



Symbiotic binaries at P. J. Šafárik University

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Outline

- **Symbiotic binaries**
 - Spectral appearance
 - Importance
- **Symbiotics at UPJŠ**
 - New Online Database of Symbiotic Variables
 - Z And-type symbiotics
 - Symbiotic candidates
 - New symbiotic stars
- **Conclusions**

21 „symbiotic“ publications in last 5 years (2015 – 2020)
+ 2 accepted (arXiv)
+ 1 submitted
+ 3 in preparation

Symbiotic binaries

References:

Kenyon, 1986, *The Symbiotic Stars*

ISBN: 978-0521093316

Mikołajewska, 2012, *Baltic Astronomy*

doi: 10.1515/astro-2017-0352

Munari, 2019, *Review in The Impact of Binary Stars on Stellar Evolution*

arXiv:1909.01389

Merc et al., 2019, *Astronomische Nachrichten*

doi: 10.1002/asna.201913662

- strongly **interacting binary** systems
 - mass transfer via stellar wind or Roche lobe overflow
 - open binaries
- consist of a **cool giant** and **hot compact star**, mostly a white dwarf
 - circumbinary envelope
- significant **variability**, „composite“ spectra

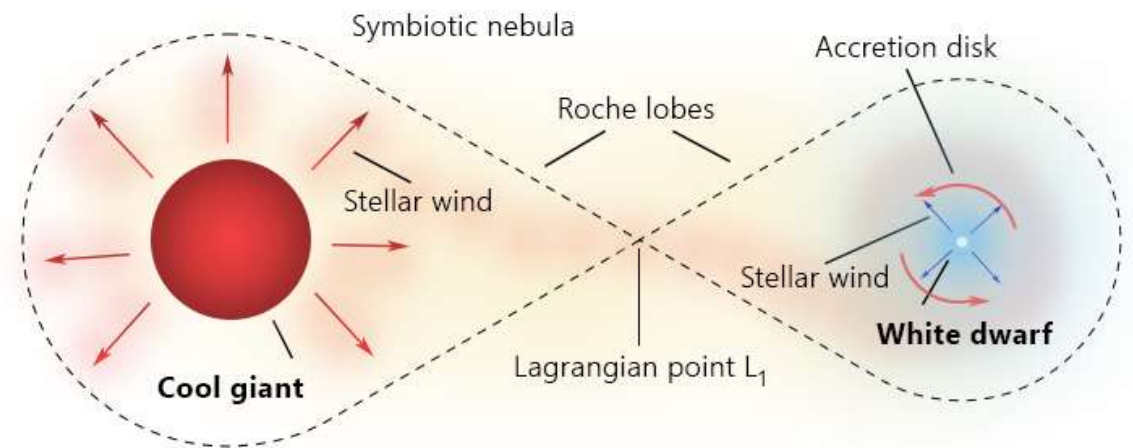


Figure: Simplified model of a symbiotic binary.

Symbiotic binaries Spectra

CI Cyg observation:
ARAS Group

References:

Skopal et al., 2015, *New Astronomy*
doi: 10.1016/j.newast.2013.10.009

Teyssier, 2019, *Contributions of the
Astronomical Observatory Skalnaté Pleso*

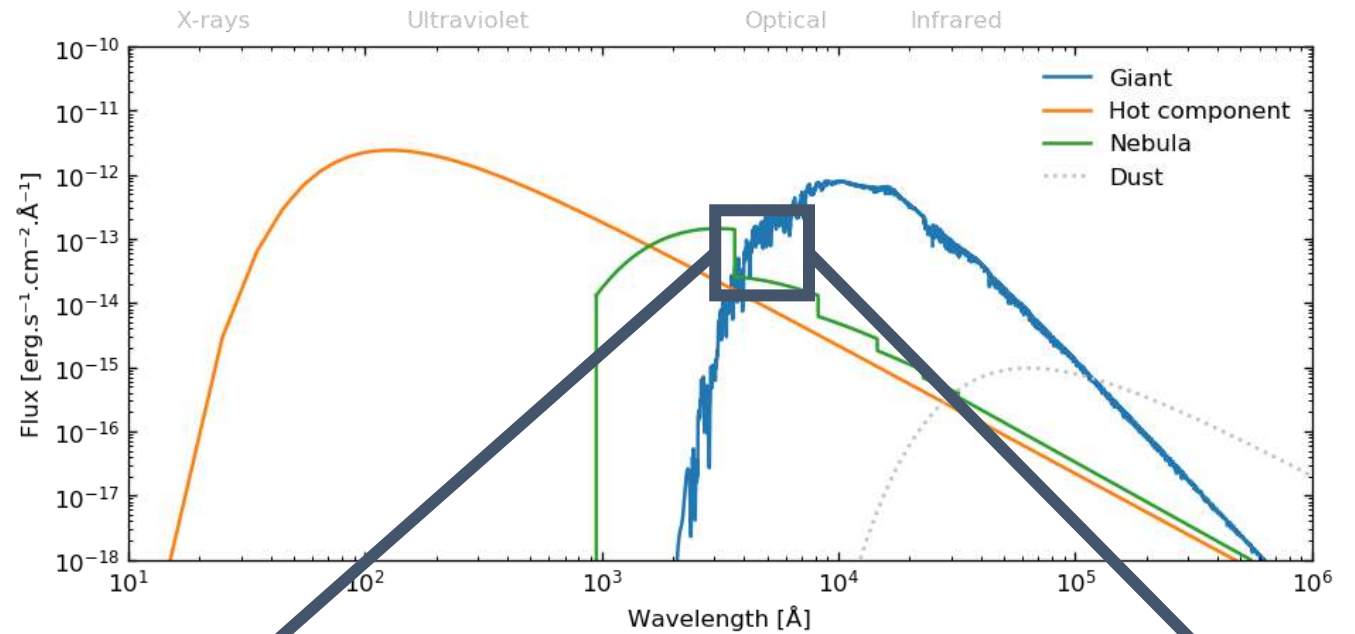


Figure: Radiation sources observed in symbiotic spectrum.

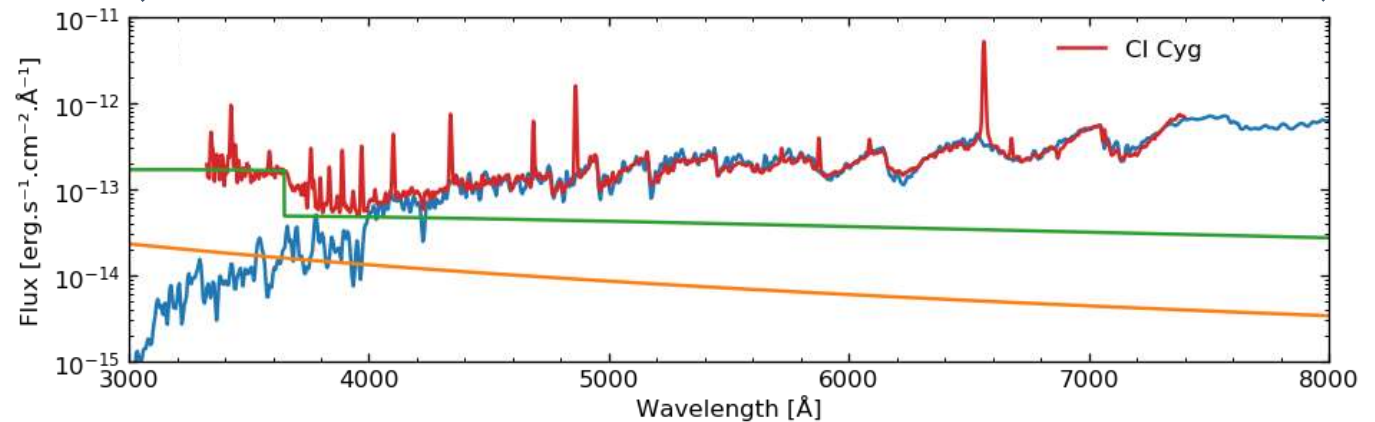


Figure: Optical and near-UV spectrum of CI Cyg.

Symbiotic binaries

Importance

References:

Kenyon, 1986, The Symbiotic Stars

ISBN: 978-0521093316

Mikołajewska, 2013, Proceedings of the

International Astronomical Union

doi: 10.1017/S1743921312014925

Łkiewicz et al., 2019, Monthly Notices of the

Royal Astronomical Society

doi: 10.1093/mnras/stz760

- unique **astrophysical laboratories**
 - **stellar interaction** – mass transfer, accretion processes
 - stellar **winds** and their collision
 - formation and collimation of **jets**
 - **dust formation** and destruction
 - thermonuclear **outbursts**
- important in study of **stellar evolution**
 - **evolution** of binaries
 - possible **supernovae Ia** progenitors



New Online Database
of Symbiotic Variables

References:

Merc et al., 2019, RNAAS

doi: [10.3847/2515-5172/ab0429](https://doi.org/10.3847/2515-5172/ab0429)

Merc et al., 2019, Astronomische Nachrichten

doi: [10.1002/asna.201913662](https://doi.org/10.1002/asna.201913662)

Merc et al., 2020, Contributions of the
Astronomical Observatory Skalnaté Pleso

doi: [10.31577/caosp.2020.50.2.426](https://doi.org/10.31577/caosp.2020.50.2.426)

- more than **400** in the Milky Way
- concentration towards **Galactic plane**
- **New Online Database of Symbiotic Variables**

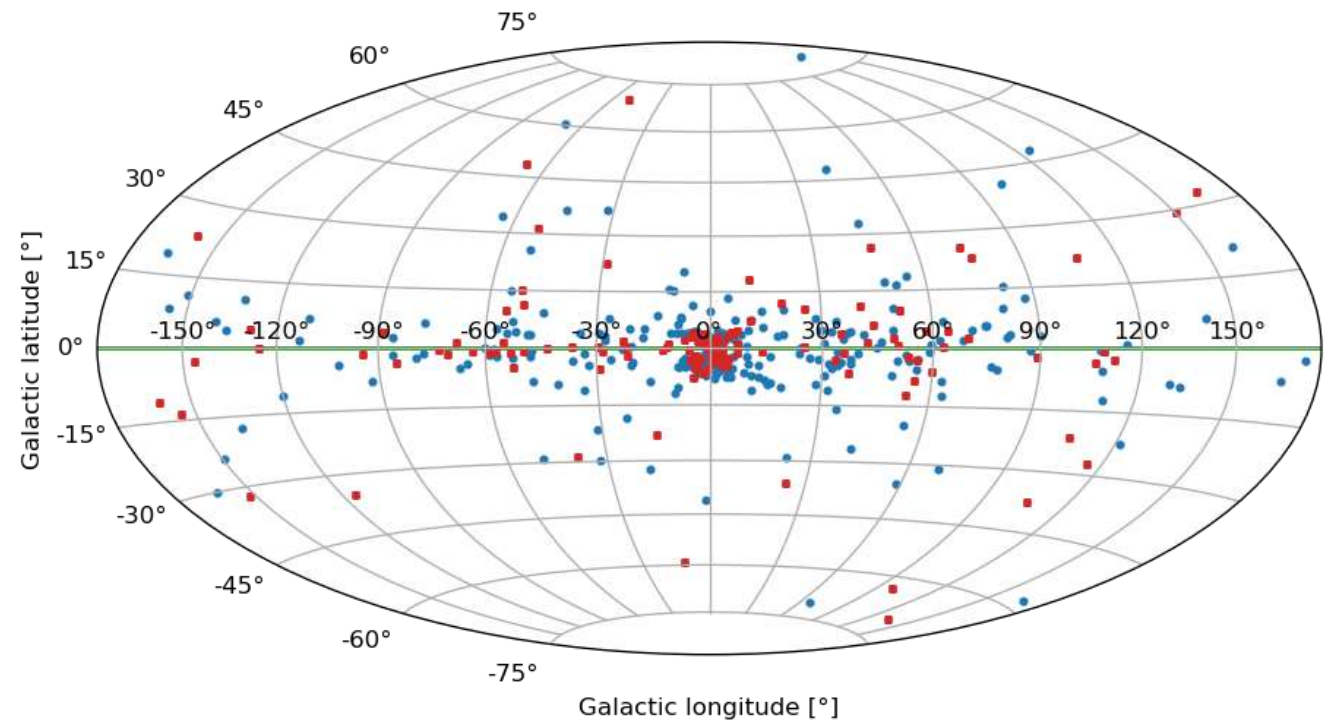
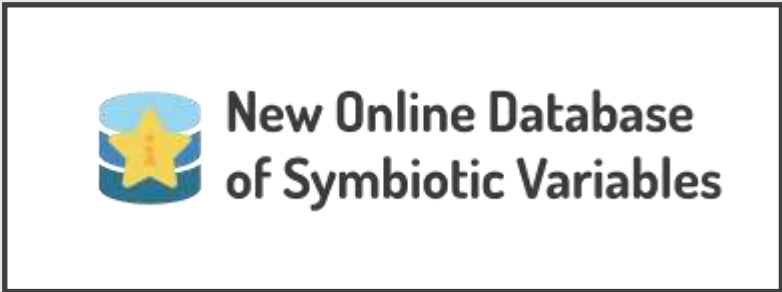


Figure: Distribution of the galactic symbiotic stars according to their galactic coordinates.



References:

Merc et al., 2019, RNAAS

doi: 10.3847/2515-5172/ab0429

Merc et al., 2019, Astronomische Nachrichten

doi: 10.1002/asna.201913662

Merc et al., 2020, Contributions of the
Astronomical Observatory Skalnaté Pleso

doi: 10.31577/caosp.2020.50.2.426

- almost **160 objects** in the Local Group
- advantage in **known distance**

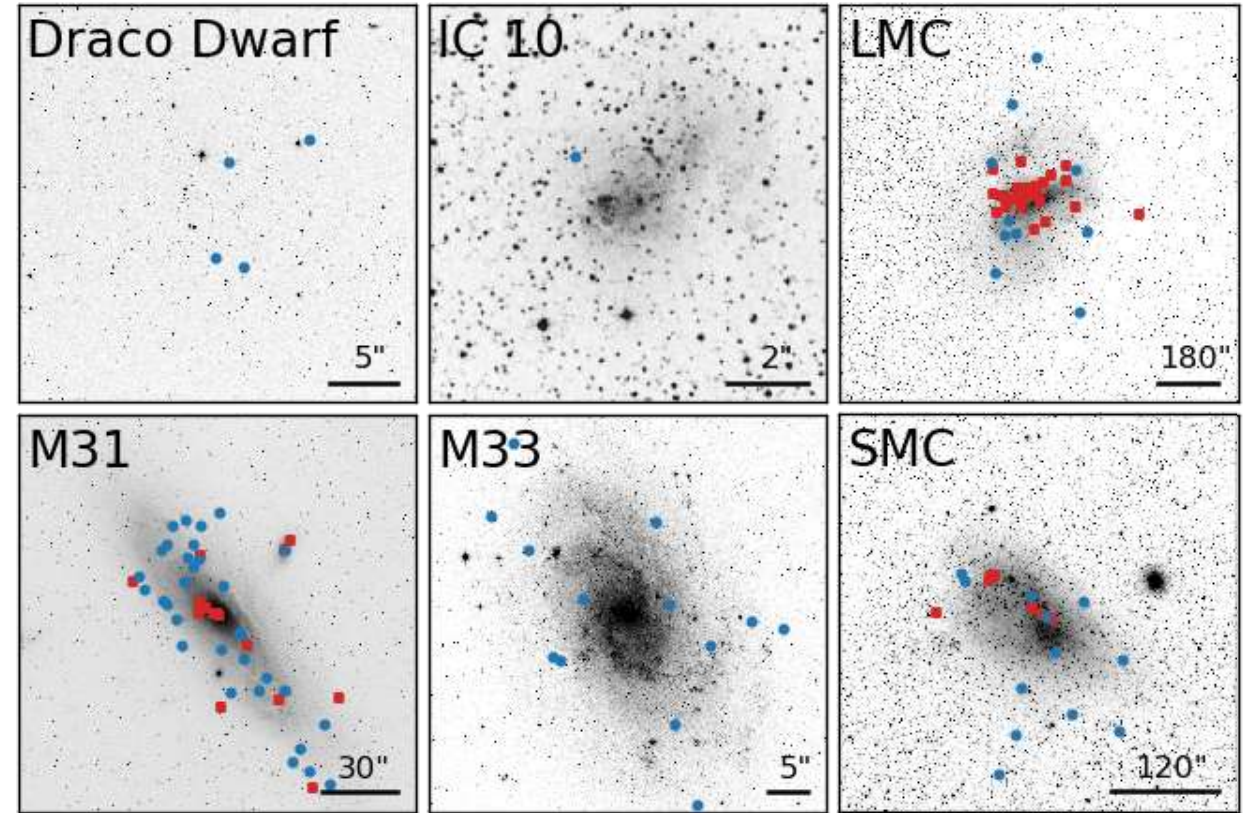


Figure: Position of extragalactic symbiotic stars in their host galaxies.



New Online Database
of Symbiotic Variables

References:

Merc et al., 2019, RNAAS

doi: 10.3847/2515-5172/ab0429

Merc et al., 2019, Astronomische Nachrichten

doi: 10.1002/asna.201913662

Merc et al., 2020, Contributions of the

Astronomical Observatory Skalnaté Pleso

doi: 10.31577/caosp.2020.50.2.426

- tables with data
- object pages

<http://astronomy.science.upjs.sk/symbiotics/>

New Online Database of Symbiotic Variables Galactic Extragalactic

Database information **Symbiotics in LMC**

ALL CONFIRMED SUSPECTED

Basic Data Identifiers Observations Position Orbit Cool Component Hot Component

Column visibility Copy CSV Excel PDF Print

Show 10 entries Search:

Star Name	Confirmed	Galaxy	α (°)	δ (°)	B (mag)	V (mag)	R (mag)	I (mag)
(BP2006) 490	✓	LMC	84.381322	-71.179952		16.98	15.91	
LMC N19	✓	LMC	75.848970	-67.942676		16.40	15.34	14.27
LMC N67	✓	LMC	84.031584	-64.722593	16.90	15.90	14.70	12.70
LMC S147	✓	LMC	73.514485	-70.992264	12.80	15.47	15.57	13.90

Utilities
Cross-identification with other catalogs

What's new?
 May 16, 2019 - List of galactic objects added
 May 15, 2019 - New objects added

Figure: Catalog data for symbiotic stars in LMC.



New Online Database
of Symbiotic Variables

References:

Merc et al., 2019, RNAAS

doi: [10.3847/2515-5172/ab0429](https://doi.org/10.3847/2515-5172/ab0429)

Merc et al., 2019, Astronomische Nachrichten

doi: [10.1002/asna.201913662](https://doi.org/10.1002/asna.201913662)

Merc et al., 2020, Contributions of the

Astronomical Observatory Skalnaté Pleso

doi: [10.31577/caosp.2020.50.2.426](https://doi.org/10.31577/caosp.2020.50.2.426)

- tables with data
- object pages

<http://astronomy.science.upjs.sk/symbiotics/>

The screenshot shows the object page for LIN 9. At the top, there is a navigation bar with 'Galactic' and 'Extragalactic' tabs and a search icon. The main content area is divided into several sections:

- Database information**: Includes links for 'About the Database', 'User's Guide', 'Usage Policy', 'Statistics', and 'Contact'.
- Utilities**: Includes a link for 'Cross-identification with other catalogs'.
- What's new?**: Lists recent updates, such as 'May 16, 2019 - List of galactic objects added' and 'May 15, 2019 - New objects added'.
- Identifiers**: A section for alternative names or identifiers.

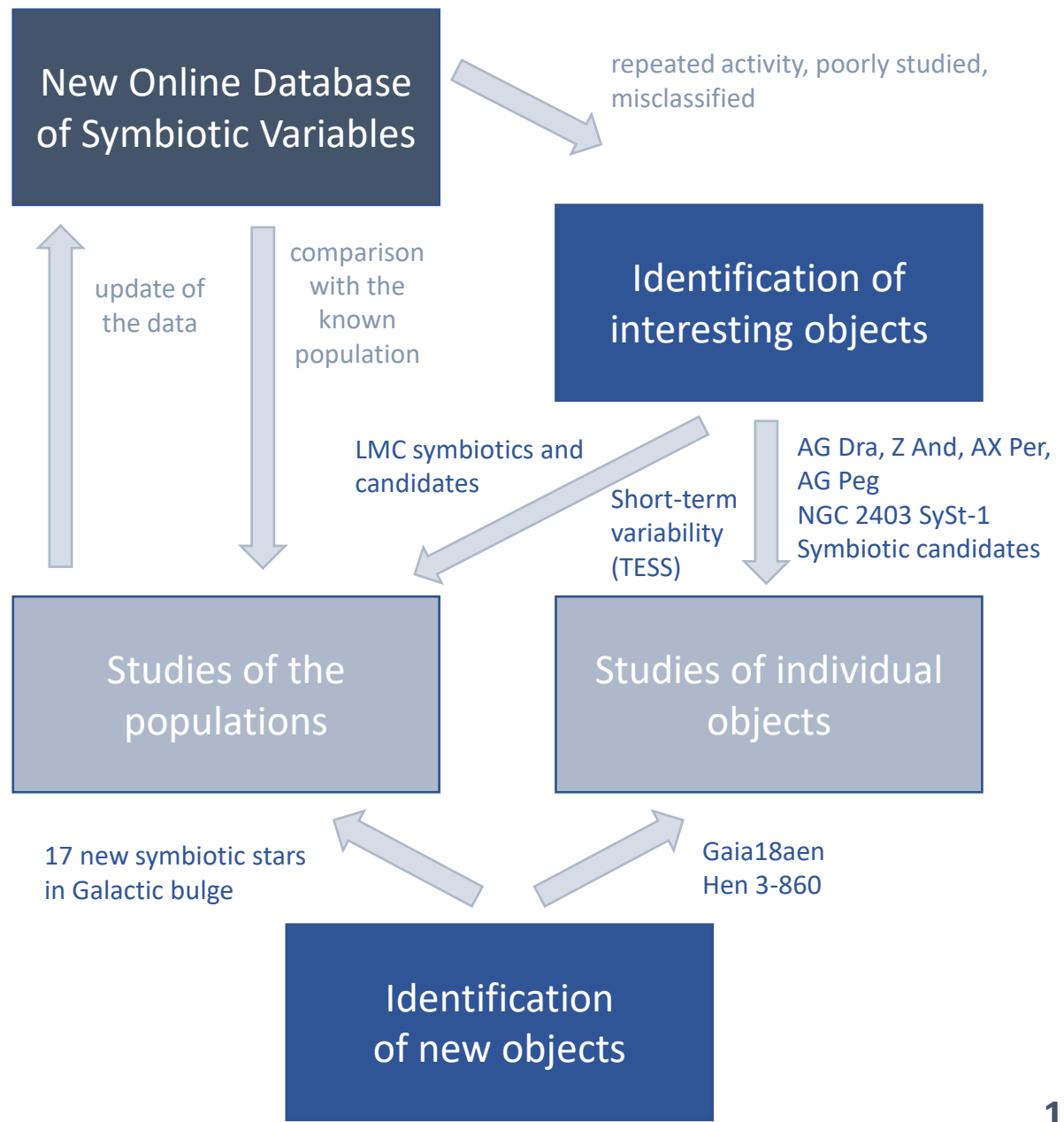
The central part of the page displays the object name 'LIN 9' with 'CONFIRMED' and 'SMC' status tags. Below this, the equatorial coordinates are given as $\alpha = 7.530781 \pm 0.031503$ | 00 30 07.389688 and $\delta = -73.621971 \pm 0.026315$ | -73 37 19.062127. A table of properties is also shown:

Constellation	Tucana
Symbiotic IR Type	S ⁺
Spectral Type	K5 ⁻
Magnitude range (V)	14.8-15.3 ^m
Outbursts	Z Anil

On the right side, there is a small image of the star field with a red star highlighted, and a 'WIKI' button at the bottom left of the image.

Figure: Example of the object page of symbiotic star LIN9.

Symbiotics at UPJŠ Workflow



AG Draconis

- **seven years of flat quiescence** following the 2006-08 major outbursts
- new activity **started in 2015**
- **four minor outbursts**
- returned to **quiescence** in 2018/2019

References:

Merc et al., 2017, Proceedings of Science
doi: 10.22323/1.315.0060

Gális et al., 2019, Contributions of the
Astronomical Observatory Skalnaté Pleso

Merc et al., 2019, Contributions of the
Astronomical Observatory Skalnaté Pleso

Gális, Merc, Leedjäv et al., in preparation

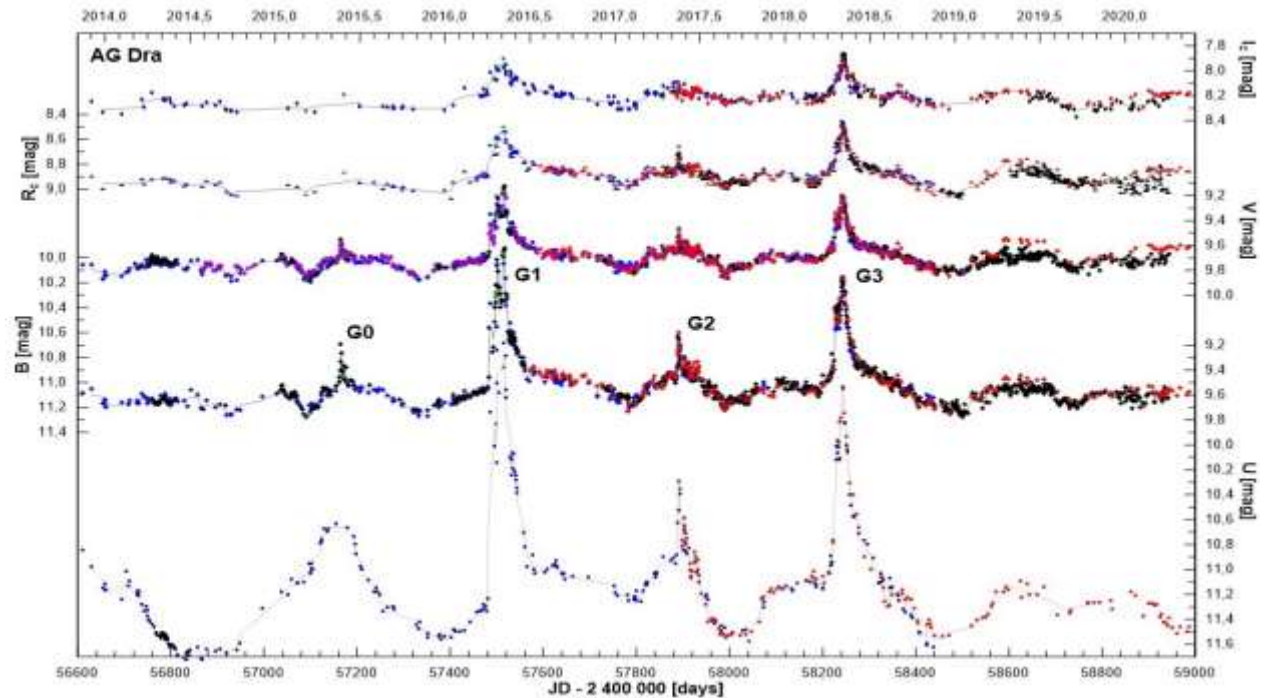


Figure: The recent light curves of AG Dra (2014 – 2020). 11

AG Draconis

References:

Merc et al., 2017, Proceedings of Science
doi: 10.22323/1.315.0060

Gális et al., 2019, Contributions of the
Astronomical Observatory Skalnaté Pleso

Merc et al., 2019, Contributions of the
Astronomical Observatory Skalnaté Pleso

Gális, Merc, Leedjävrv et al., in preparation

- spectroscopic campaigns focused on the recent activity
- more than **750 spectra** (2014 – 2020)
 - various observers (many from the ARAS Group, recently M. Vrašťák)

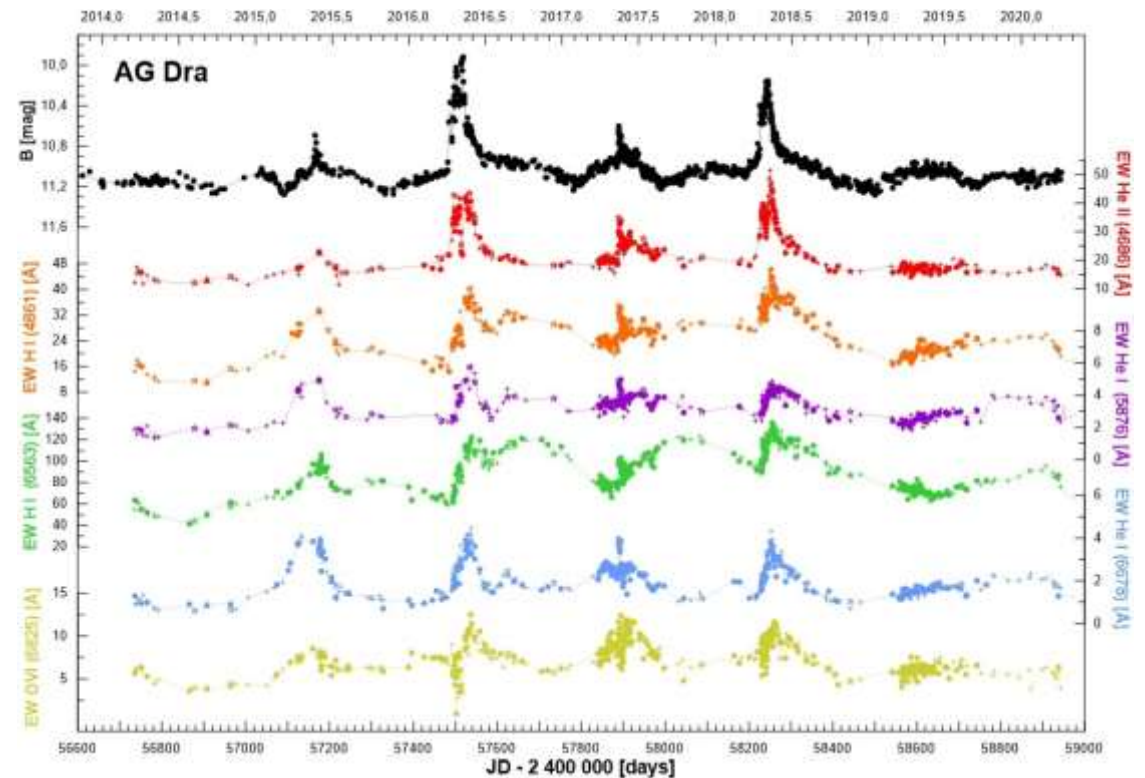


Figure: EWs of selected emission lines.

Z Andromeda

References:

Skopal et al., 2018, *Astrophysical Journal*
doi: 10.3847/1538-4357/aabc11

Merc et al., 2019, *Open European Journal on
Variable Stars*

Merc et al., 2019, *Contributions of the
Astronomical Observatory Skalnaté Pleso*

- current activity **started in 2000**
 - recent outburst recorded at the turn of **2017 and 2018**
- Z And is **one of few** symbiotic stars producing **jets**
 - observed during maxima in **2006 and 2009-2010**
 - **not during** the recent outburst

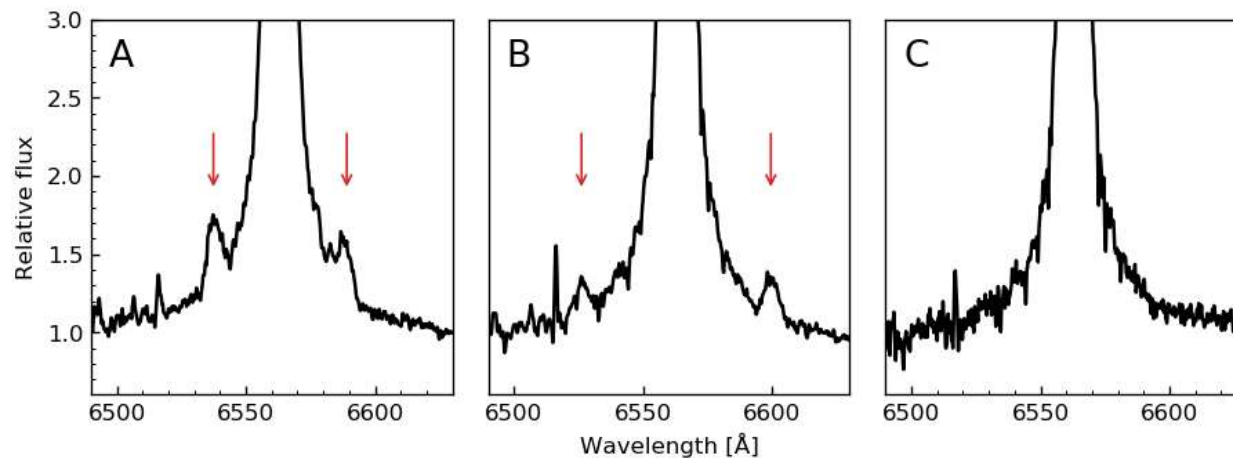


Figure: The jet components (marked with red arrows) of the H α emission line. The spectra are from 2006 (A), 2010 (B) and from 2018 (C).

AG Pegasi

References:

Skopal et al., 2017, *Astronomy & Astrophysics*
doi: 10.1051/0004-6361/201629593

Merc et al., 2019, *Contributions of the
Astronomical Observatory Skalnaté Pleso*

- **slowest** symbiotic nova
- showed Z And-type outburst **165 years after** its nova-like flare-up
 - **transition** from symbiotic nova to **classical symbiotic star**
 - also some other had gone **through this evolution?**

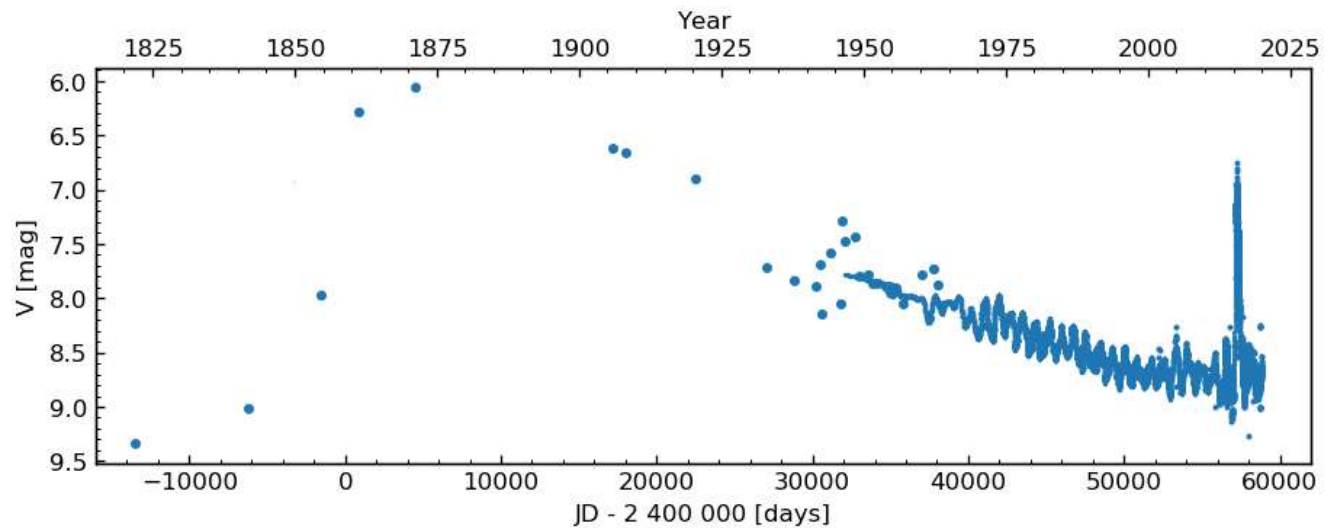


Figure: The historical light curve of AG Peg covering the period of 1821 to 2020.

NGC 2403 SySt-1

References:

Merc, Gális, Kára et al., 2020, accepted in Monthly Notices of the Royal Astronomical Society

arXiv: 2009.14784

- classified as a **possible symbiotic binary**, cataclysmic variable, supernova remnant, H II region
 - located in the field of NGC 2403
 - **X-ray source**
- our **multiwavelength analysis** proved that this object is an **active, young red dwarf**
 - data from Gaia, TESS, ASAS-SN, ZTF, XMM-Newton, Chandra, Swift, 2MASS, WISE

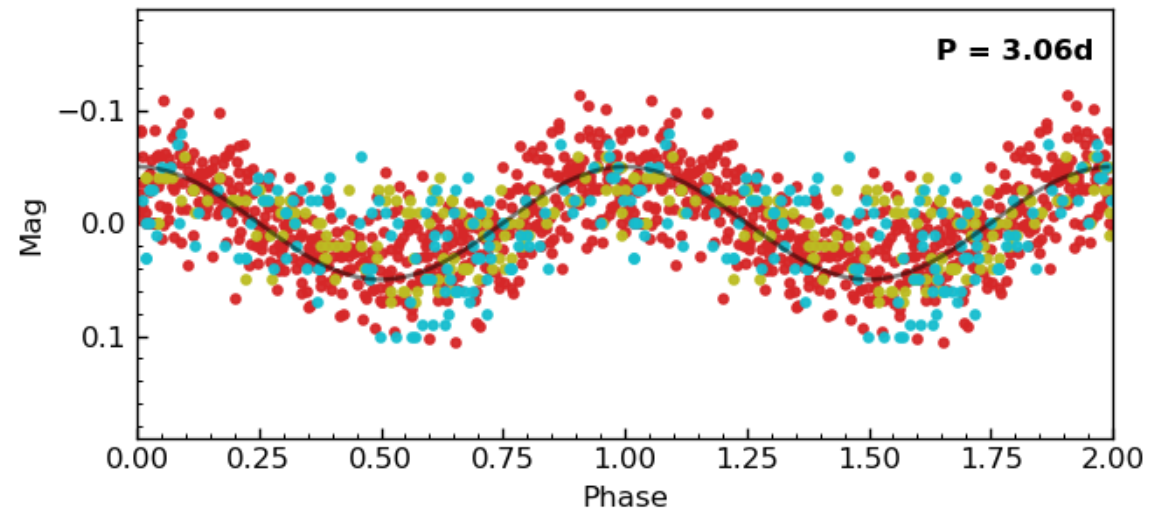


Figure: Phased light curve of NGC 2403 SySt-1.

Hen 3-860

Spectrum:

P. Velez, ARAS Group

References:

Merc, Gális, Velez et al., in preparation

- selected for spectroscopic campaign based on the **peculiar light curve**
 - **outburst in 2018 – 2019 (ASAS-SN)**
 - **eclipse-like features**
- spectrum **confirmed** the symbiotic nature
 - **M2 III continuum**, emission lines of H I, He I, He II
- orbital period of **550 days**
- **two** or three **outbursts** in past

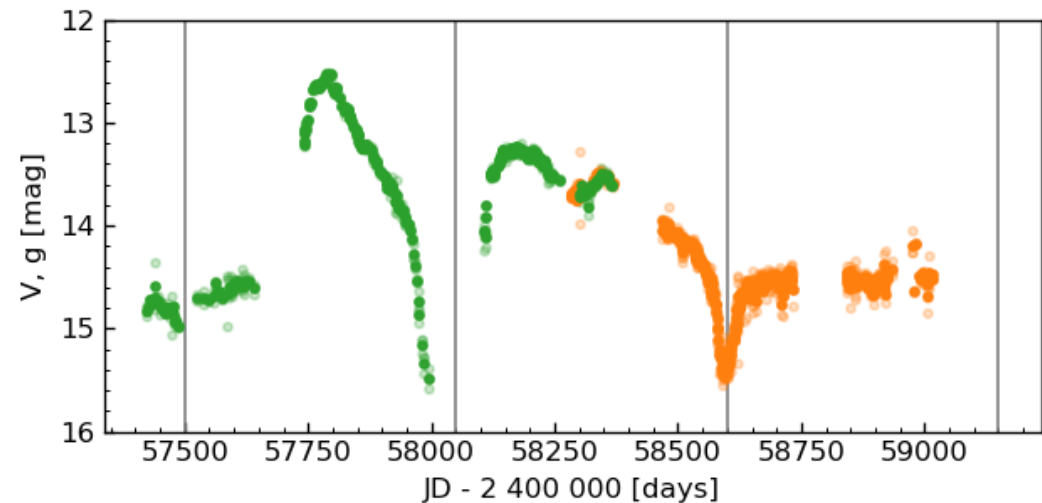


Figure: Recent light curve of Hen 3-860 from ASAS-SN survey.

Hen 3-860

Spectrum:

P. Velez, ARAS Group

References:

Merc, Gális, Velez et al., in preparation

- selected for spectroscopic campaign based on the **peculiar light curve**
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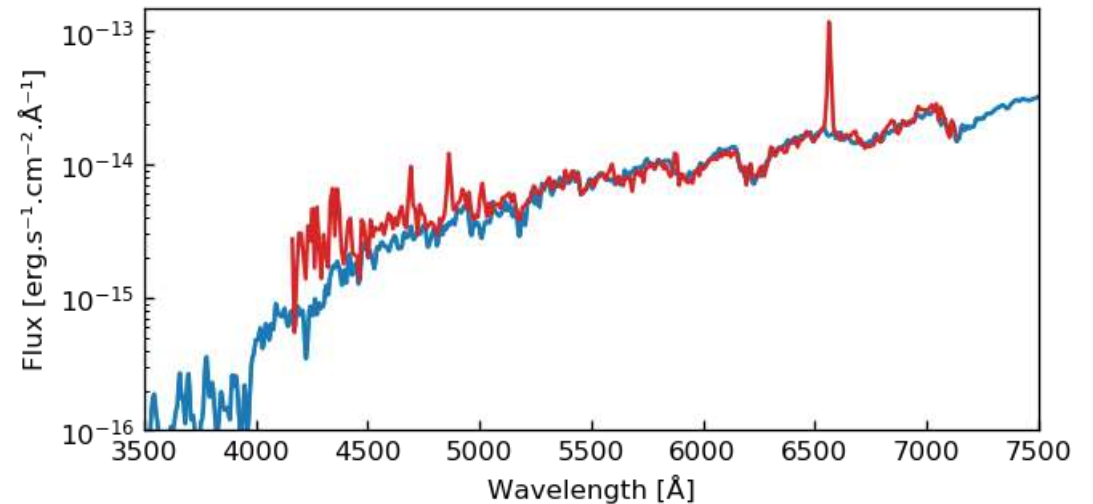


Figure: Spectrum of Hen 3-860.

Hen 3-860

Spectrum:

P. Velez, ARAS Group

References:

Merc, Gális, Velez et al., in preparation

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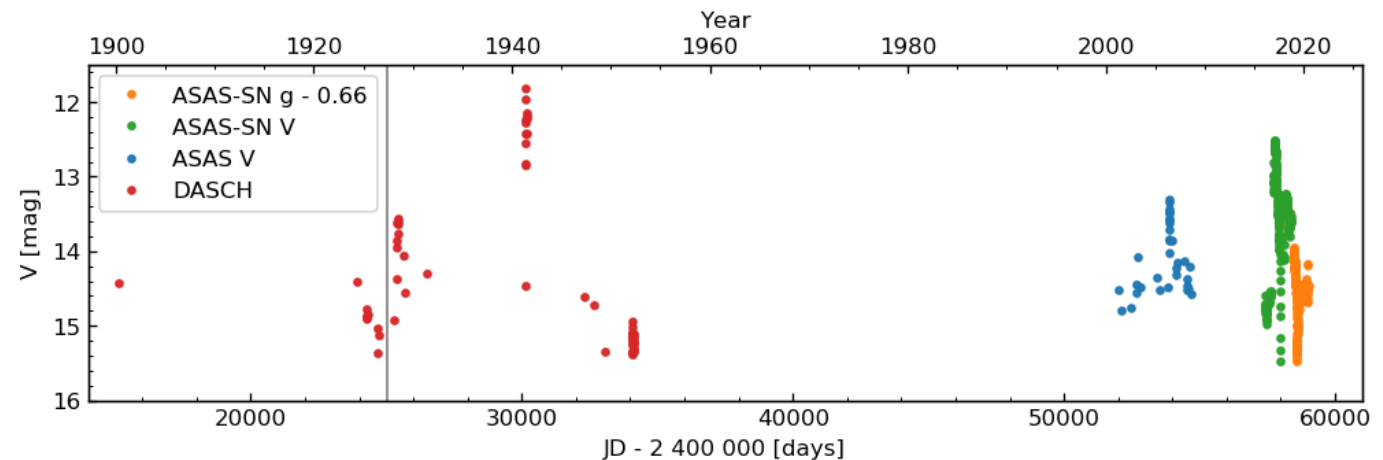


Figure: Historical light curve of Hen 3-860.

Gaia18aen

References:

Merc, Mikołajewska, Gromadzki et al., 2020,
accepted in Astronomy & Astrophysics
arXiv: 2009.14709

- at the beginning of 2018, *Gaia* detected the **brightening of Gaia18aen**
 - soon classified as a ‘nova?’
 - light curves and the spectra **confirmed** the **symbiotic** nature
 - **first ever symbiotic star** discovered by *Gaia*

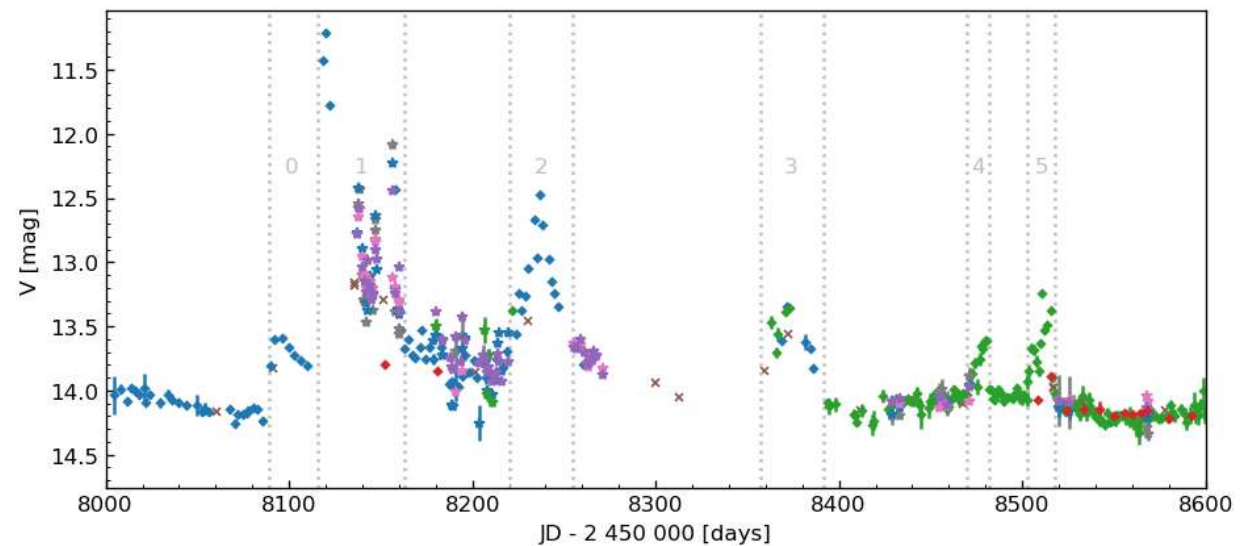


Figure: The light curve of Gaia18aen.

Conclusions

Why to bother?

Thank you for
your attention.

Acknowledgements:

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Why?

- **basic** research – expanding our **knowledge**
- **unique** astrophysical laboratories
 - accretion processes, winds or jets
- important for **evolutionary models**
 - binary evolution
 - possible progenitors of supernovae Ia

How?

- studies of **individual systems**
 - long-term monitoring
 - understanding of the processes
 - parameters of the components
- **systematic** studies
 - population of symbiotic stars