THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS

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1911

The Z CamPaign: Past, Present and Future

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AAVSO
September 2016

What Are Z Cams?

A sub-set of dwarf novae.

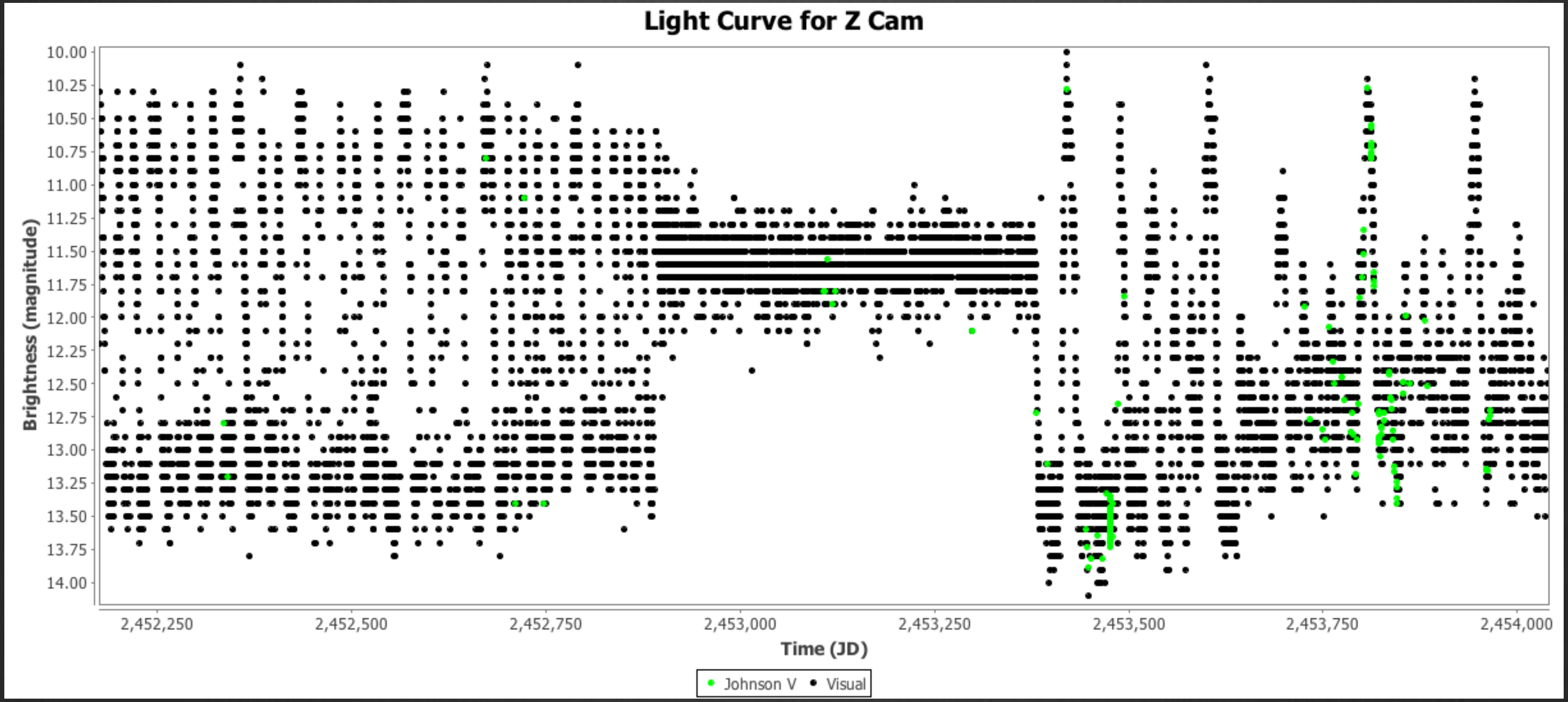
The modern day definition in the *General Catalogue of Variable Stars* stresses the importance of standstills as the determining characteristic of Z Cams.

"Z Camelopardalis type stars. These also show cyclic outbursts, differing from UGSS variables by the fact that sometimes after an outburst they do not return to the original brightness, but during several cycles retain a magnitude between maximum and minimum. The values of cycles are from 10 to 40 days, while light amplitudes are from 2 to 5 magnitudes in V."

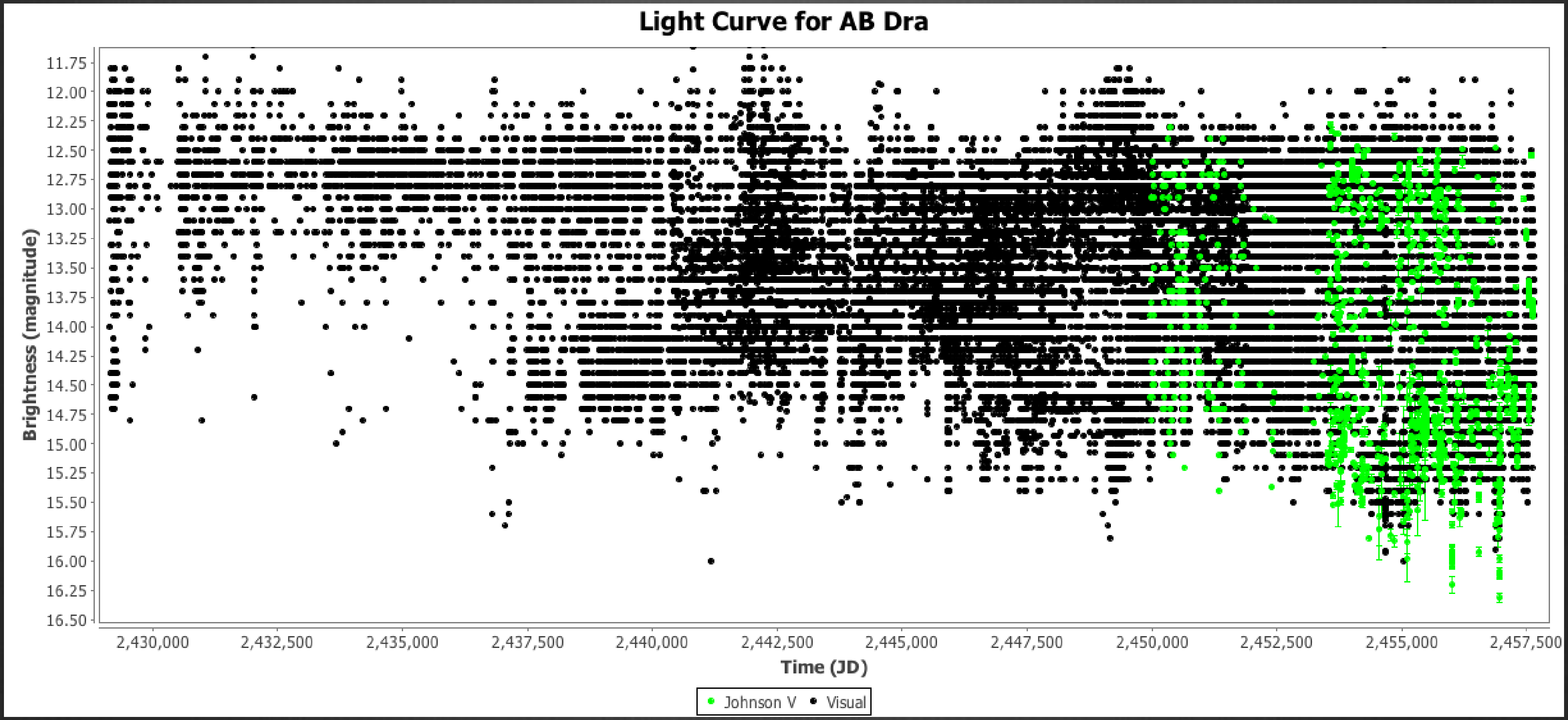
It's all about the standstills

Cyclic outbursts (10 - 40 days, 2 – 5 magnitudes in V).

Standstills- A standstill usually starts at the end of an outburst and consists of a period of relatively constant brightness 1 to 1.5 magnitudes below maximum light that may last from a few days to 1,000 days.



Inspiration



- AB Draconis- Listed in every major catalog as a Z Cam.
- Yet, in all the AAVSO data, 1938 to present, there is no evidence of a standstill.

Further Confusion

Name	GCVS	Downes	Ritter
HL CMa	UGSS+XM	ug/ugz	DN/ZC
WW Cet	UG	ugz:	DN/IP?
AM Cas	UGSS	ugz	DN/ZC
FS Aur	UGZ:	ug	CV/DN
V426 Oph	NL	ugz/dq:	CV/DN/IP?/ZC

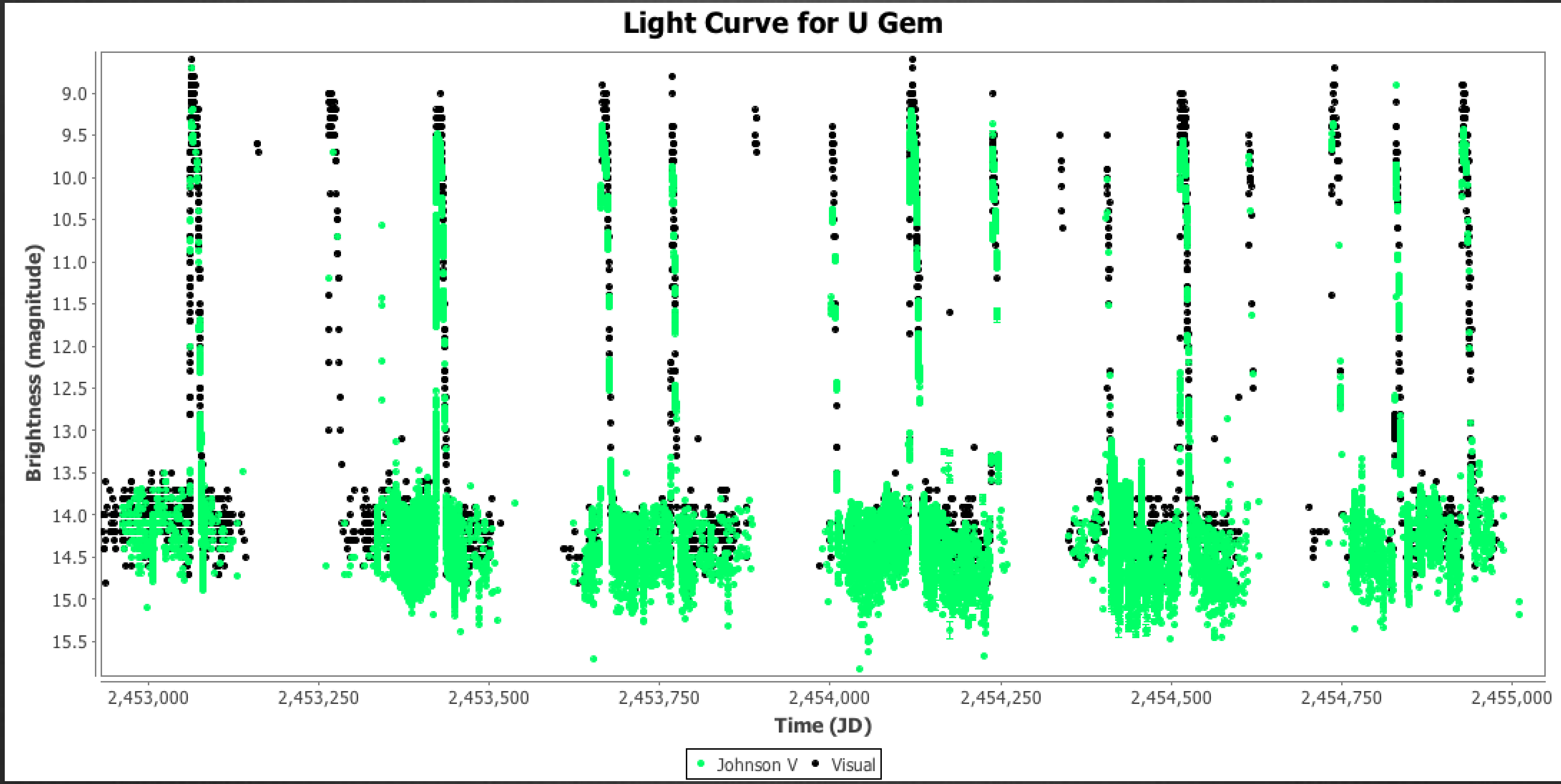
History

The English astronomer, J. R. Hind, discovered U Gem on December 15, 1855.

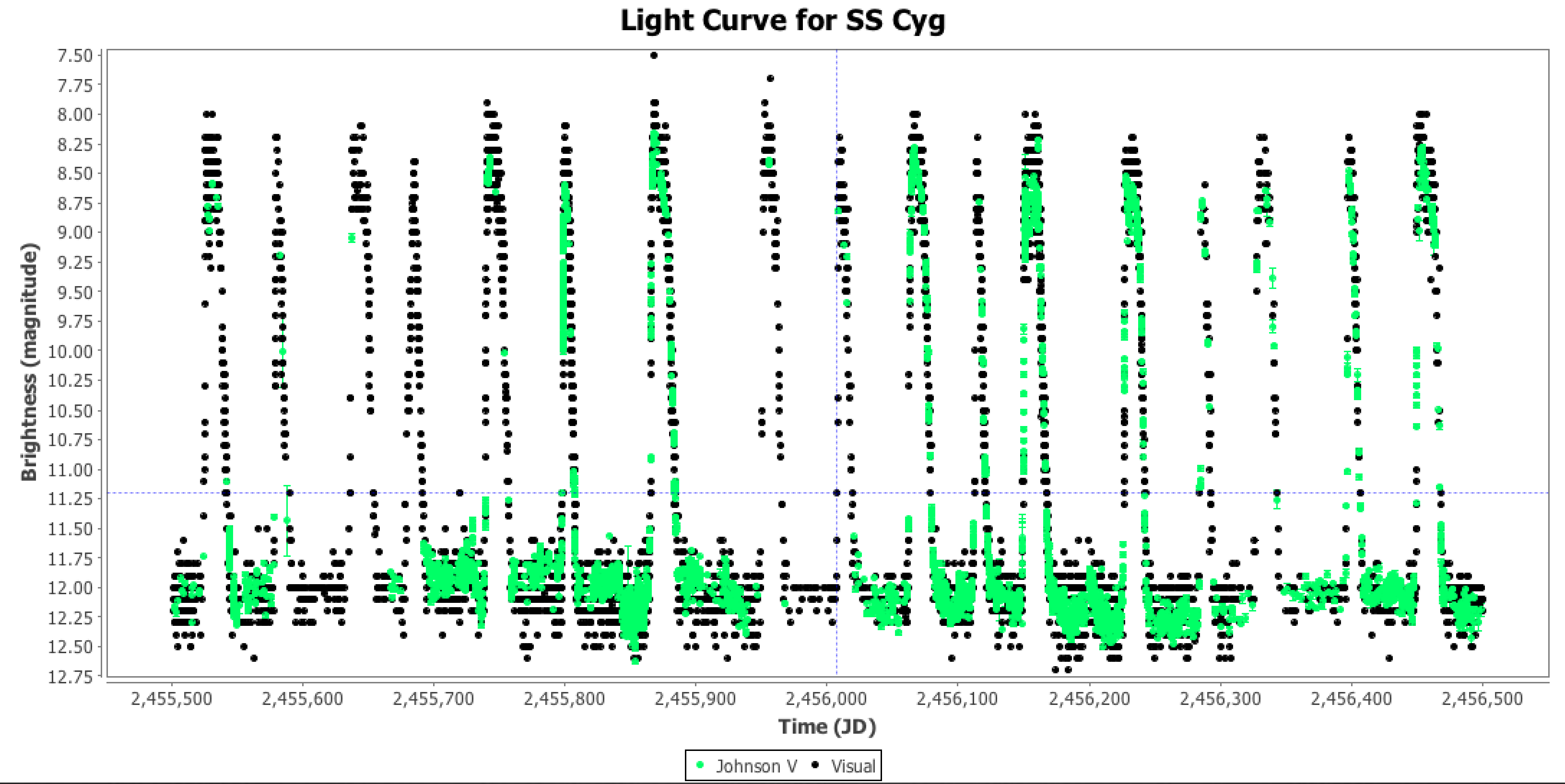
In 1896, Miss Louisa D. Wells discovered SS Cyg on plates taken at the Harvard College Observatory

The classification of U Gem stars was introduced, based on light curves of stars that stayed at minimum for the majority of the time, but at intervals between 40 and 100 days they erupted by 3-5 magnitudes

U Gem outburst cycles



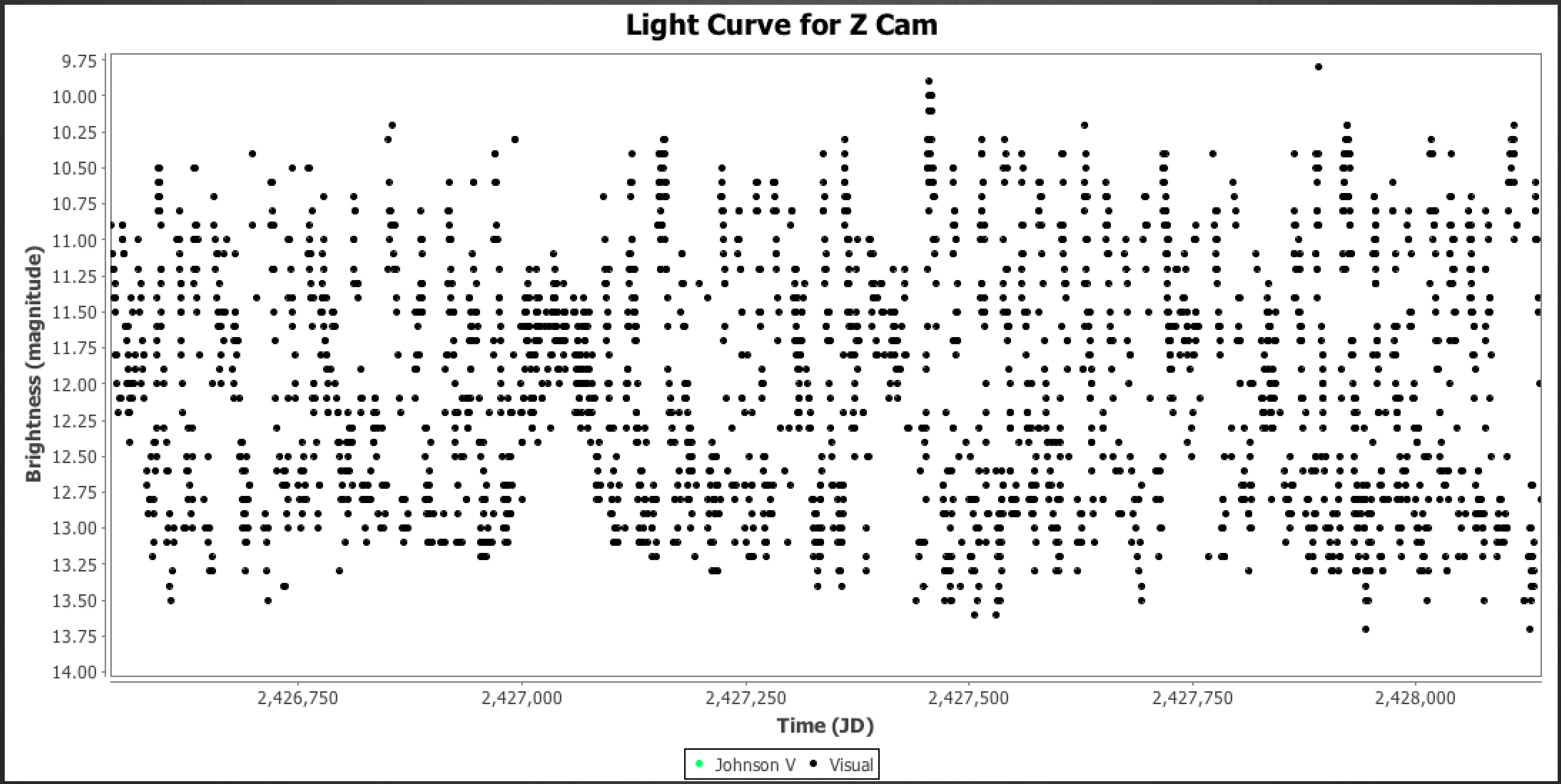
SS Cygni outburst cycles



Early Z Cam definition

- Two stars, Z Cam and RX And, discovered in 1904 and 1905 respectively, were initially classified as UG.
- Years of observation revealed these two stars to have much shorter periods (at that time, defined as the time between maxima) and they spent very little time at minimum.
- A. A. Nijland proposed a new class of variable stars, the Z Cam type (1930).
- Director of the British Astronomical Association Variable Star Section, Felix De Roy, in a 1932 paper, *A New Variable Star Class, The Z Camelopardalis Type*, described the state of knowledge of these stars to date

Z Cam visual obs 1930s



Original definition

- The short duration of minimum.
- The irregularity of the light curve, described as rare for U Gem types and almost the norm for Z Cams.
- The lesser amplitudes of variation compared to U Gems, 2.64 magnitudes for Z Cams versus 3.8 magnitudes for U Gems.
- A "curious and very special feature" where the variable remains nearly constant at a magnitude in between the maximum and minimum.

The standstill factor

Campbell and Jacchia note in *The Story of Variable Stars* (1941), "from time to time they take a sort of vacation, and remain at almost constant brightness."

Elvey and Babcock (1943) "Whenever they go through their regular variations, they behave similarly to the short period group of SS Cygni stars. However, these stars may remain for weeks at relatively constant brightness, approximately one-third from maximum to minimum brightness."

The Variable Star Observers Handbook (Glasby 1971) "The major difference, and that which justifies their inclusion in a separate group, is the periods of standstill."

Modern Definition

- “Z Camelopardalis type stars. These also show cyclic outbursts, differing from UGSS variables by the fact that sometimes after an outburst they do not return to the original brightness, but during several cycles retain a magnitude between maximum and minimum. The values of cycles are from 10 to 40 days, while light amplitudes are from 2 to 5 magnitudes in V.”
- So, Z Cam systems can be classified by their light curves alone.
- **If they don’t exhibit standstills, they are not Z Cams.**

The Z CamPaign Objectives

1. To determine convincingly which CVs are indeed UGZ and which are imposters.

2. To improve the overall data available on each of these stars and fill the gaps in the light curves.

3. To determine if some UGZ actually do go into outburst from standstill, or if perhaps we have just missed the sudden drop to quiescence before the next outburst, leading to the appearance of outburst from standstill behavior.

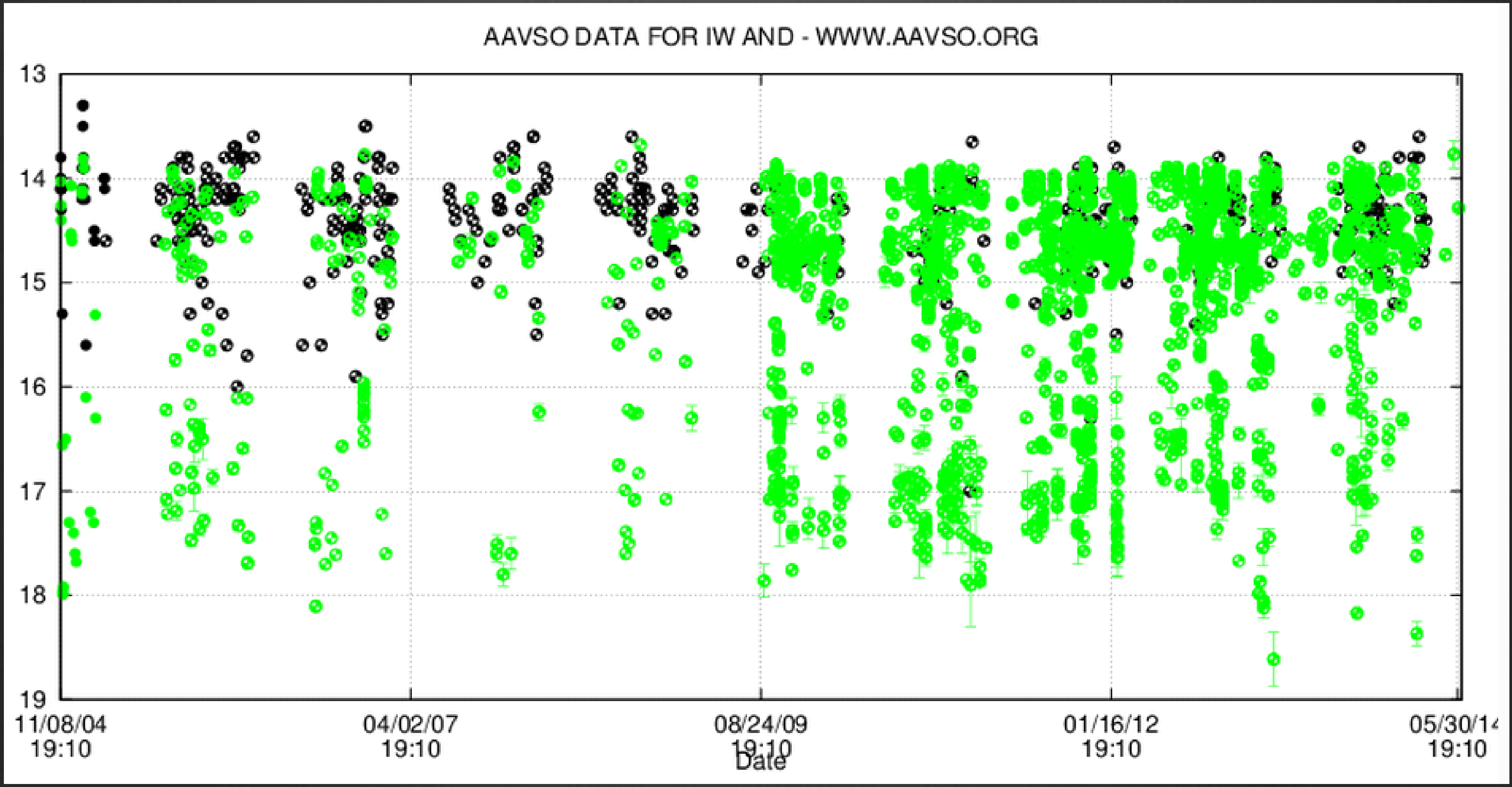
4. To make any other serendipitous discoveries about 'UGZ-ness' that come to light as a result of improved coverage.

5. To publish the results in peer-reviewed journals, such as the Journal of the AAVSO.

Early Results

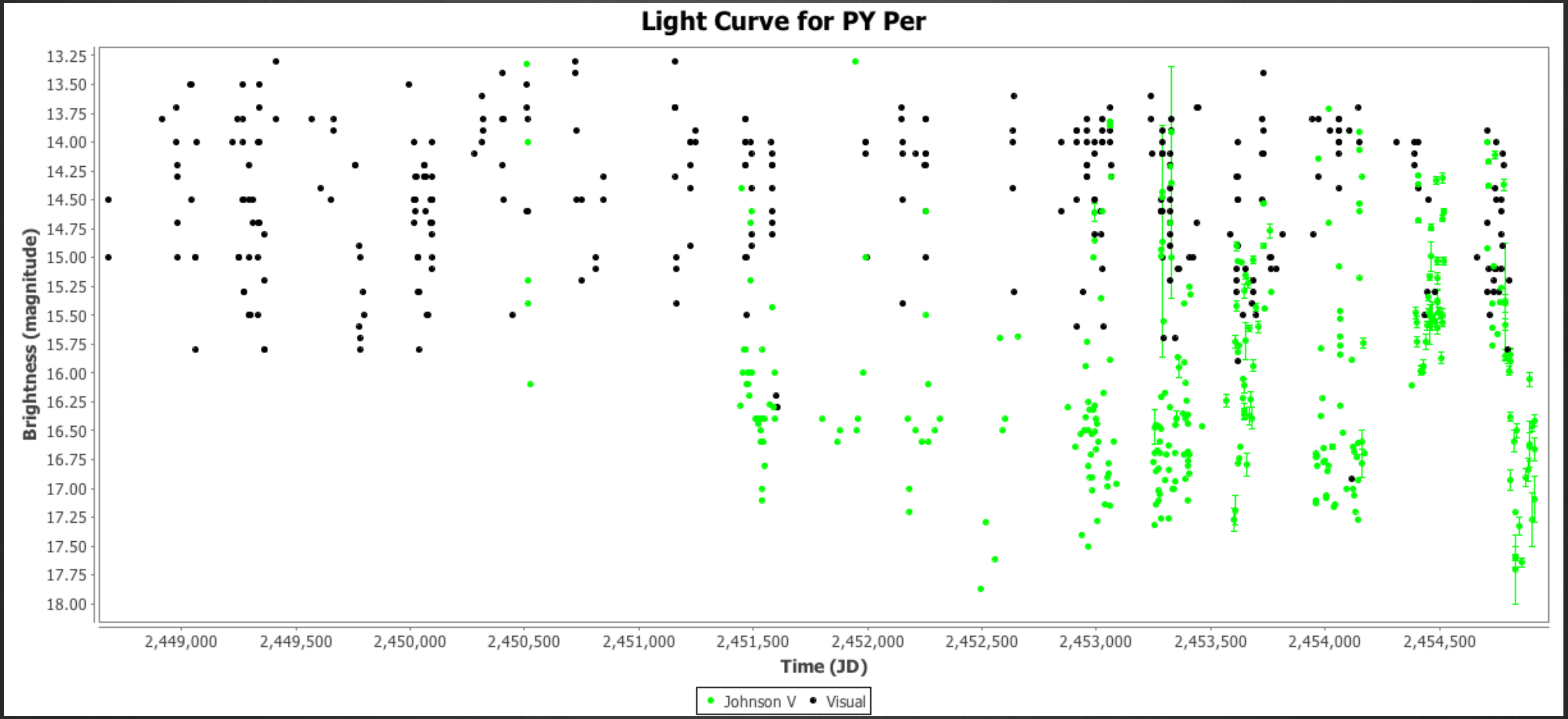
- In 2014, after four and a half years of Z CamPaign observations and analysis, and an exhaustive examination of the AAVSO International Database…
- 22 bona fide Z Cam type systems had been identified, out of the 65 stars listed in the literature at one time or another as Z Cam stars.
- 24 were eliminated from the list, leaving 19 stars that required further investigation.

Better Data

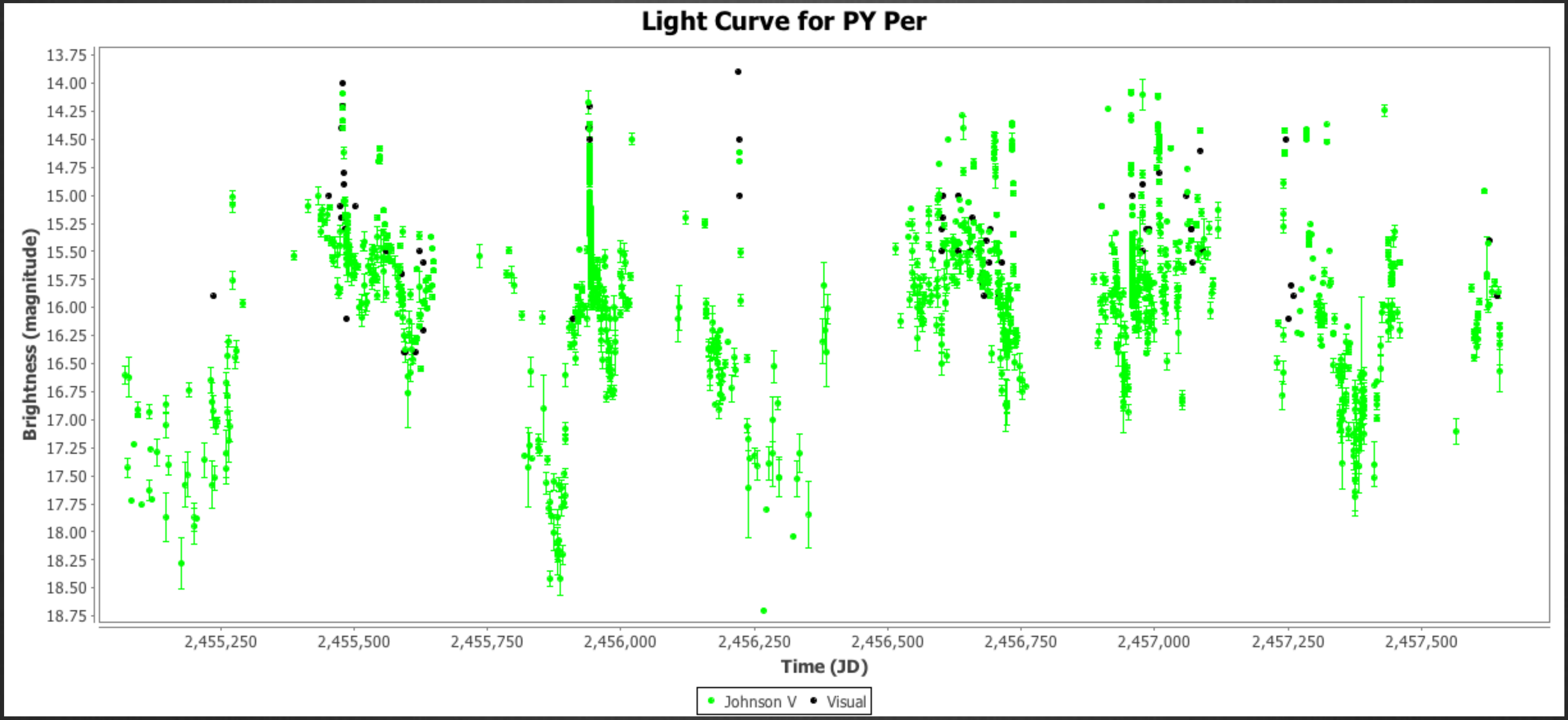


AAVSO DATA FOR IW AND - WWW.AAVSO.ORG
13
14
15
16
17
18
19
11/08/04 19:10
04/02/07 19:10
08/24/09 19:10
01/16/12 19:10
05/30/14 19:10
Date

PY Per Before



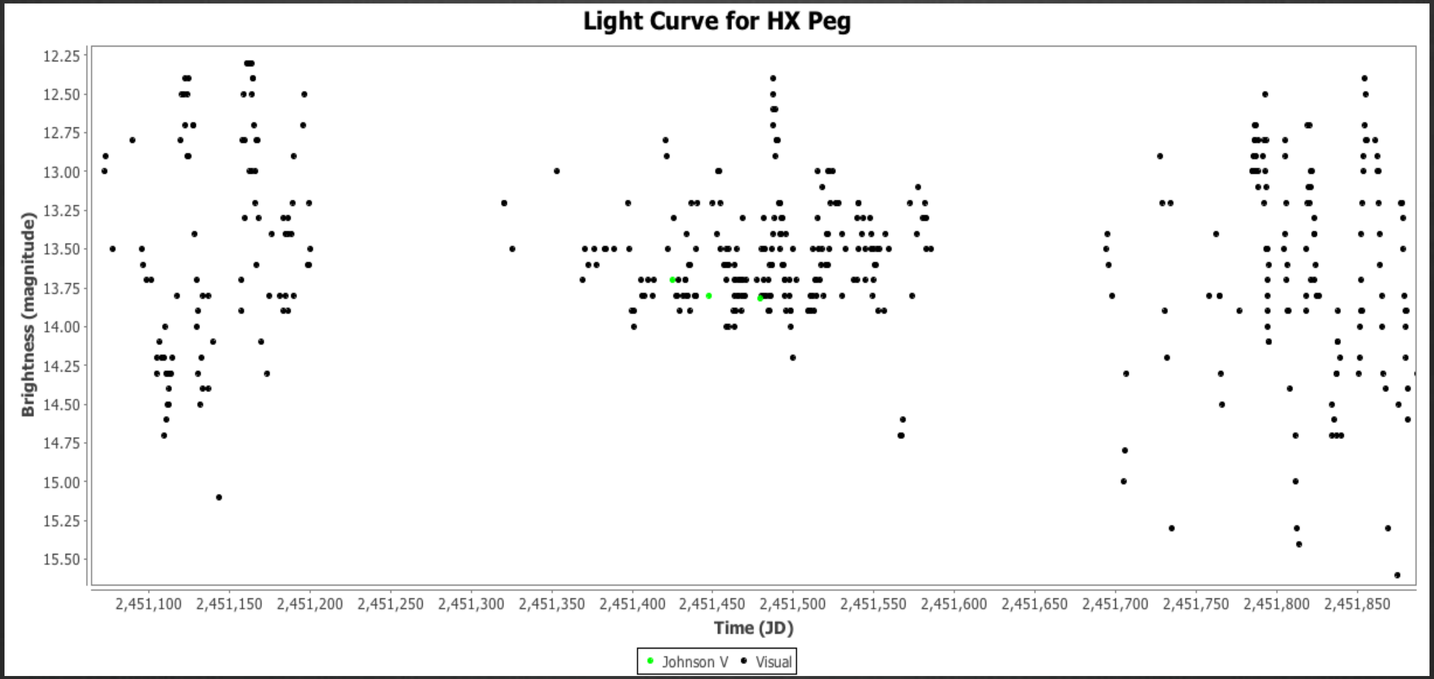
PY Per After



Light Curve for PY Per
Brightness (magnitude)
13.75
14.00
14.25
14.50
14.75
15.00
15.25
15.50
15.75
16.00
16.25
16.50
16.75
17.00
17.25
17.50
17.75
18.00
18.25
18.50
18.75
2,455,250
2,455,500
2,455,750
2,456,000
2,456,250
2,456,500
2,456,750
2,457,000
2,457,250
2,457,500
Time (JD)
Johnson V
Visual

Outbursts from Standstills?

- YES!
- More common than we thought.
- There are <u>nine</u> Z Cam stars that have been shown to go into outburst from standstill: Z Cam, HX Peg, AH Her, HL CMa, UZ Ser, AT Cnc, Leo5, V513 Cas and IW And.

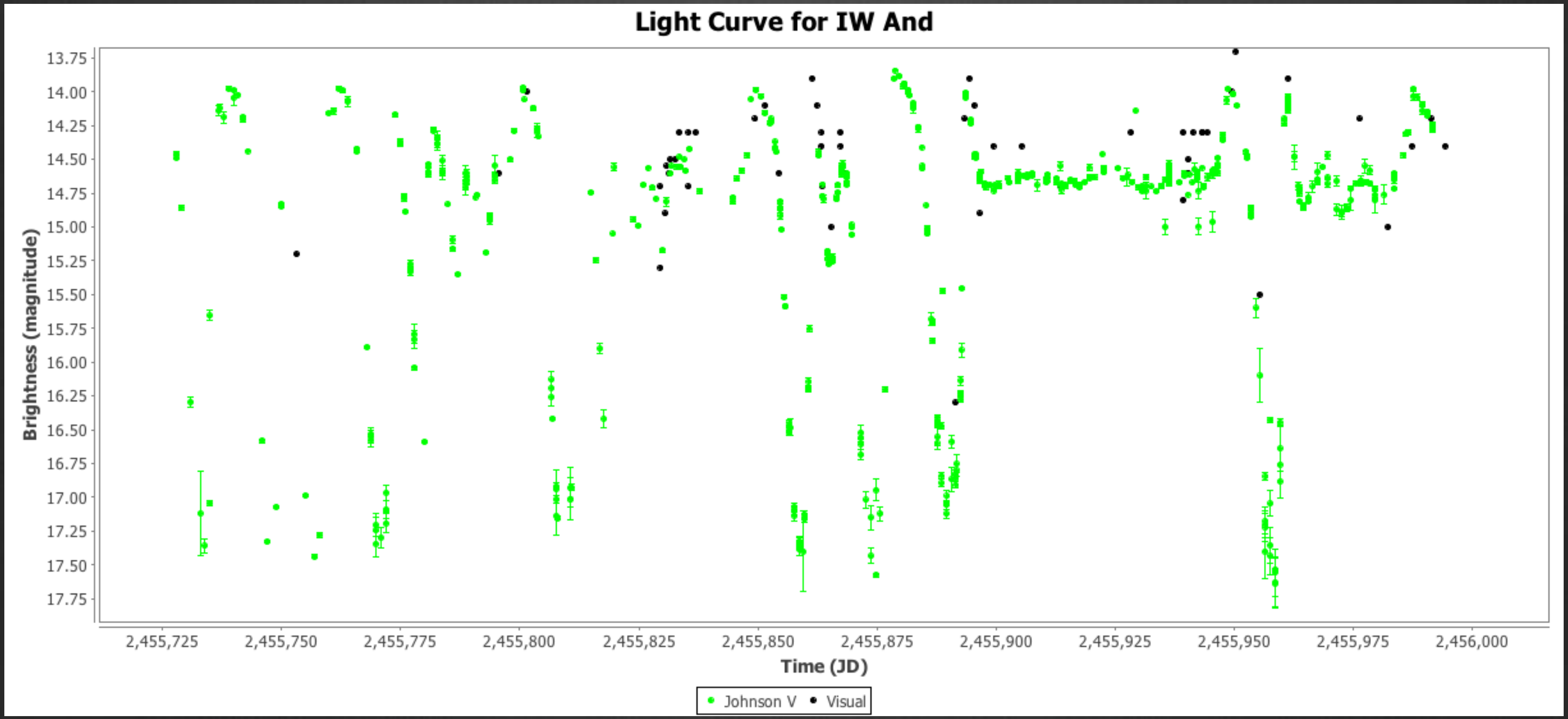


An Inconvenient Truth

If it is true that the accretion disk has been drained in the plateau phase just before a standstill (as put forth in Oppenheimer, Kenyon and Mattei, 1998), then what is the underlying cause of outbursts that occur immediately after standstills?

Serendipity

- We uncovered a new class of variable stars – the *"Anomalous Z Cams"*
- IW And, V513 Cas, ST Cha and recently, UY Pup.



Publications

- Z CamPaign- Simonsen, M., 2011, JAVSO, 39, 66
- The First Historical Standstill of WW Ceti - Simonsen, M. Stubbings, R., 2011, JAVSO, 39, 73
- Leo5 is a Z Cam Type Dwarf Nova - Wils, P.; Krajci, T.; Simonsen, M., 2011, JAVSO, 39, 77
- A Study of the Unusual Z Cam Systems IW Andromedae and V513 Cassiopeia– Szkody, P., Howell S., Simonsen, M. 2013, PASP..125.1421S
- Z Cams in the 21st Century – Simonsen et al, 2014, JAVSO, 42, 177S
- ST Chamaeleontis and BP Coronae Australis- Simonsen, M., Bohlsen, T., Hambsch, J., Stubbings, R. 2014, JAVSO, 42, 199S
- OQ Carinae: A New Southern Z Cam Type Dwarf Nova- Stubbings, R., Simonsen, M., 2014, JAVSO, 42, 204S

New Results

- UY Puppis- A New Anomalous Z Cam Type Dwarf Nova
  Stubbings, R., Simonsen, M., submitted JAAVSO, August 2016
- 1RXS J062954.6-033520 is a Z Cam Type Dwarf Nova
  Simonsen, M., Hambsch, J., (in preparation)
- The Nature of Z Cam Standstills
  Simonsen, M., (in preparation)
- There are now 24 confirmed Z Cam systems and 15 suspect systems

An Online Catalog

The Z Cam List

Contents

The List
Z Cam List Home Page
Z CamPaign Papers
Why Observe Z Cam Stars?
OQ Car- The Discovery Story

The List

A website summarizing our Z Cam research, that will also act as a living catalog of bona fide Z Cam stars, suspected Z Cams and Z Cam impostors.

This website and the Z Cam List created and maintained by Mike Simonsen.

Updated March 10, 2014

BONA FIDE Z CAMS

Dwarf novae that exhibit standstills in their light curves.

* Outbursts from standstill have been observed.

Click on the star names for more information.

Name	RA (2000)	Dec (2000)	Max	Min	Type
WW Cet	00 11 24.78	-11 28 43.1	10.4V	15.8V	UGZ
V513 Cas	00 18 14.91	66 18 13.6	14.9V	18.9V	UGZ*
IW And	01 01 08.91	43 23 25.7	13.8V	17.7V	UGZ*
RX And	01 04 35.54	41 17 57.8	10.2V	15.1V	UGZ
AY Psc	01 36 55.45	07 16 29.3	15.3V	17.0V	UGZ+E

SUSPECTED Z CAMS

Stars requiring further observation to determine their type.

1RXS J015017.0+375614	01 50 16.19	37 56 19.0	14.2C	19.1C	UGZ:
HS 0139+0559	01 41 39.93	06 14 37.5	14.2v	15.7V	NL:
HS 0229+8016	02 35 58.20	80 29 44.2	13.7v	15.1V	NL:
V392 Per	04 43 21.39	47 21 25.8	14.2V	16.8V	UG:
PY Per	02 50 00.15	37 39 22.2	13.8V	19.5V	UGZ
HS 0642+5049	06 46 19.60	50 45 49.3	14.7v	16.1V	NL
WZ CMa	07 18 49.20	–27 06 43.2	14.5p	18.3p	UGSS:
V426 Oph	18 07 51.69	05 51 47.9	11.5V	13.5V	UGZ:/DQ:
HS 1857+7127	18 57 20.36	71 31 18.8	13.9v	17.2V	UGSS+E:
V868 Cyg	19 29 04.50	28 54 26.0	14.3p	<17.8p	UGZ:
V1505 Cyg	19 29 49.00	28 32 54.0	15.2p	<17.5p	UGZ:

Z CAM IMPOSTORS

Stars listed in the literature at one time or another as Z Cams or suspected Z Cams that are not Z Cams.

TW Tri	01 36 37.01	32 00 39.9	13.3p	17.0p	UGSS
KT Per	01 37 08.78	50 57 20.3	10.6V	16.1V	UGSS+ZZ
AM Cas	02 26 23.38	71 18 31.5	12.3p	15.2p	UGSS
V368 Per	02 47 32.70	34 58 27.4	15.2CR	21.0CR	UGSU
FO Per	04 08 34.98	51 14 48.2	11.8V	16V	UGSS
AQ Eri	05 06 13.12	–04 08 07.3	12.5p	16.5p	UGSU
BI Ori	05 23 51.77	01 00 30.6	13.2p	16.7p	UGSS
FS Aur	05 47 48.36	28 35 11.1	14.4p	16.2p	UGSU:
CN Ori	05 52 07.79	–05 25 00.5	11.9v	16.3v	UGSS
V344 Ori	06 15 18.95	15 30 59.3	14.2p	17.5:p	UG
SV CMi	07 31 08.40	05 58 48.4	13.0p	16.9V	UGSS

WW Cet

List Status: UGZ

Alternate Names: 1RXS J001124.6-112843

Coordinates (2000): 00 11 24.77 -11 28 43.2

Range: 10.5- 16.0V

Type: UGZ

Orbital Period: 0.17578 days (4.22 hrs)

Outburst Cycle: 31.2 days

Primary Mass: 1.05 solar

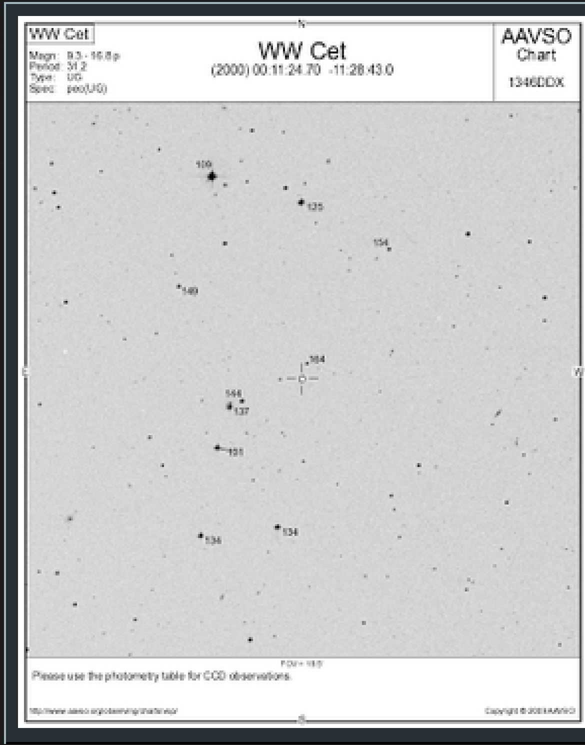
Secondary Mass: 0.393 solar

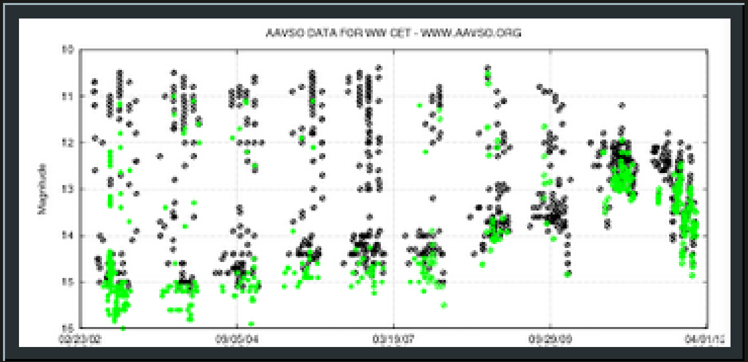
Orbital Inclination: 48 deg +/-11

Eclipses: No

Comments:

Revised: February 1, 2014





Ten year light curve showing the 2010–2011 standstill.

References:

2012ApJS..199....7F

Astrophys. J., Suppl. Ser., 199, 7 (2012)

A survey of Far Ultraviolet Spectroscopic Explorer observations of cataclysmic variables.

FRONING C.S., LONG K.S., GANSICKE B. and SZKODY P.

2012ApJS..203...29G

Astrophys. J., Suppl. Ser., 203, 29 (2012)

An online catalog of cataclysmic variable spectra from the Far-Ultraviolet Spectroscopic Explorer.

GODON P., SION E.M., LEVAY K., LINNELL A.P., SZKODY P., BARRETT P.E., HUBENY I. and BLAIR W.P.

2012MNRAS.419.1442P

Mon. Not. R. Astron. Soc., 419, 1442-1454 (2012)

The space density and X-ray luminosity function of non-magnetic cataclysmic variables.

PRETORIUS M.L. and KNIGGE C.

2012MmSAI..83..539S

Mem. Soc. Astron. Ital., 83, 539-548 (2012)

White dwarfs in cataclysmic variable stars: accretion physics and evolution.

Continuing the CamPaign

- Continued long-term, nightly monitoring of the bona fide Z Cams is highly encouraged. We have only begun to examine the unpredictable and fascinating nature of these cataclysmic variables in greater detail.
- Of the remaining 15 suspects, most are very likely to be NL or UGSS, but they cannot be ruled out with the existing data.

Questions

- What causes standstills?
- What proportion of Z Cams go back into outburst from standstill, and how is that even possible?
- Do star spots play a role in bringing standstills to an end?
- Is it the ugly red dwarves wreaking havoc in these systems?

Spots, flares and winds, oh my…

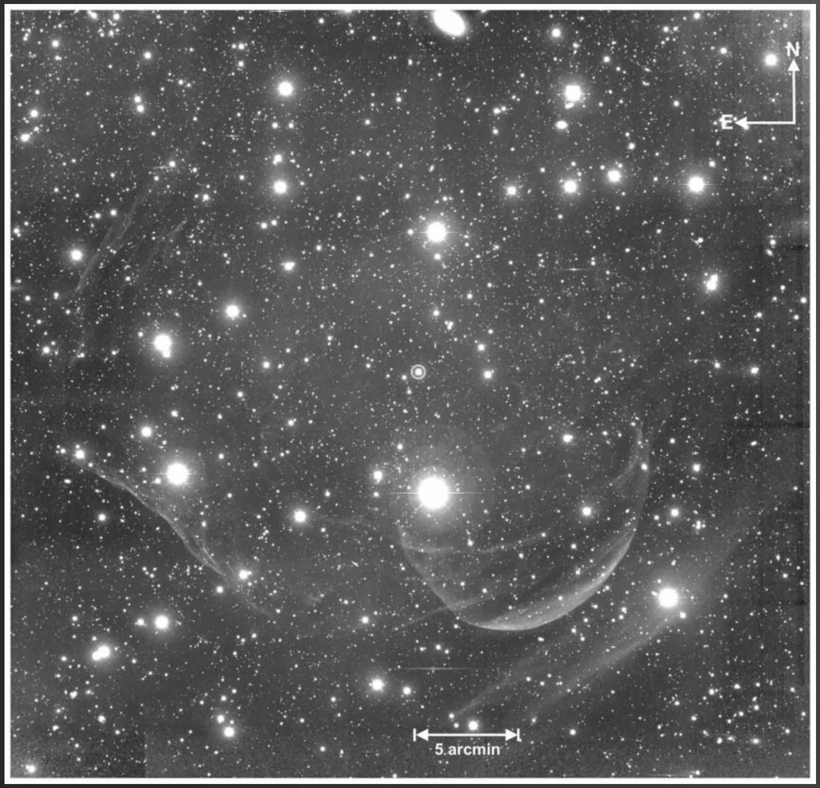
NASA's Hubble Telescope has revealed red dwarf stars that produce flares equivalent to more than 100 million atomic bombs, blasting any orbiting planets with X-rays, ultraviolet light and a stellar wind.

What might this do to an accretion stream?

More questions

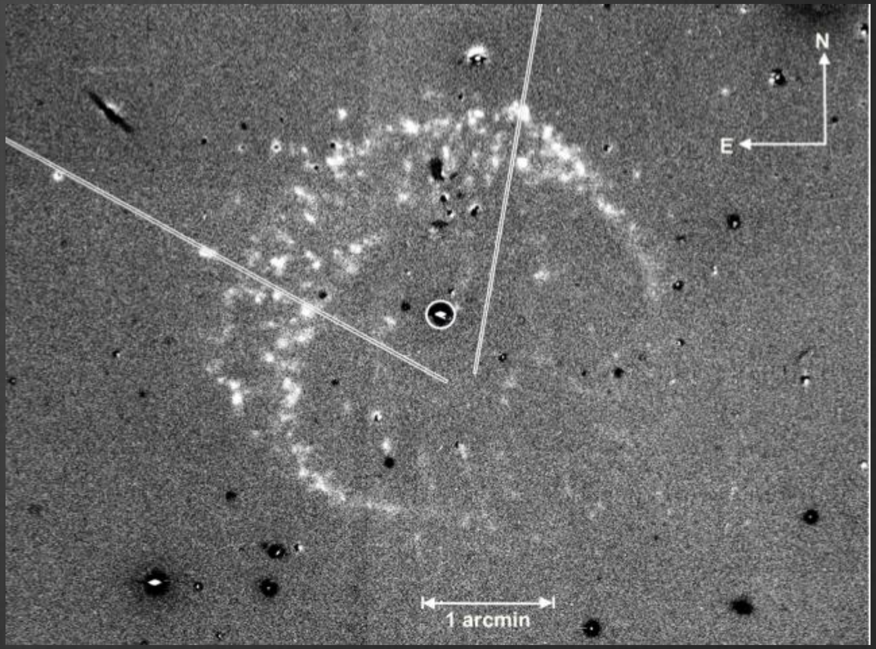
- Why are there so few Z Cams among the thousands of known dwarf novae?
- Do they represent a short period in the evolution of cataclysmic variables from one type to another?
- Is there a relationship or continuum between Z Cams, NLs and VY Scl type systems since they share some of the same characteristics?

Are some or all of the Z Cams 'hibernating novae' as put forth in Shara et al 2007 and 2012?



Nova shell around Z Cam

AT Cnc nova shell



URLs

Z CamPaign Page

https://sites.google.com/site/aavsocvsection/z-campaign

The Z Cam List

https://sites.google.com/site/thezcamlist/

Z CamPaign Publications

https://sites.google.com/site/thezcamlist/z-campaign-papers

Thank you