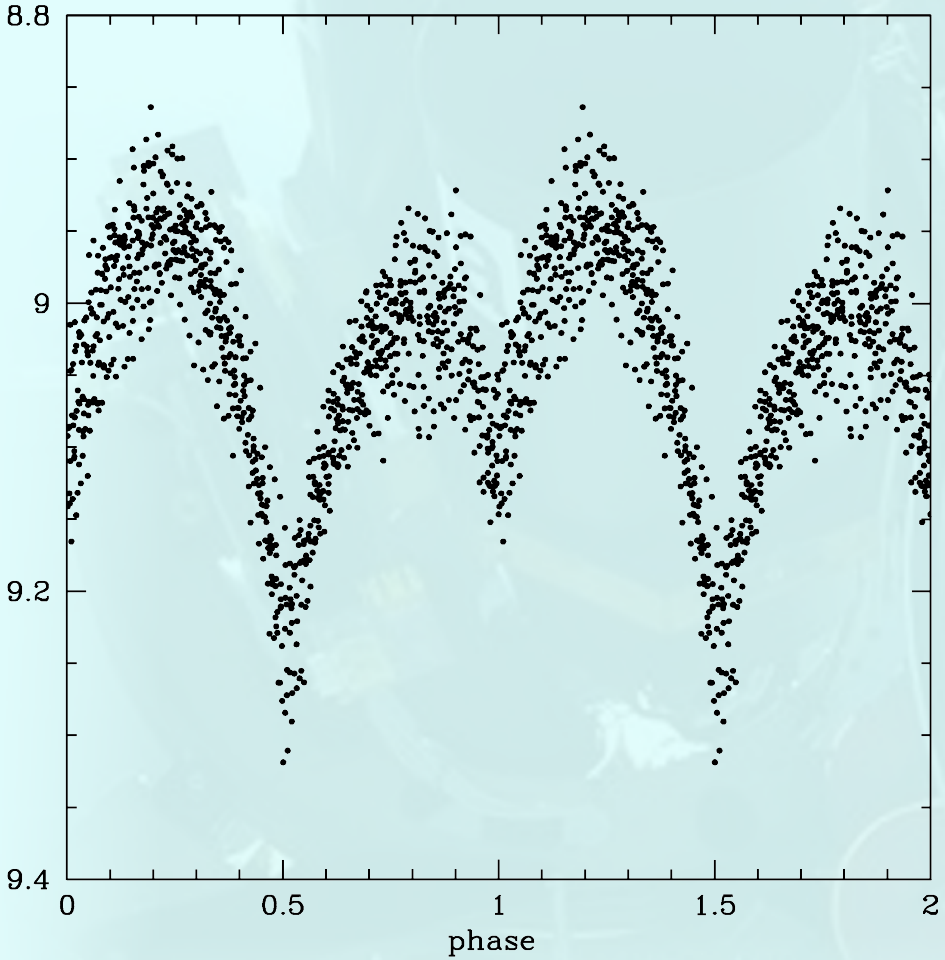
Phased light curves of the eclipsing binaries

YW Cet EA

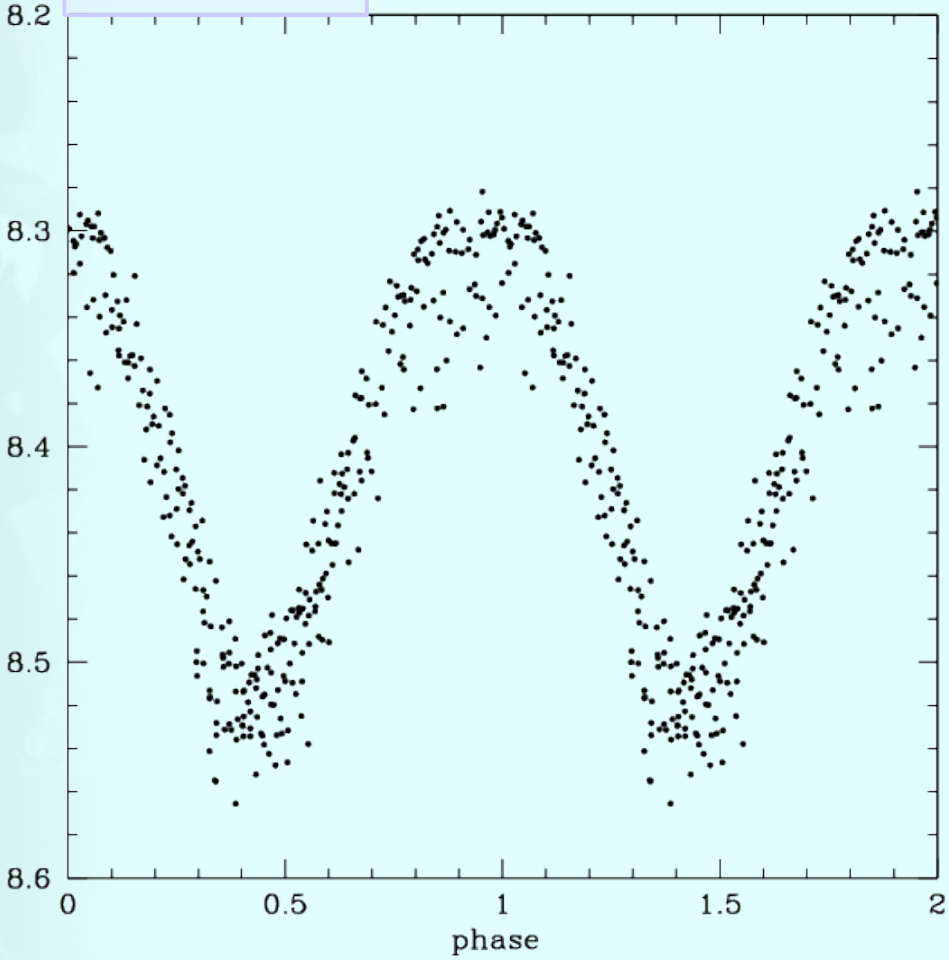


Phased light curves of the eclipsing binaries

QY Hya EB

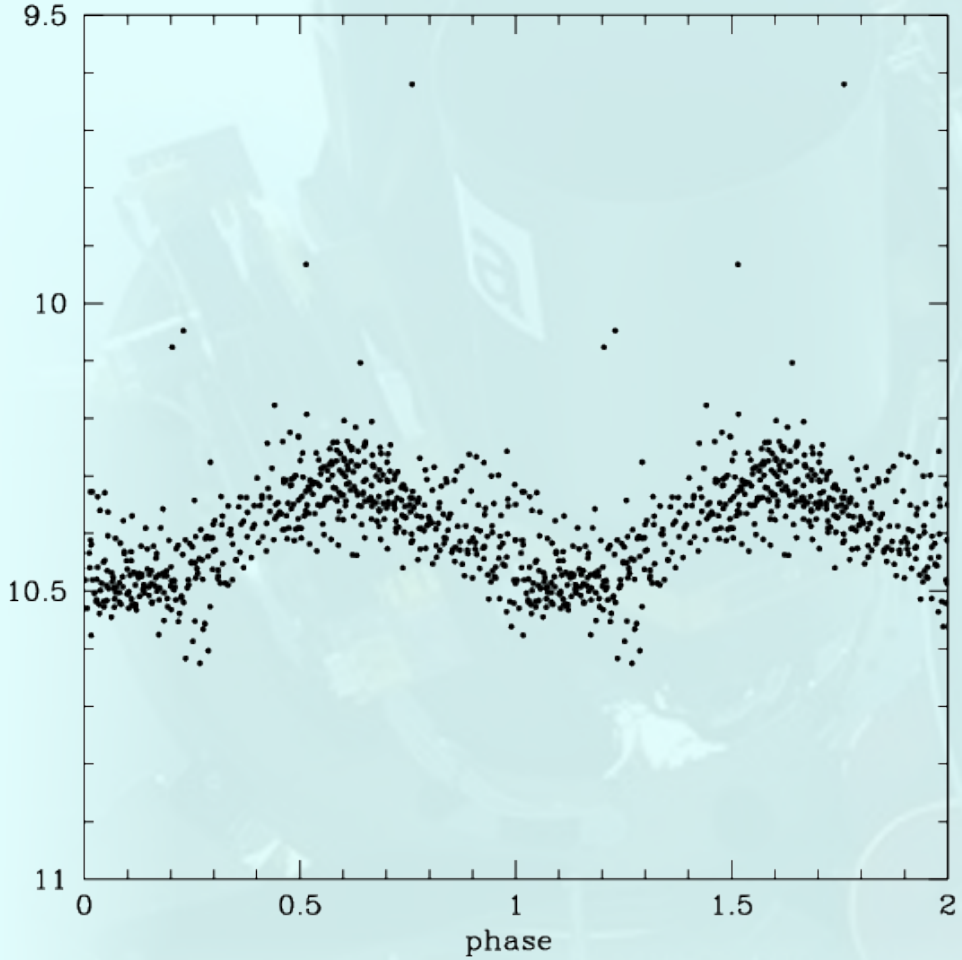


SS Leo
EW

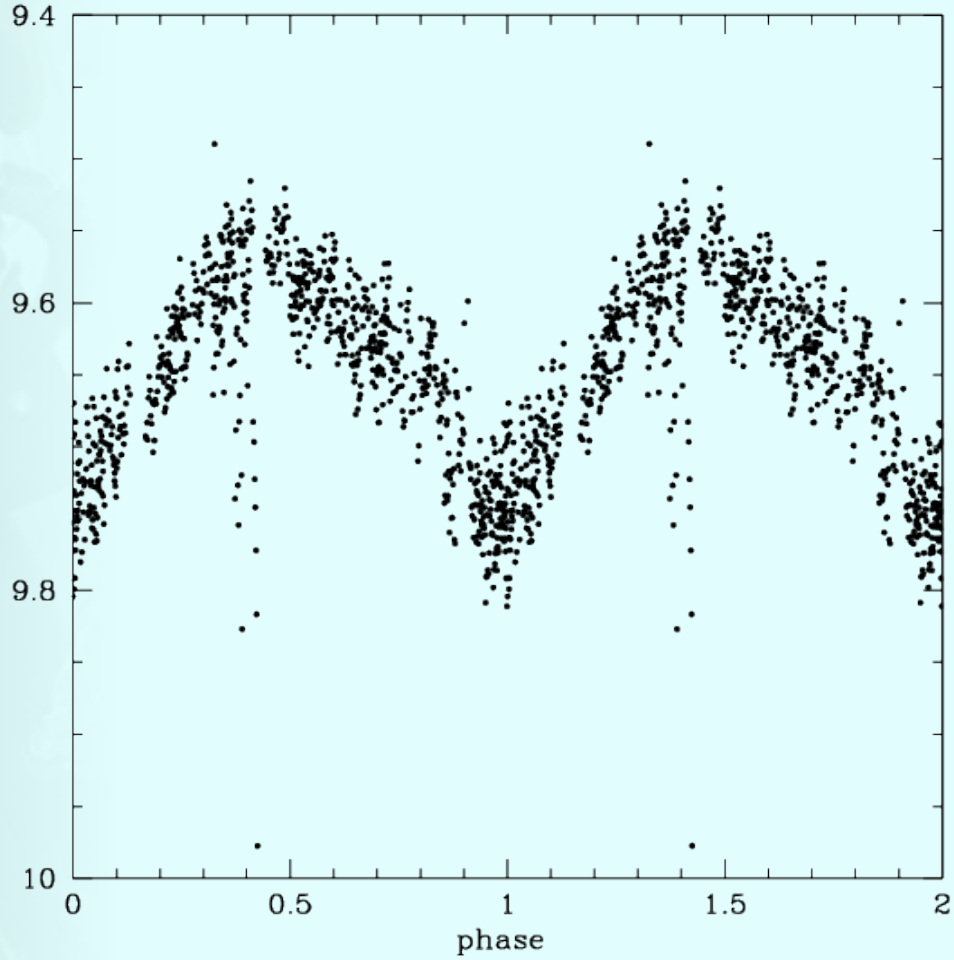


Phased light curves

GSC00790-01124 DSCT

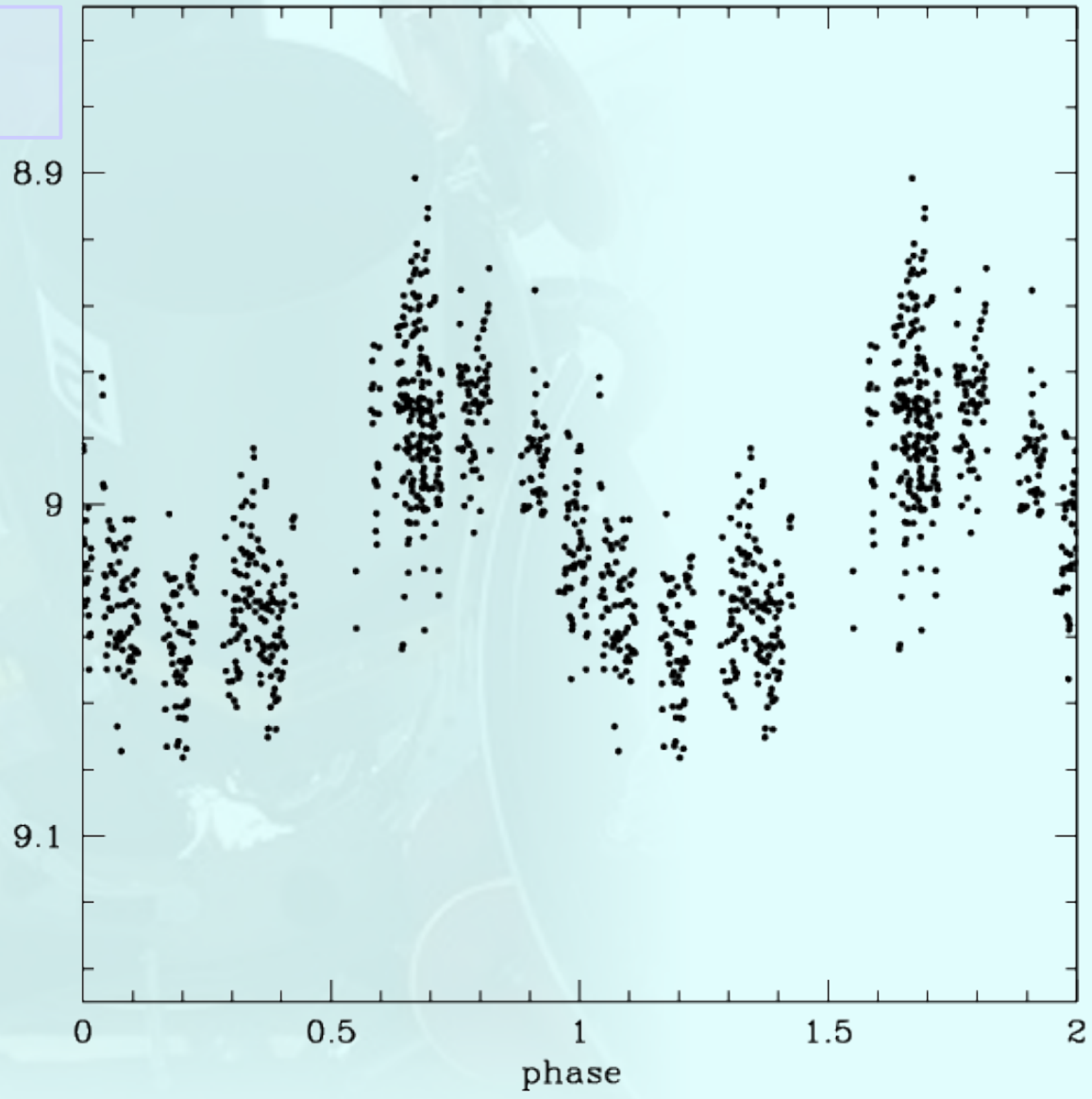


NSV15941 MICS/CW



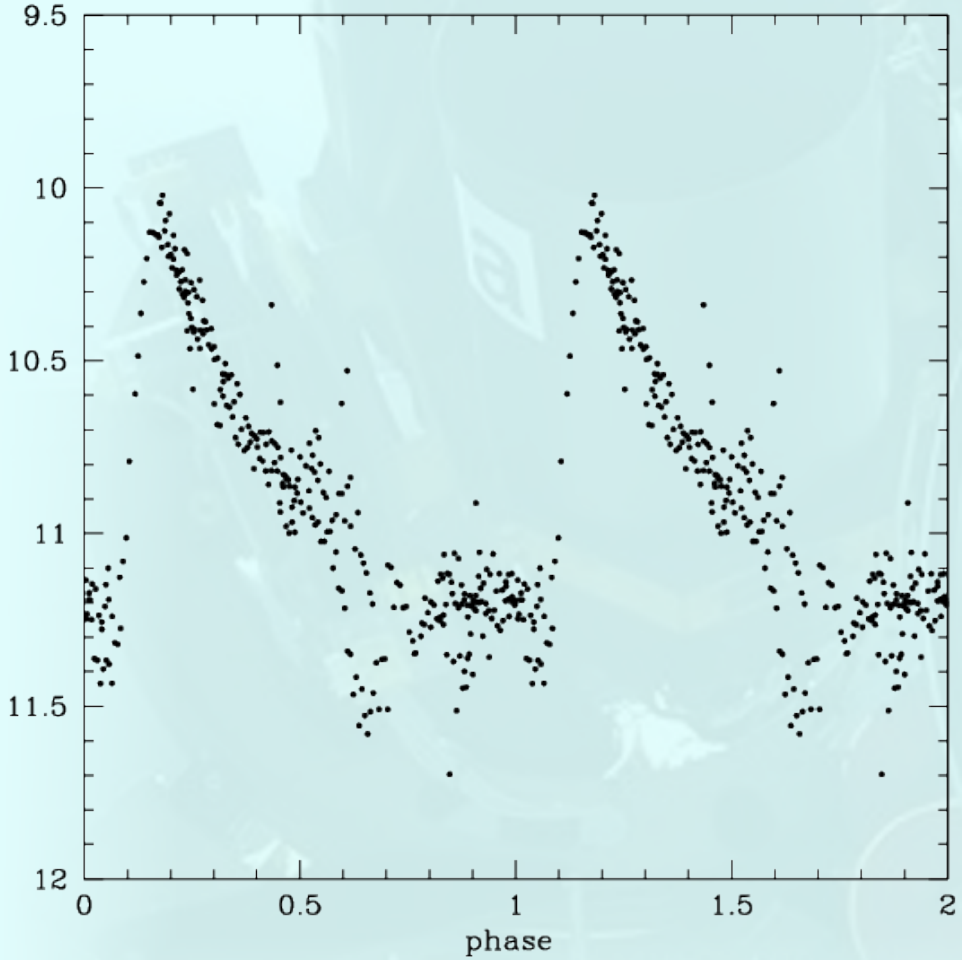
Phased light curves

NSV16849
ACV

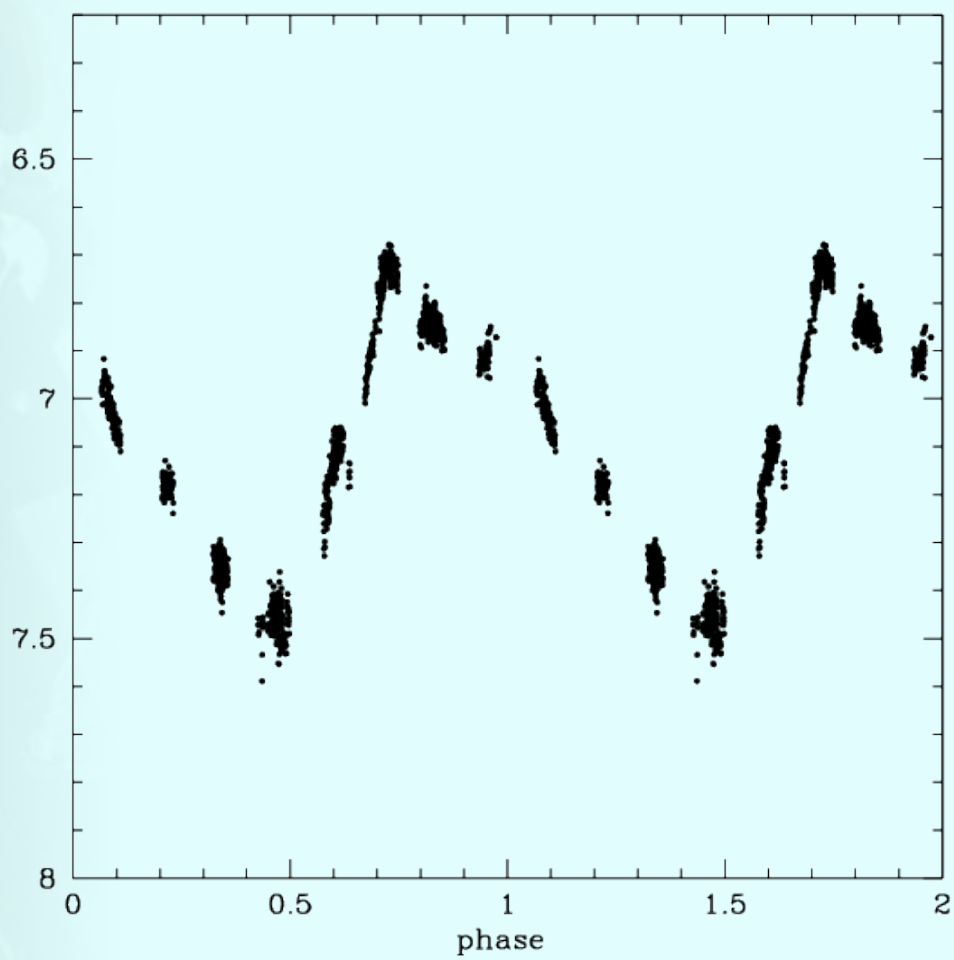


Phased light curves

RR Leo RRAB



W Gem DCEP-FU



Summary

Number of stars each type from the project ”Pi of the Sky”

Type	Number of stars	Type	Number of stars
EA	43	RR	2
EA:	4	RRAB	36
EB	83	RRC	11
EB:	10	RRC/DSCT	3
EW	163	RR/DCEP	1
EW:	50	DCEP	18
EA/EB	40	DCEPS	4
EB/EW	35	BCEP	1
E	10	DSCT	48
E:	26	BCEP/DSCT	1
EW/RR	1	DSCT/BY	1
EW/RRC	5	CW	5
EW/DSCT	12	ACV	3
INT/IT	1	CW/DCEP	1
EW/DSCT/RRC	1	var	73
var:	33		

The End