FACULTY
OF MATHEMATICS
AND PHYSICS
Charles University

New Online Database
of Symbiotic Variables

Symbiotic binaries: A 100-year-old puzzle

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Astronomical Institute of Charles University in Prague, Czech Republic

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Symbiotic binaries
Historical perspective

- sudden **changes of brightness** (outbursts)
  - already in **the early 20th century**
  - observations **> 100** years
- stars with „**combination spectra**“
- „**symbiotic**“ by Merrill in 1941
- **models** to explain photometric and spectroscopic changes
  - in the **thirties of 20th century**
  - **binary** models vs. **single star** alternatives
- single star models **cannot explain** the observational data
  - **direct evidence of binary nature** (RVs, eclipses, SEDs, etc.)

References:
Fleming & Pickering, 1912, Annals of Harvard College Observatory
Kenyon, 1986, The Symbiotic Stars
ISBN: 978-0521093316
Kogure & Leung, 2007, The Astrophysics of Emission-Line Stars
ISBN: 978-0-387-34500-0

Symbiotic binaries
Introduction

- strongly **interacting binaries**
  - among the **widest** interacting systems
  - **detached/semi-detached** binaries
- consist of a **cool giant** and **hot compact star**, mostly a white dwarf
  - circumbinary envelope
  - mass transfer via stellar wind or Roche lobe overflow

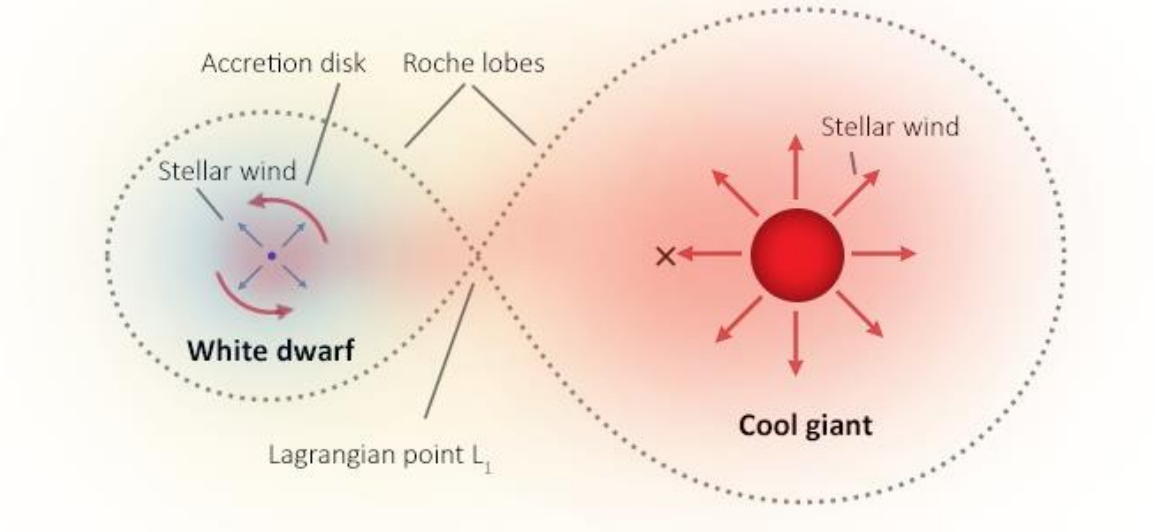


Figure: Simplified model of a symbiotic binary.

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

Symbiotic binaries
Observations

Credit:
NASA, ESA

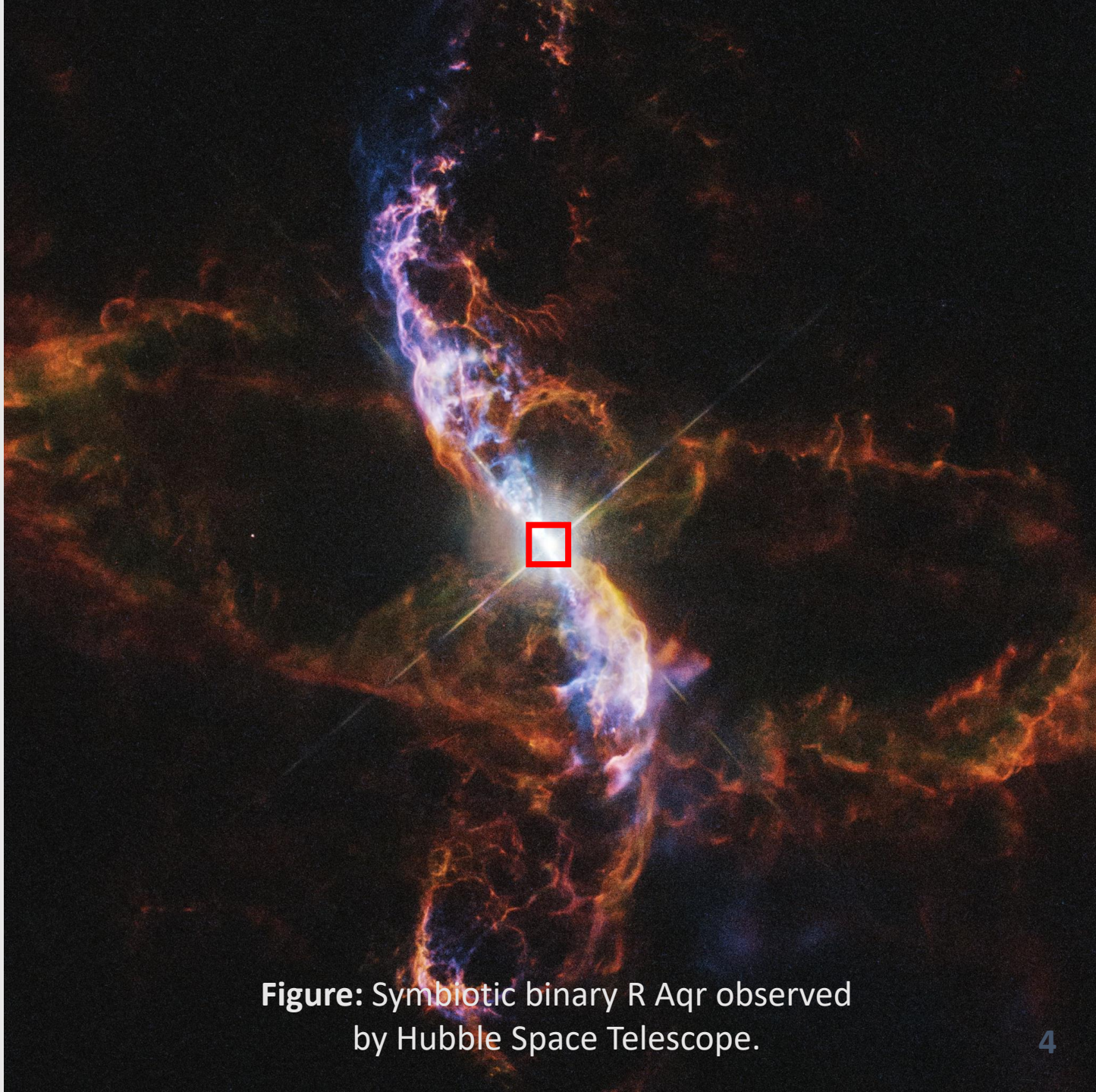


Figure: Symbiotic binary R Aqr observed by Hubble Space Telescope.

Symbiotic binaries
Observations

References:
Schmid et al., 2017, Astronomy&Astrophysics
doi: 10.1051/0004-6361/201629416

Credit:
ESO, Schmid et al., 2017

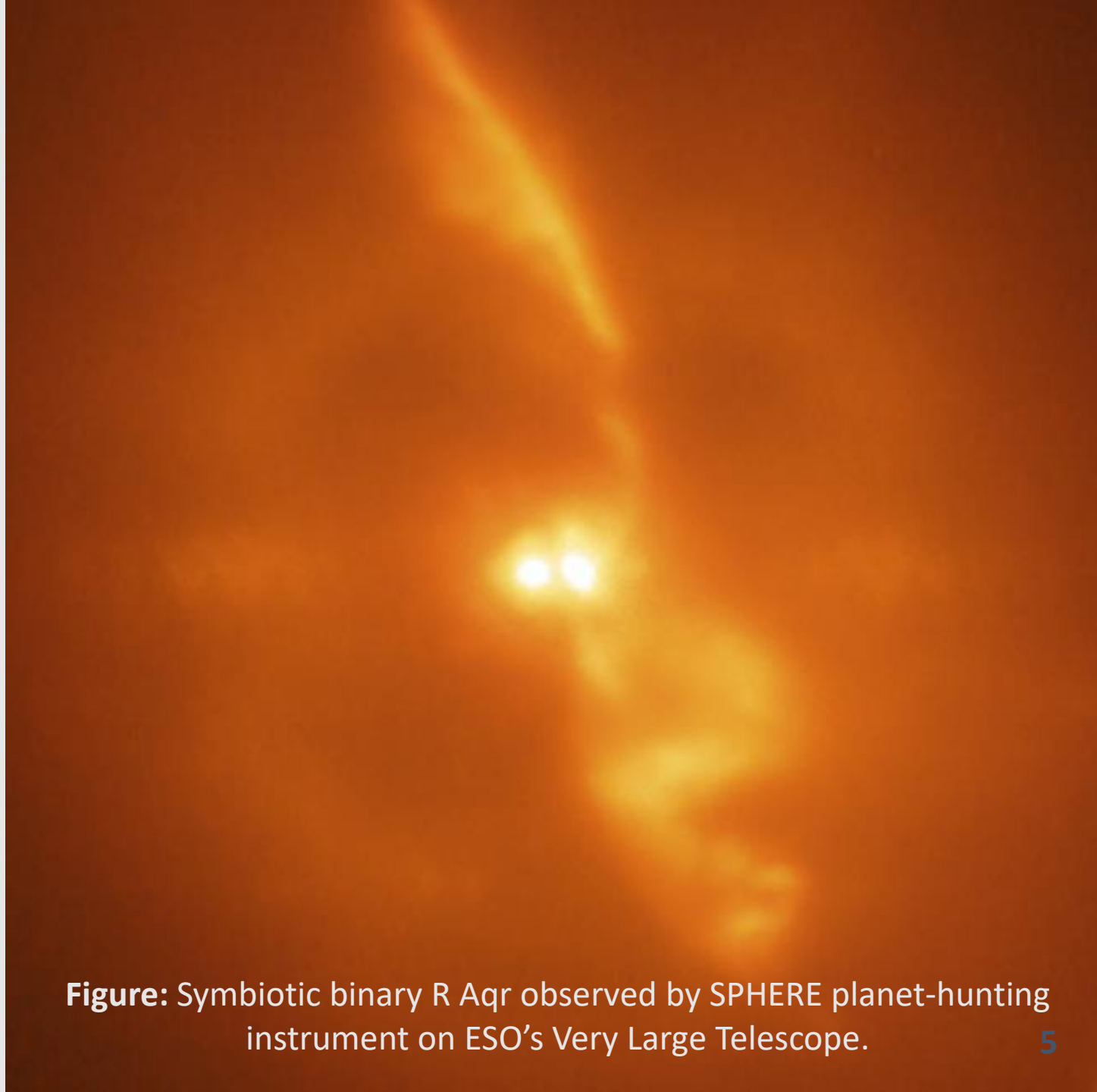


Figure: Symbiotic binary R Aqr observed by SPHERE planet-hunting instrument on ESO's Very Large Telescope.

Symbiotic binaries
Observations

Credit:
NASA, ESA, and STScI

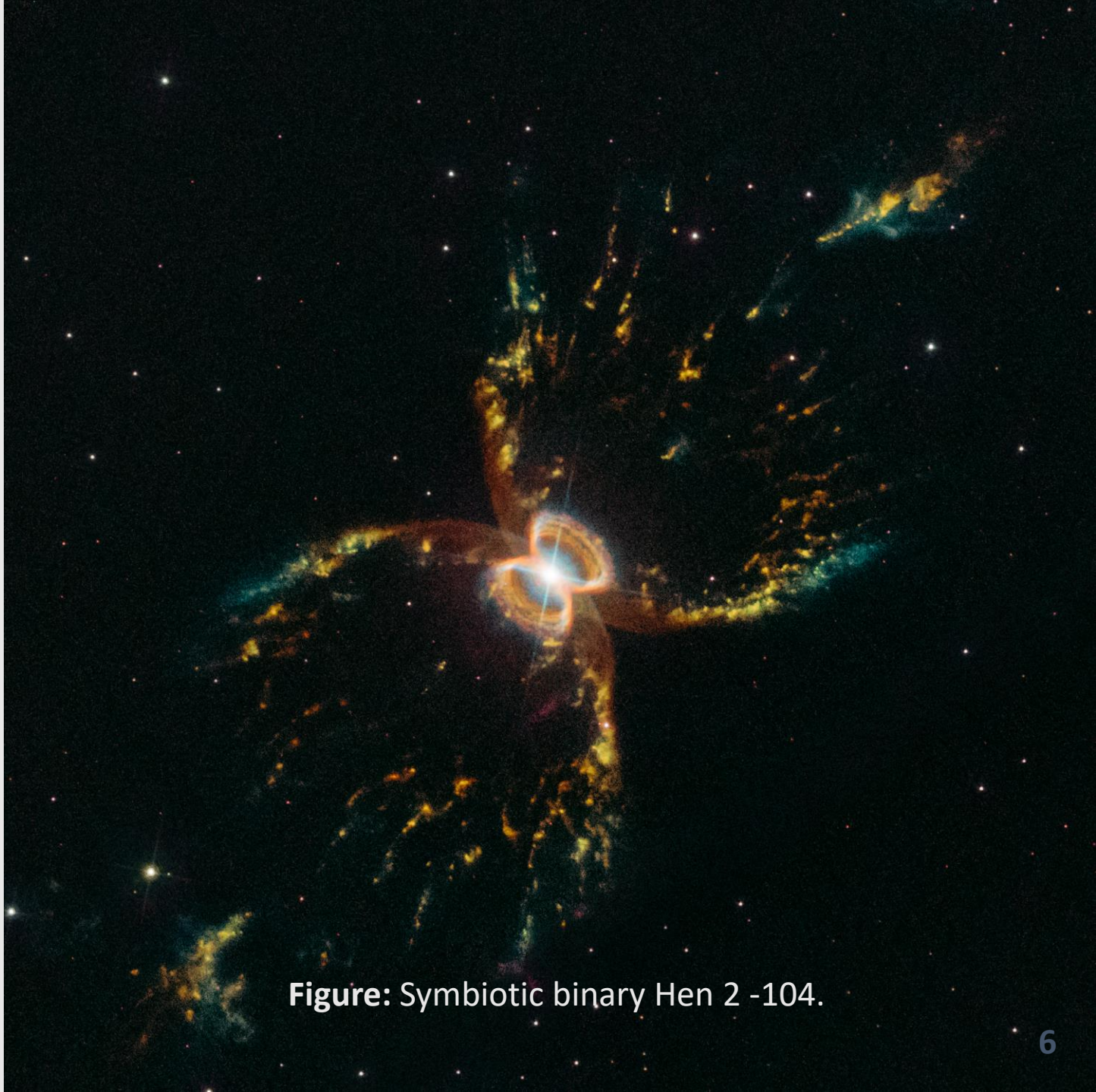


Figure: Symbiotic binary Hen 2 -104.

Symbiotic binaries
Observations

References:

Merc et al., 2019, WDS'19 Proceedings of Contributed Papers

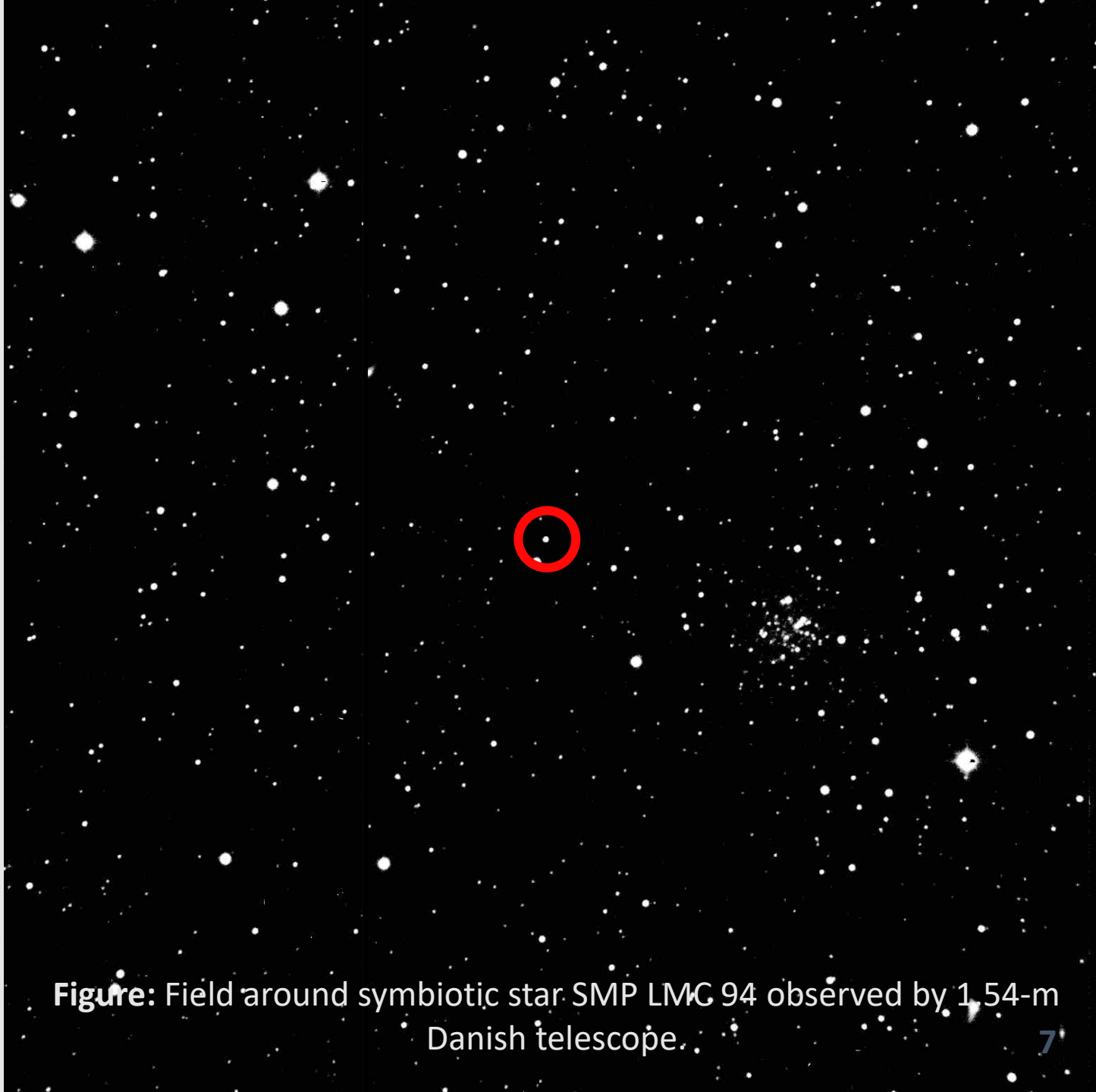


Figure: Field around symbiotic star SMP LMC 94 observed by 1.54-m Danish telescope.

Symbiotic binaries
Observations

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

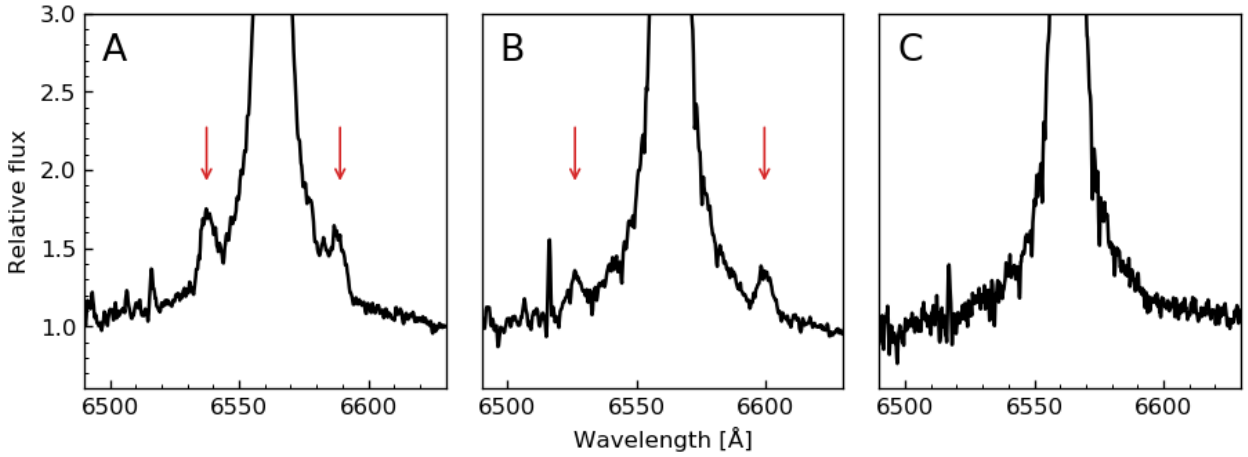


Figure: The jet components (marked with red arrows) of the Hα emission line of Z And. The spectra are from 2006 (A), 2010 (B) and from 2018 (C).

Symbiotic binaries
SED

- hot components – **X-rays and UV**
- cool giants in **IR** (+ dust)
- nebular emission in **optical**
  - **emission lines** as a probe of a hot component

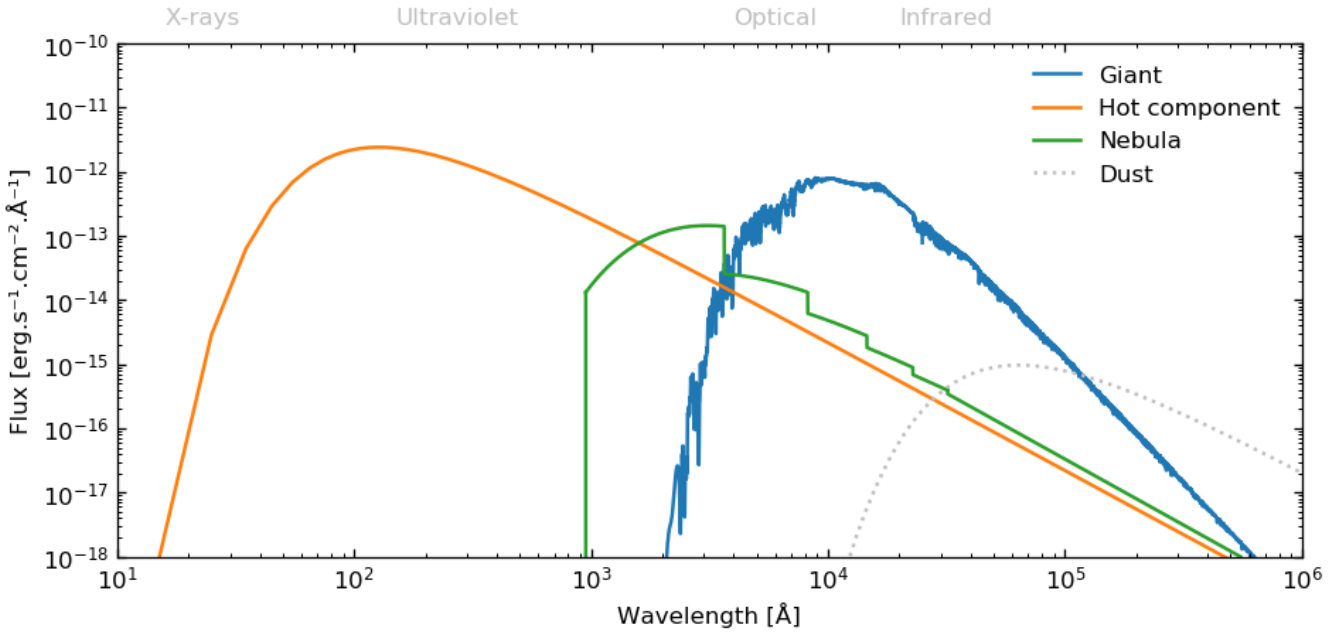
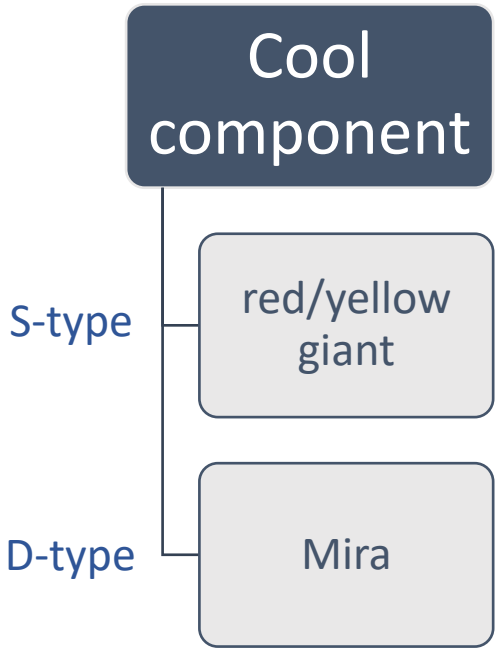


Figure: Radiation sources observed in symbiotic spectrum.

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

Symbiotic binaries
SED

References:
Mikołajewska, 2012, Baltic Astronomy
doi: 10.1515/astro-2017-0352



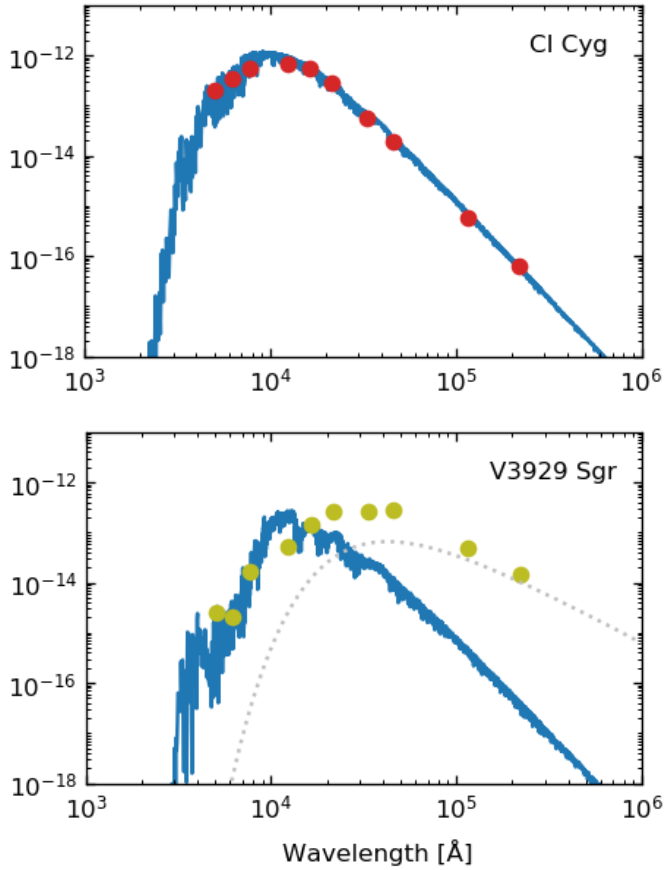
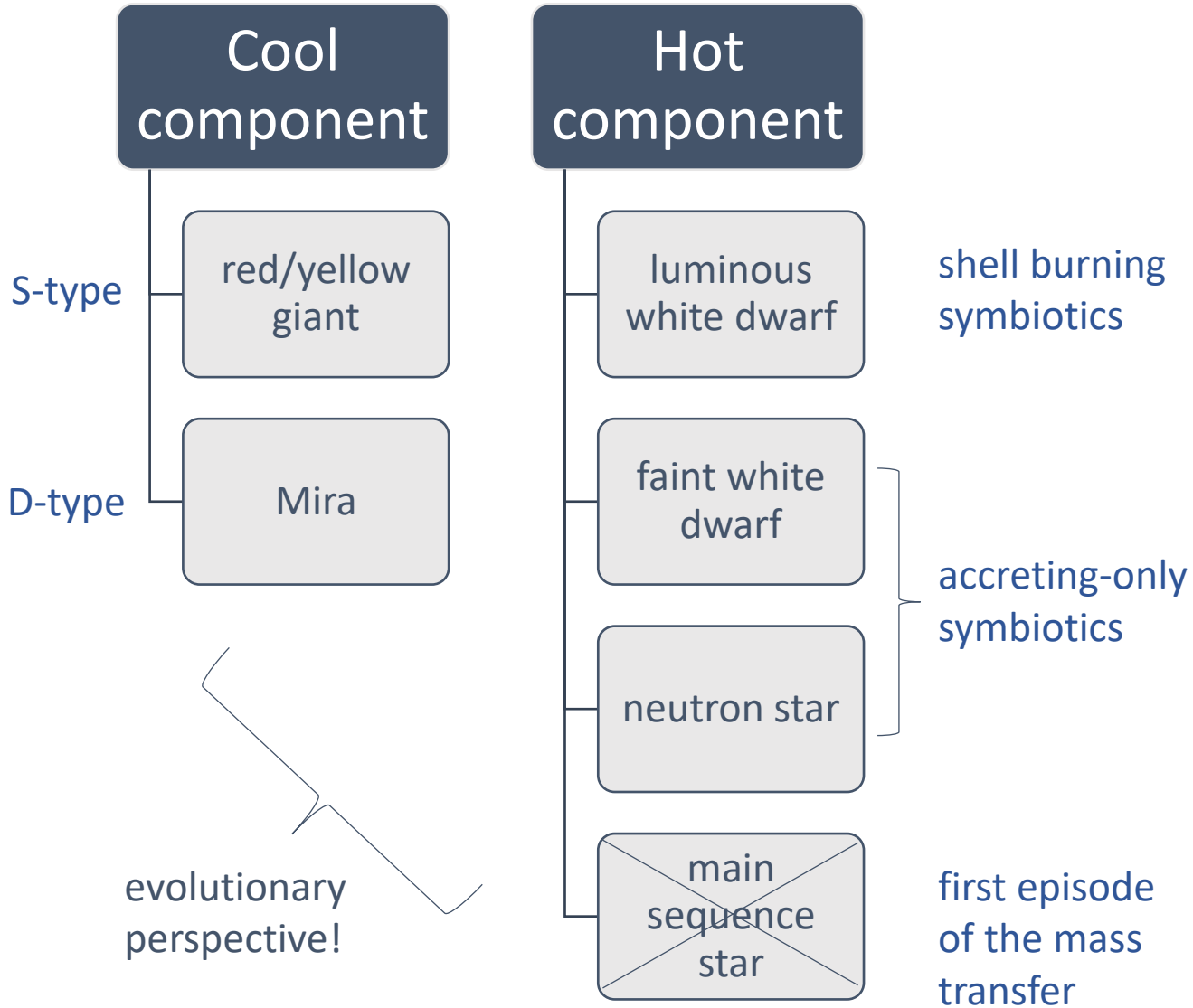


Figure: Comparison of SEDs of S- and D-type symbiotic stars.

Symbiotic binaries
SED



References:
Mikołajewska, 2012, Baltic Astronomy
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Symbiotic binaries
SED

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

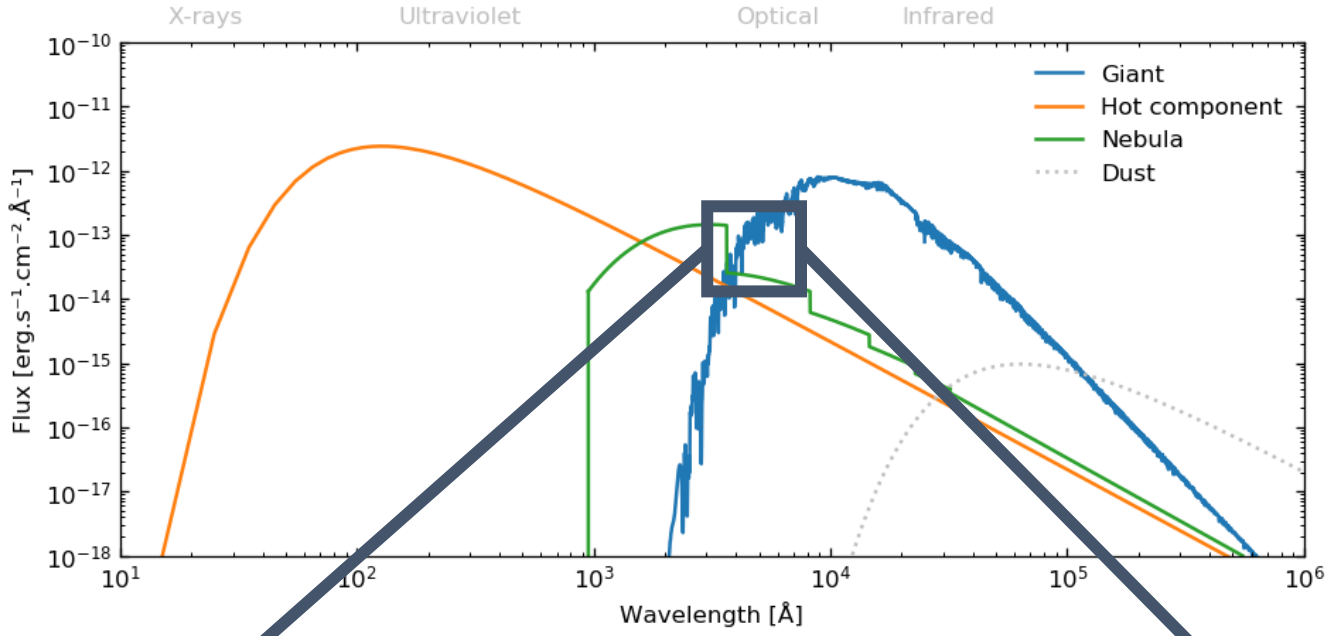

Figure: Radiation sources observed in symbiotic spectrum.

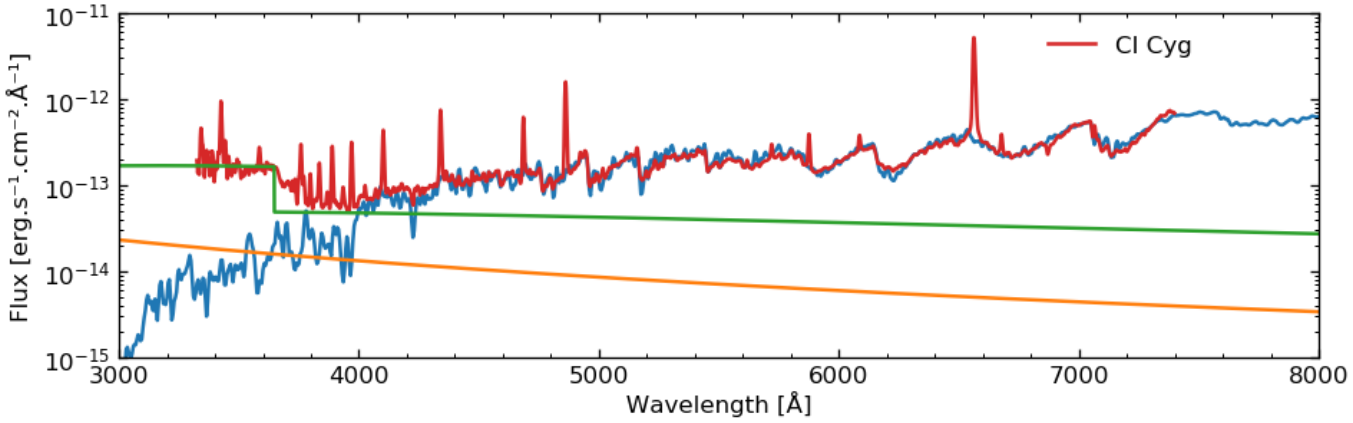

Figure: Optical and near-UV spectrum of CI Cyg.

Symbiotic binaries
Classification criteria

- exact definition has **changed** over time
  - **usually** based on the (optical) **spectra** (shell-burning symbiotics)
- **broader** definition in recent years
  - signs of **the interaction** at **any** wavelength (accreting-only symbiotics)

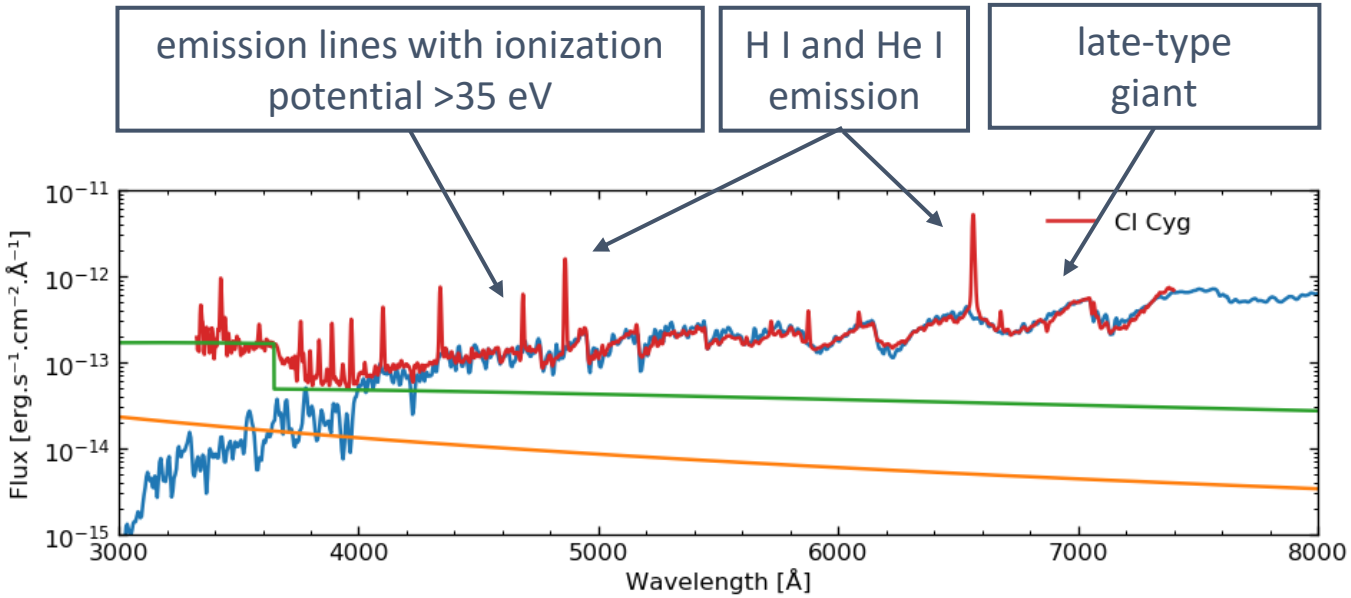

Figure: Typical spectrum of a symbiotic binary.

CI Cyg observation:
ARAS Group

References:
Kenyon, 1986, The Symbiotic Stars
ISBN: 978-0521093316
Belczyński et al., 2000, Astronomy and Astrophysics Supplement
doi: 10.1051/aas:2000280
Merc et al., 2020, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/staa3063

Symbiotic binaries
Classification criteria

CI Cyg, V1261 Ori observation:
ARAS Group, IUE satellite

References:
Kenyon, 1986, The Symbiotic Stars
ISBN: 978-0521093316
Belczyński et al., 2000, Astronomy and Astrophysics Supplement
doi: 10.1051/aas:2000280
Merc et al., 2020, Monthly Notices of the Royal Astronomical Society
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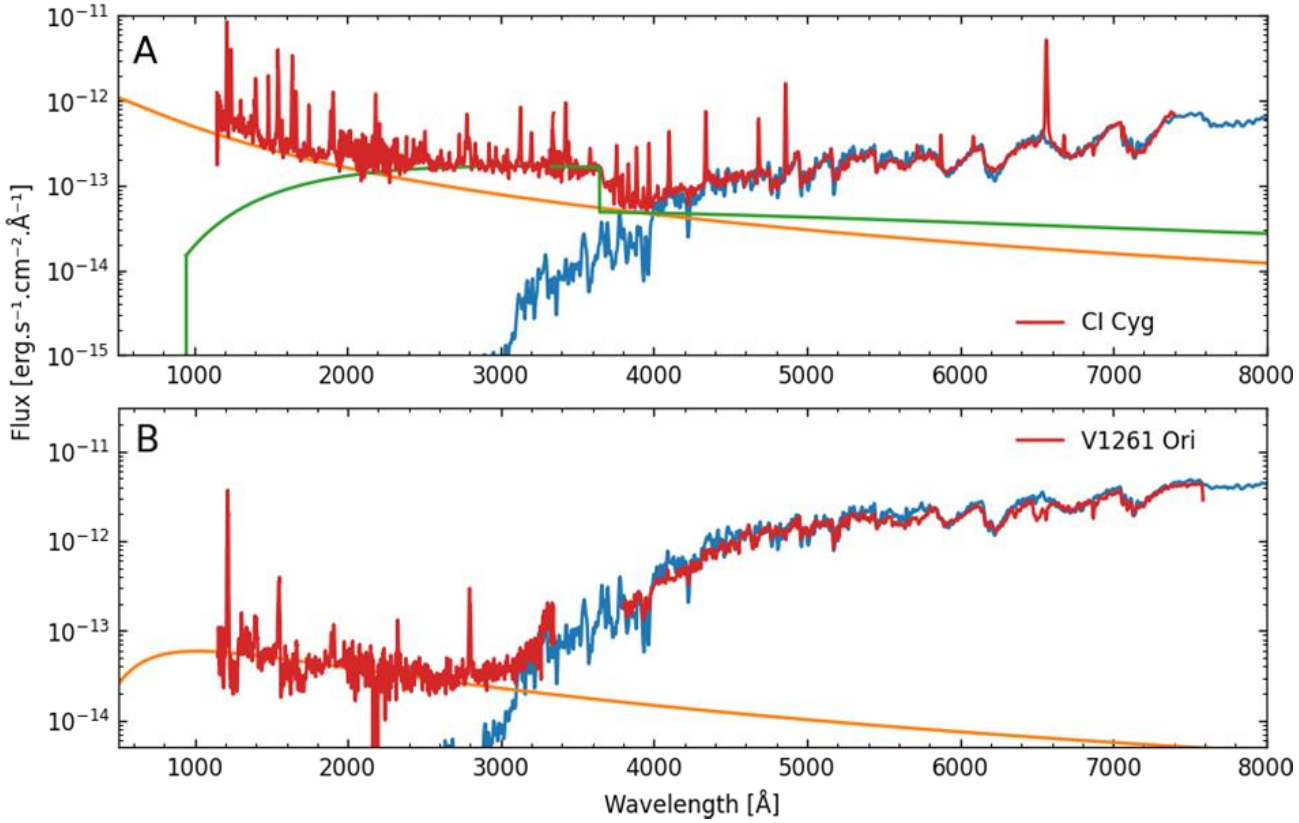

Figure: UV/optical spectrum of a shell-burning symbiotic binary (CI Cyg, panel A) and accreting-only system (V1261 Ori).

Spectroscopic appearance

Observations:
ARAS Group

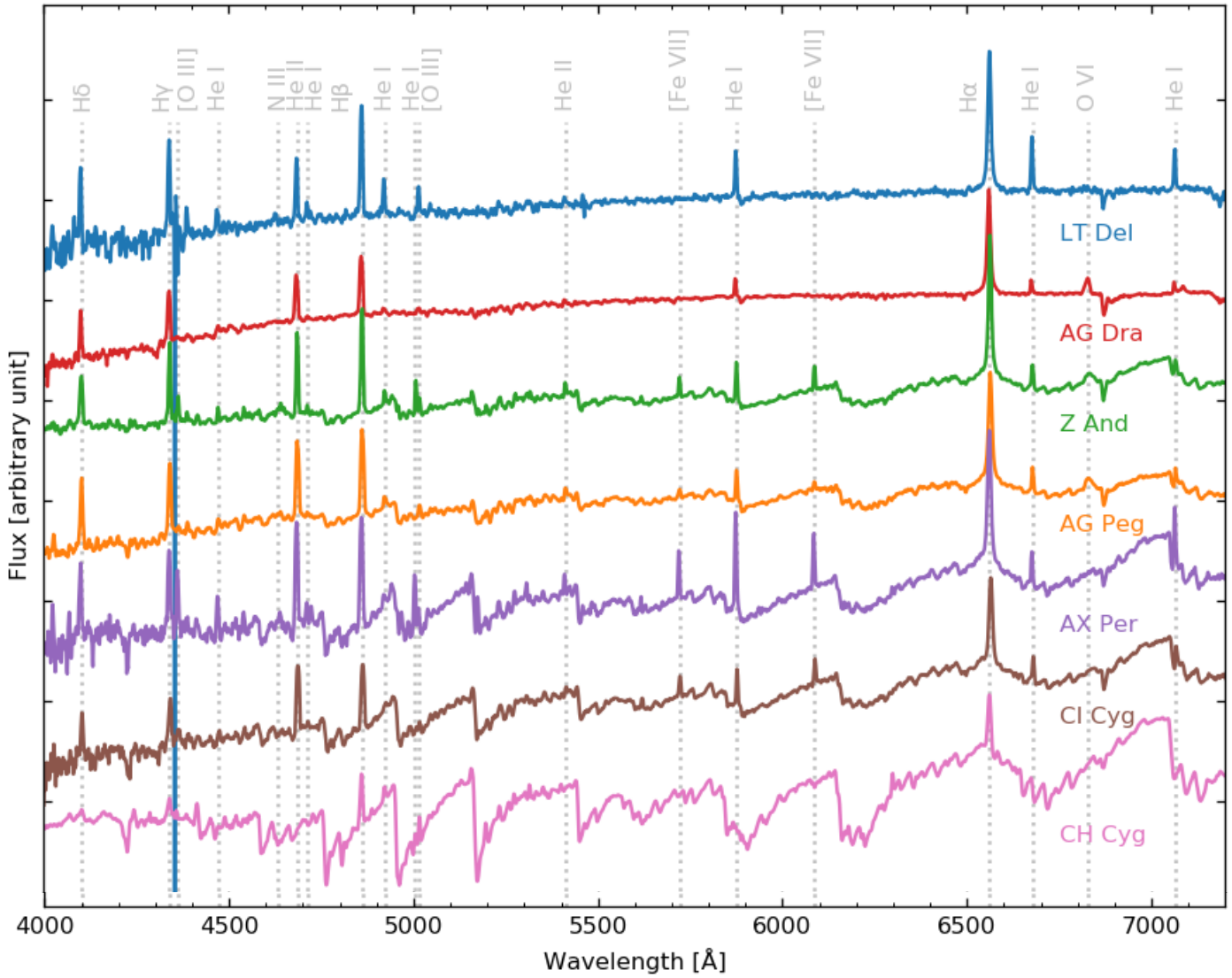

Figure: Optical spectra of selected symbiotic binaries.

Spectroscopic appearance

Observations:
ARAS Group

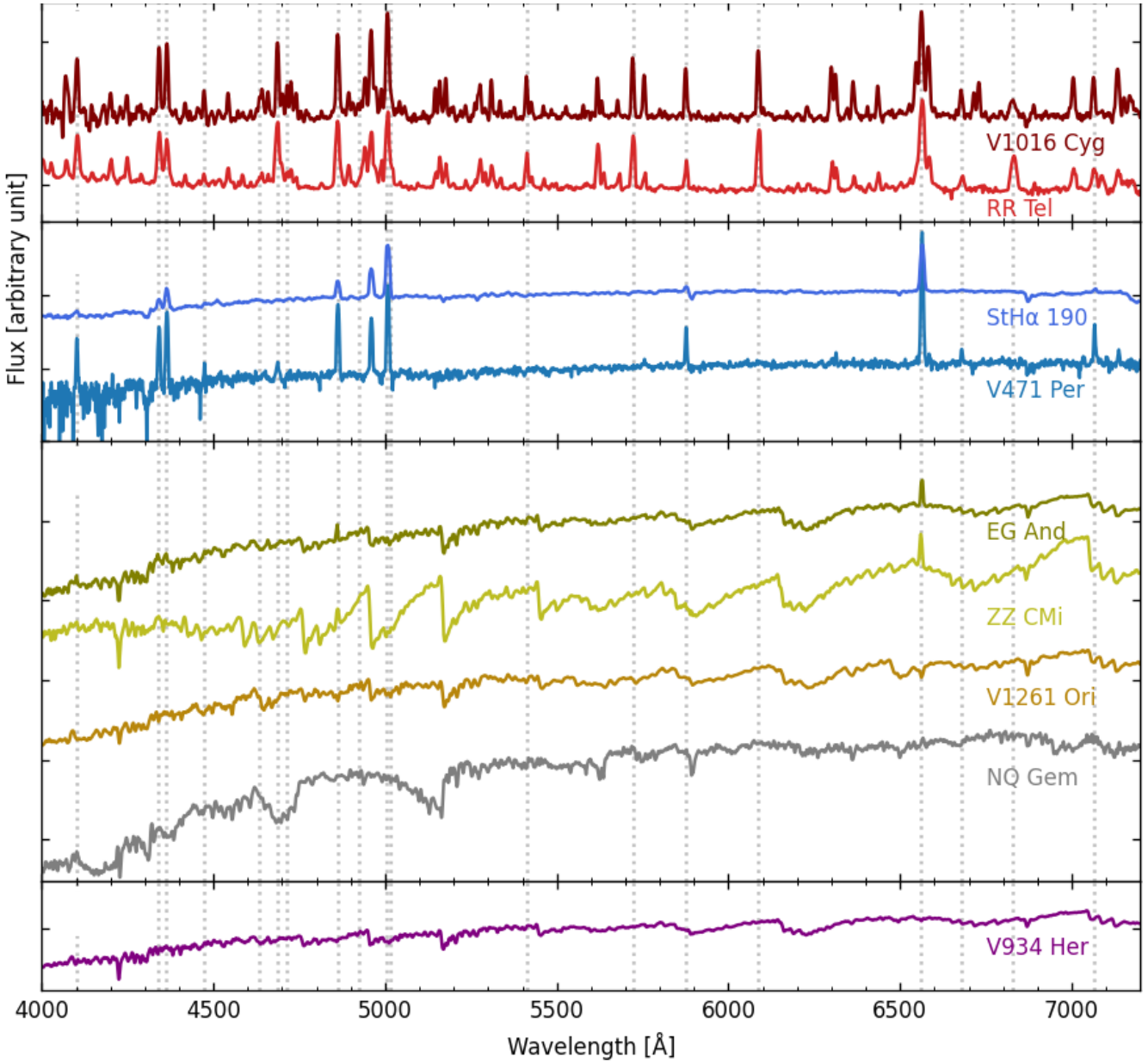

Figure: Optical spectra of selected symbiotic binaries.

Light curves

References:
Skopal, 2008, The Journal of the American Association of Variable Star Observers
Merc et al., 2019, Contributions of the Astronomical Observatory Skalnaté Pleso
Munari, 2019, Review in The Impact of Binary Stars on Stellar Evolution
arXiv:1909.01389

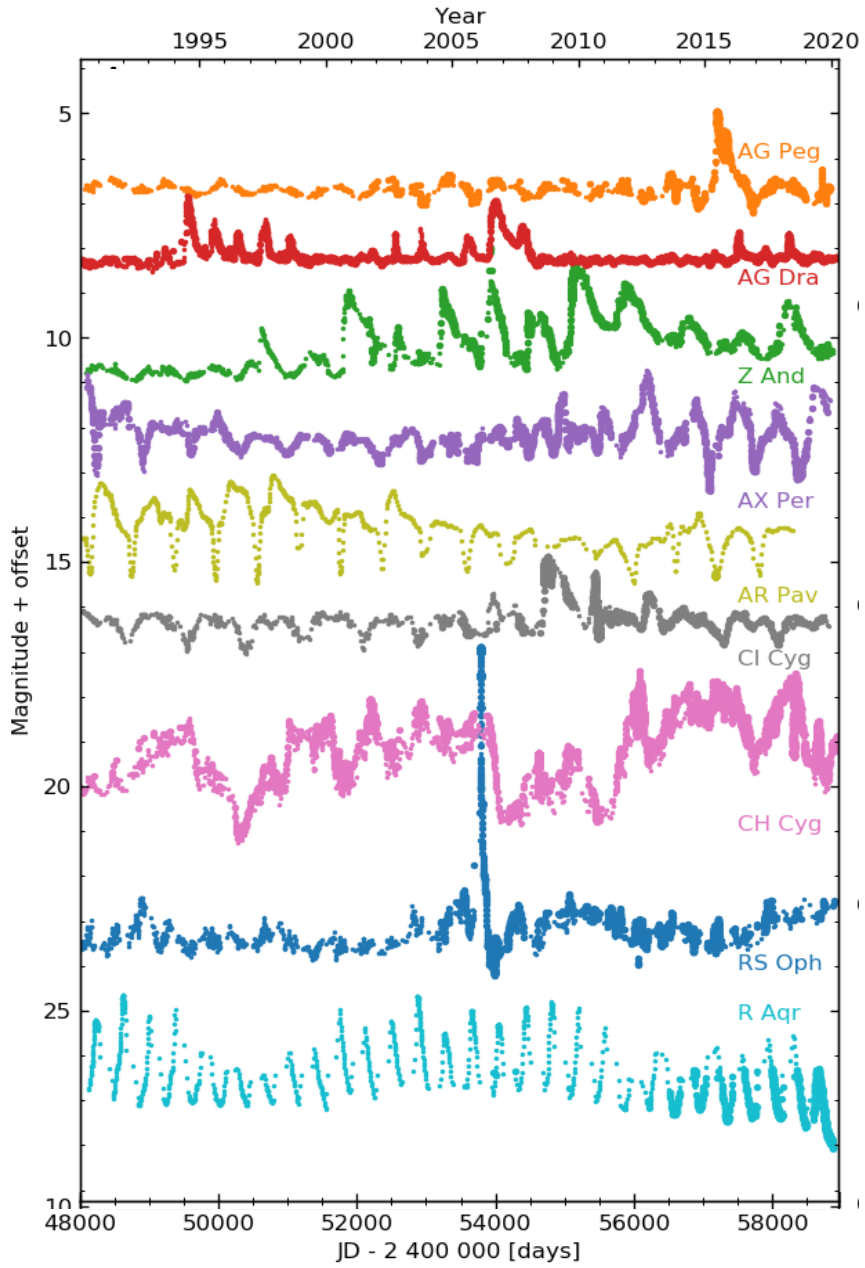

Figure: Light curves of selected symbiotic stars.

Light curves

- very **complicated** and irregular
- **outbursts** in active stages
- sinusoidal **variation** in quiescence
- **variability** of both components
- different timescales
  - **minutes** – flickering, oscilations
  - **month and years** – pulsations
  - **years and decades** – nova-like eruptions, solar-like cycles, eclipses

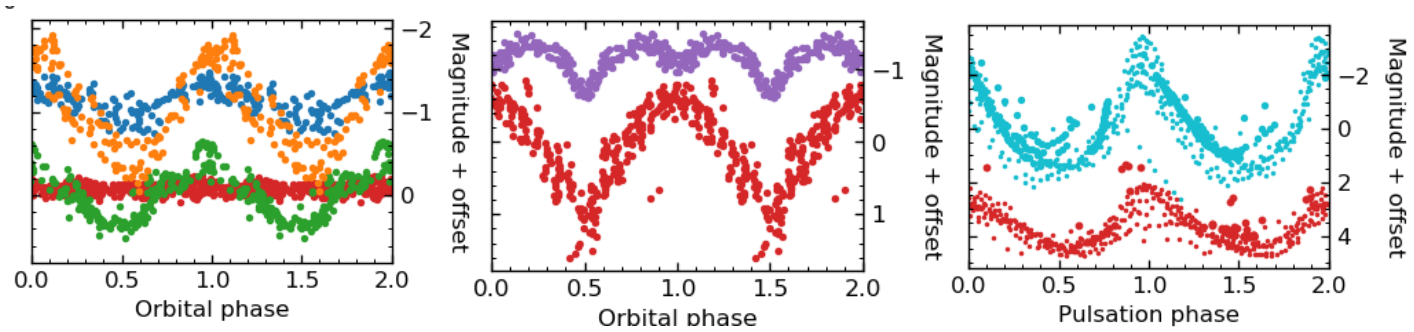

Figure: Selected effects in light curves.

References:

Skopal, 2008, The Journal of the American Association of Variable Star Observers

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

Munari, 2019, Review in The Impact of Binary Stars on Stellar Evolution *arXiv:1909.01389*

Outbursts
Symbiotic novae

- three main categories
  - **classical (Z And-type)**
  - **‘slow’ symbiotic novae**
  - **symbiotic recurrent novae**
- **‘slow’ symbiotic novae**
  - **nova outbursts** of 3 – 7 magnitude
  - slow decline for several **decades**
  - **low-mass** white dwarfs

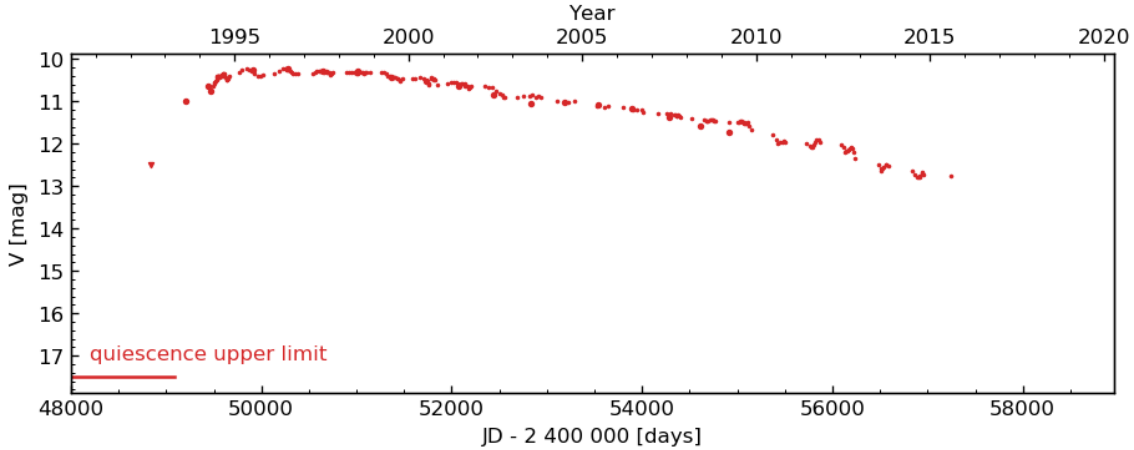

Figure: The light curve of the symbiotic nova V4368 Sgr.

References:

Mikołajewska, 2010, Proceedings of Physics of Accreting Compact Binaries
arXiv:1011.5657

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

Outbursts
Symbiotic novae

References:
Mikołajewska, 2010, Proceedings of Physics of Accreting Compact Binaries
arXiv:1011.5657
Mikołajewska, 2012, Baltic Astronomy
doi: 10.1515/astro-2017-0352
Munari, 2019, Review in The Impact of Binary Stars on Stellar Evolution
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- three main categories
  - **classical (Z And-type)**
  - **'slow' symbiotic novae**
  - **symbiotic recurrent novae**
- **'slow' symbiotic novae**
  - **nova outbursts** of 3 – 7 magnitude
  - slow decline for several **decades**
  - **low-mass** white dwarfs
- **symbiotic recurrent novae**
  - **massive** white dwarfs
  - **short** outbursts (weeks)
  - recurrence times of **few years/tens of years**

Outbursts
Z And-type

- Z And-type
  - active stages from a few weeks **to years**
  - **several** outbursts
  - very **different morphology** from one object to another

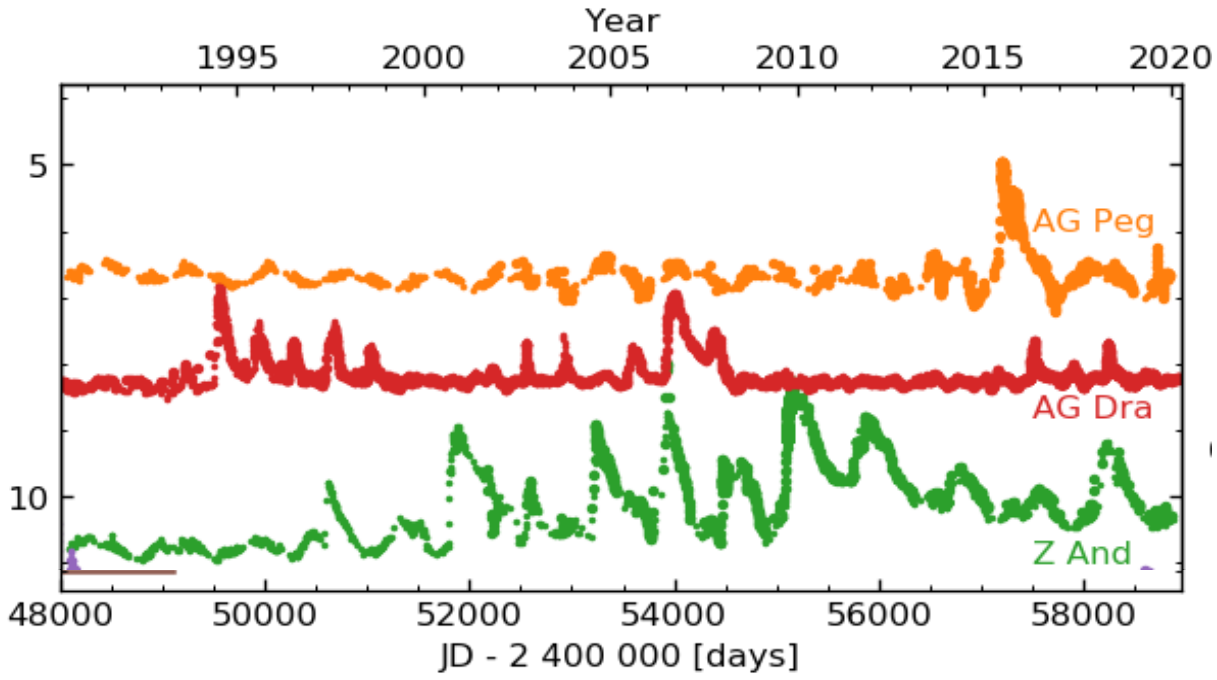

Figure: Long-term light curves of selected symbiotic binaries.

References:
Mikołajewska, 2012, Baltic Astronomy
doi: 10.1515/astro-2017-0352
Merc et al., 2019, Contributions of the Astronomical Observatory Skalnaté Pleso

Outbursts
Z And-type

References:
Mikołajewska, 2012, Baltic Astronomy
doi: 10.1515/astro-2017-0352
Merc et al., 2019, Contributions of the Astronomical Observatory Skalnaté Pleso

- Z And-type
  - active stages from a few weeks **to years**
  - **several** outbursts
  - very **different morphology** from one object to another
- outburst **mechanism**?
  - release of gravitational potential energy
  - expansion of the pseudo-atmosphere of the hot component
  - instabilities in accretion discs
  - combination of the mechanisms?

Spectroscopic changes

- **most prominent changes** in the spectra are **due to their outbursts**
  - the **overall shape of the continuum**
  - the presence, intensity, and shape of the **emission lines**

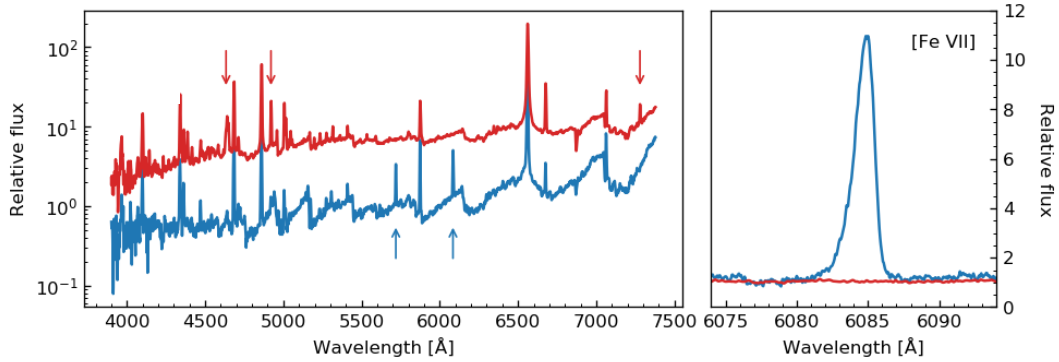

Figure: Changes in optical spectra of AX Per during the outbursts.

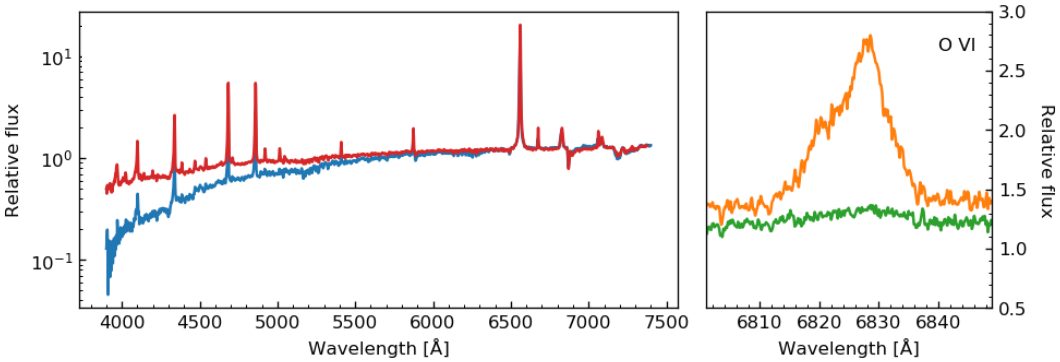

Figure: Changes in optical spectra of AG Dra during the outbursts.

References:

Skopal, 2008, The Journal of the American Association of Variable Star Observers

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

Munari, 2019, Review in The Impact of Binary Stars on Stellar Evolution *arXiv:1909.01389*

Spectroscopic changes

- **most prominent changes** in the spectra are **due to their outbursts**
  - the **overall shape of the continuum**
  - the presence, intensity, and shape of the **emission lines**
- also other variations **influence the spectra**
  - pulsations, eclipses, long-term changes

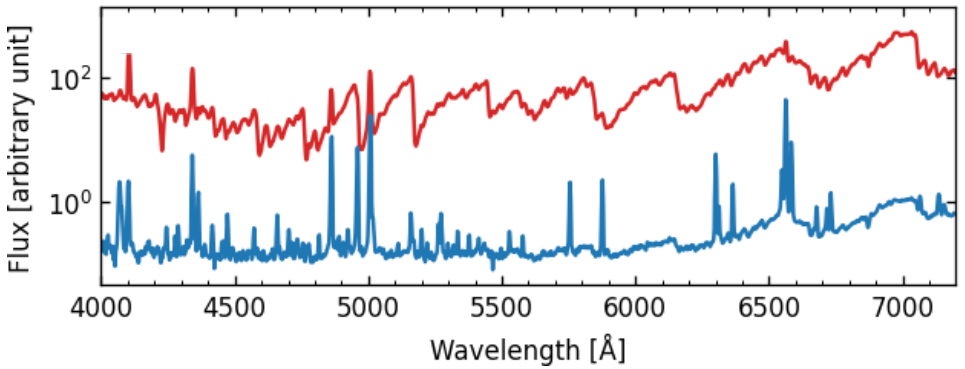

Figure: Influence of Mira pulsations on the optical spectrum of R Aqr.

References:

Skopal, 2008, The Journal of the American Association of Variable Star Observers

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

Munari, 2019, Review in The Impact of Binary Stars on Stellar Evolution *arXiv:1909.01389*

Symbiotic binaries
Importance

- 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

References:
Kenyon, 1986, The Symbiotic Stars
ISBN: 978-0521093316
Mikołajewska, 2013, Proceedings of the International Astronomical Union
doi: 10.1017/S1743921312014925
Iłkiewicz et al., 2019, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stz760

Symbiotic binaries
Open questions

- number of **open questions!**
- **size** of the symbiotic population
  - **fraction** of **accreting-only** symbiotics
- **evolution**
  - pre-symbiotic, post-symbiotic life
- distribution of **orbital periods**
- **mass transfer** mechanisms
  - fraction of **Roche-lobe filling** giants
- **outburst** mechanisms
  - connection between outburst types
- **metallicity** of cool components
- ...

References:
Mürset & Schmid, 1999, Astronomy & Astrophysics Supplement
doi: 10.1051/aas:1999105
Mikołajewska, 2012, Baltic Astronomy
doi: 10.1515/astro-2017-0352
Gałan et al., 2016, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stv2365
Skopal et al., 2020, Astronomy & Astrophysics
doi: 10.1051/0004-6361/201937199

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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

- **latest** catalog published in **2000** (Belczyński et al.)
  - **218** objects (incl. 17 extragalactic)
- new, modern, complex, online database
- **New Online Database of Symbiotic Variables**
  - http://astronomy.science.upjs.sk/symbiotics/
  - **825** (290 + 393 + 142) objects in our Galaxy
  - 179 (70 + 103 + 6) in 16 external galaxies
- **confirmed**, **candidates** (likely, possible, suspected) + **misclassified** objects

New Online Database of Symbiotic Variables

- **tables with data**
  - tabular parameters, cross-identification…
  - sortable, searchable

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Merc et al., 2019, RNAAS
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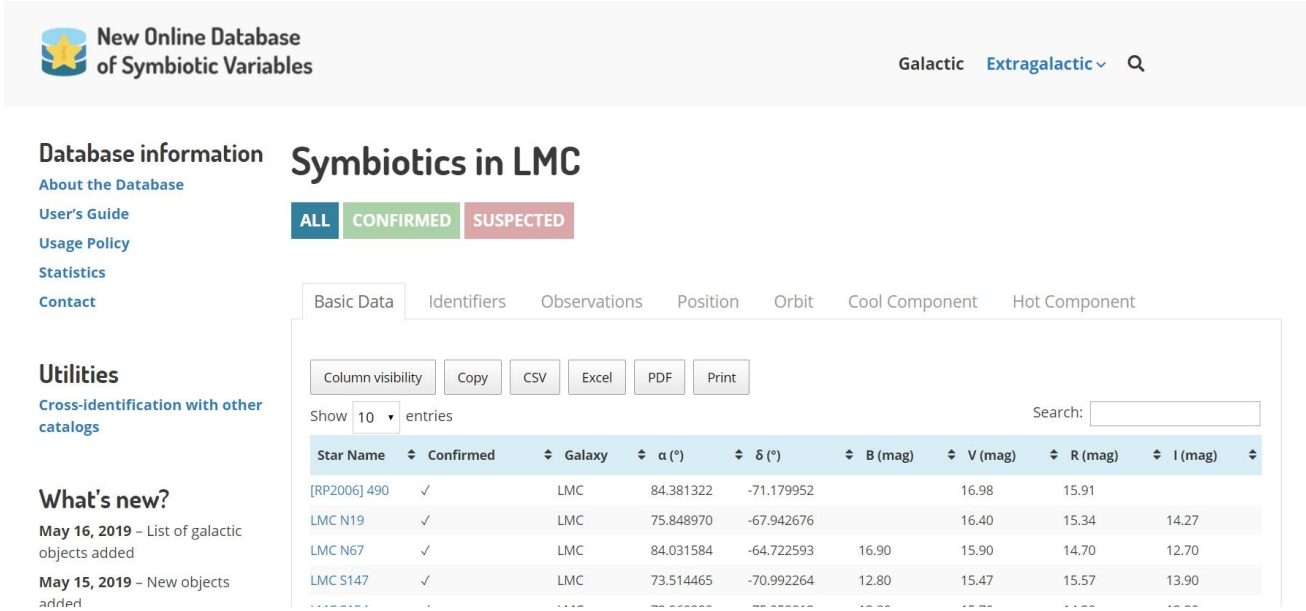

Figure: Catalog data for symbiotic stars in LMC.

New Online Database of Symbiotic Variables

- **tables with data**
  - tabular parameters, cross-identification…
  - sortable, searchable
- **object pages**
  - references
  - notes, links

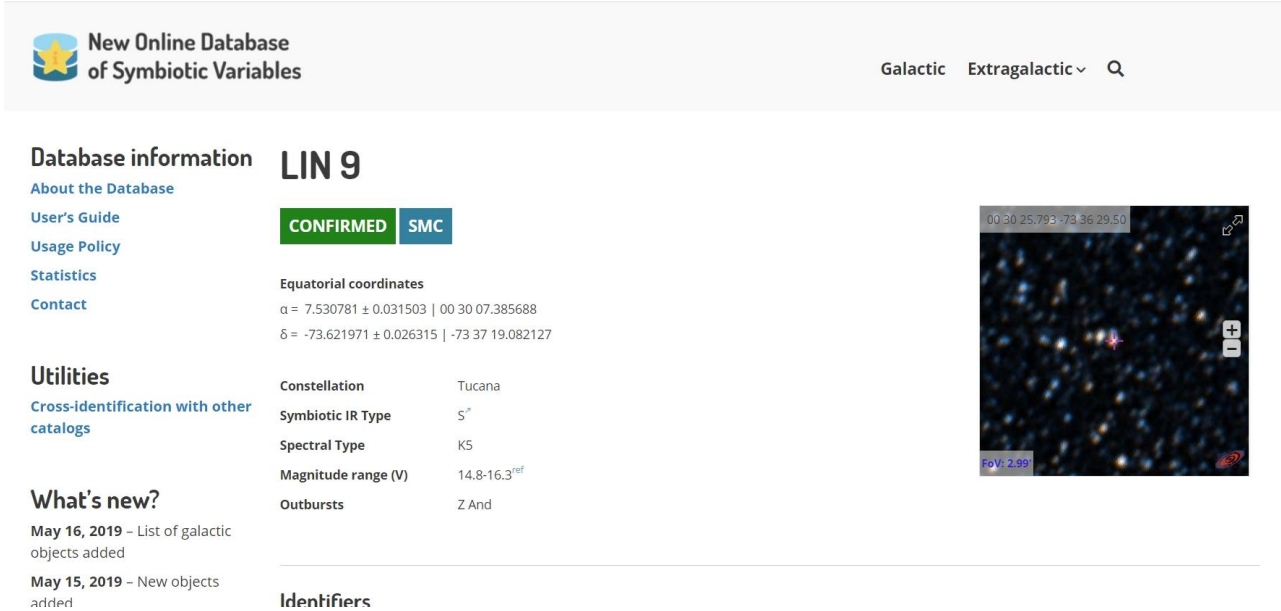

Figure: Example of the object page of symbiotic star LIN9.

References:

Merc et al., 2019, RNAAS
doi: 10.3847/2515-5172/ab0429

Merc et al., 2019, Astronomische Nachrichten
doi: 10.1002/asna.201913662

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doi: 10.31577/caosp.2020.50.2.426

- **first** release in **2019**
  - feedback from the symbiotic community
  - 25 citations (excluding autocitations)
- **most comprehensive collection** ever published
  - **orbital**, **stellar**, other **observational parameters** of the symbiotic stars
  - many **suggestions** from past based on the smaller samples **confirmed**
  - new results based on statistically **significant sample**
- **input for further research**
  - search for new symbiotic stars
  - machine-learning algorithms
  - statistical analysis of the symbiotic population

Orbital parameters

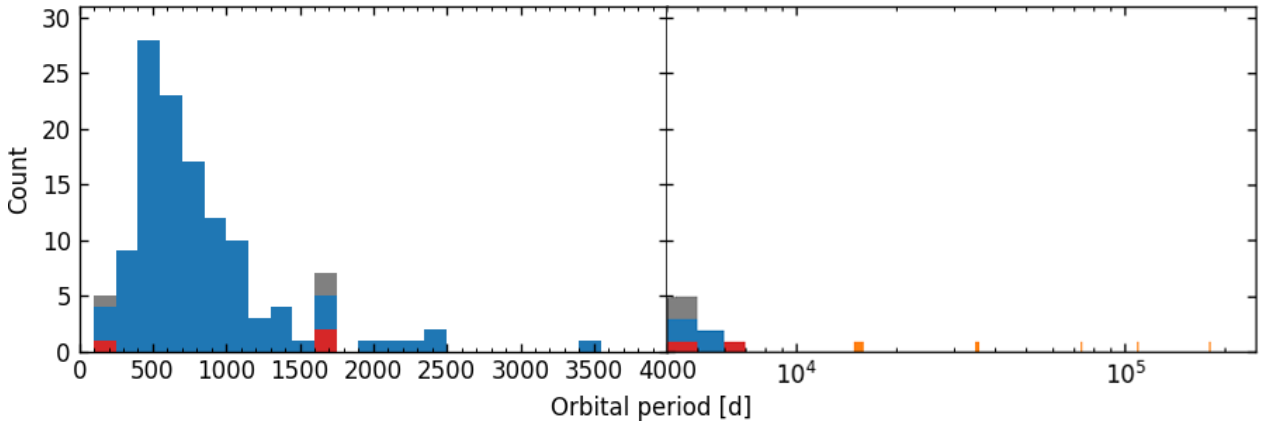


Figure: Orbital periods of symbiotic binaries.

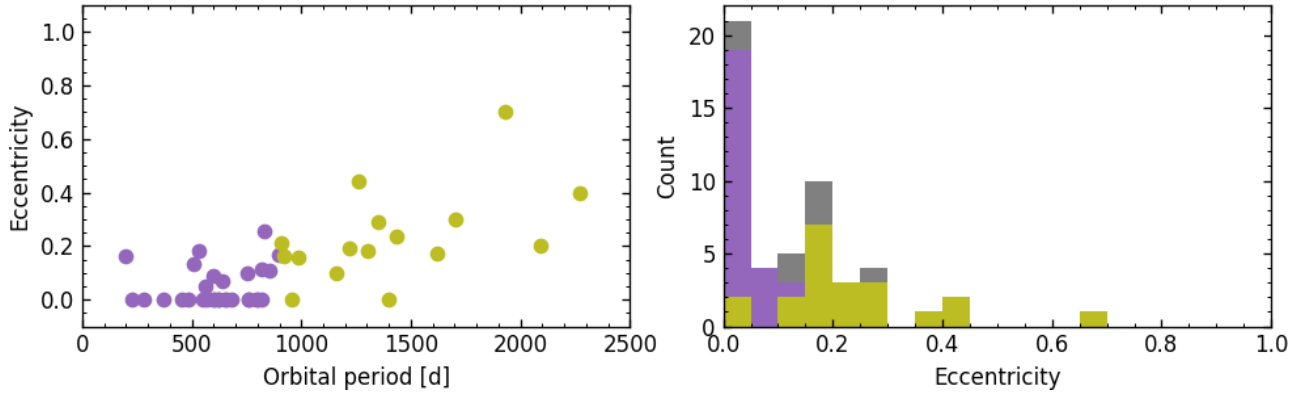


Figure: Eccentricity of symbiotic orbits.

References:

Merc et al., in preparation

Cool components

References:
Merc et al., in preparation

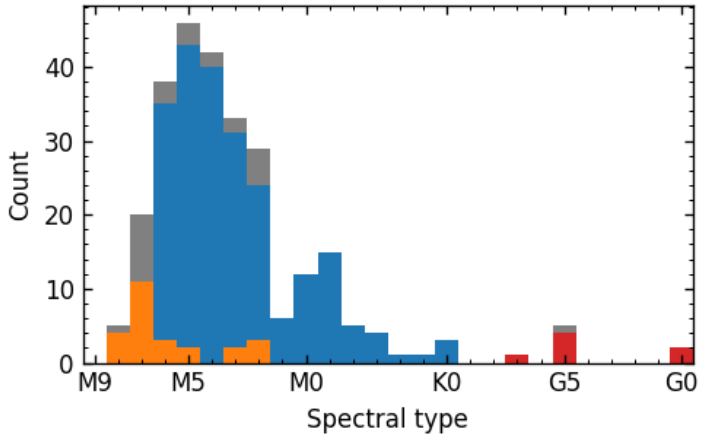


Figure: Spectral types.

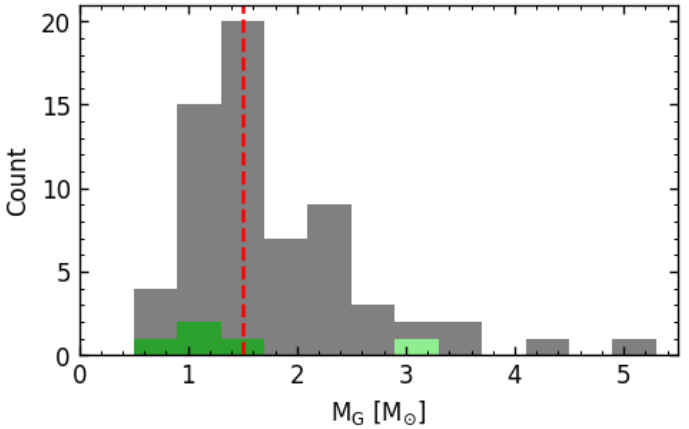


Figure: Masses.

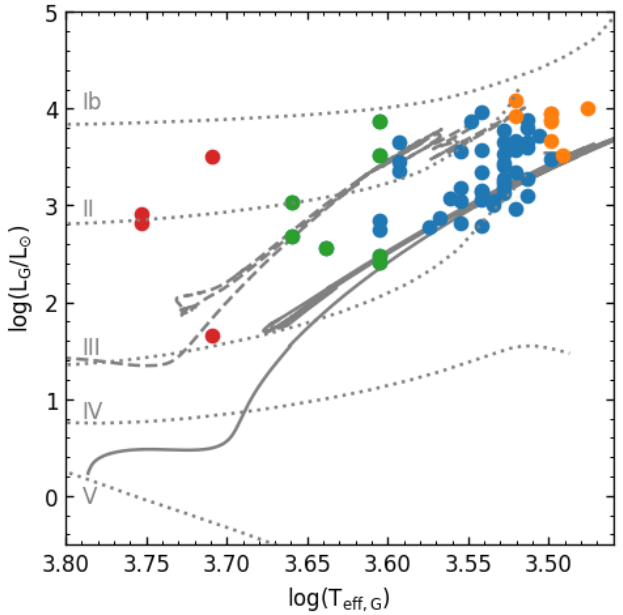


Figure: Position in HR diagram.

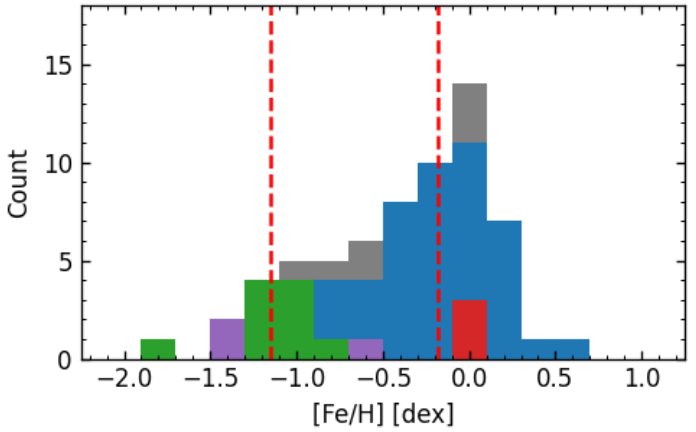


Figure: Metallicities.

Cool components

References:
Merc et al., in preparation

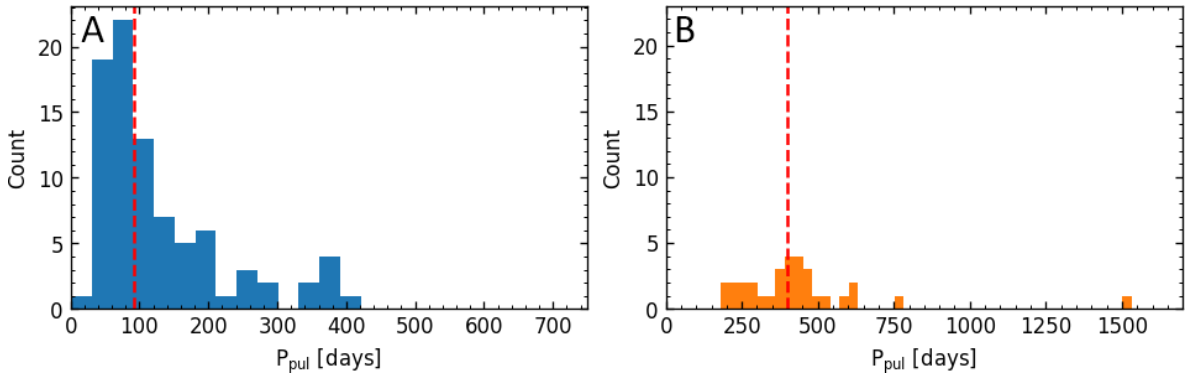


Figure: Pulsation periods.

Hot components

References:
Merc et al., in preparation

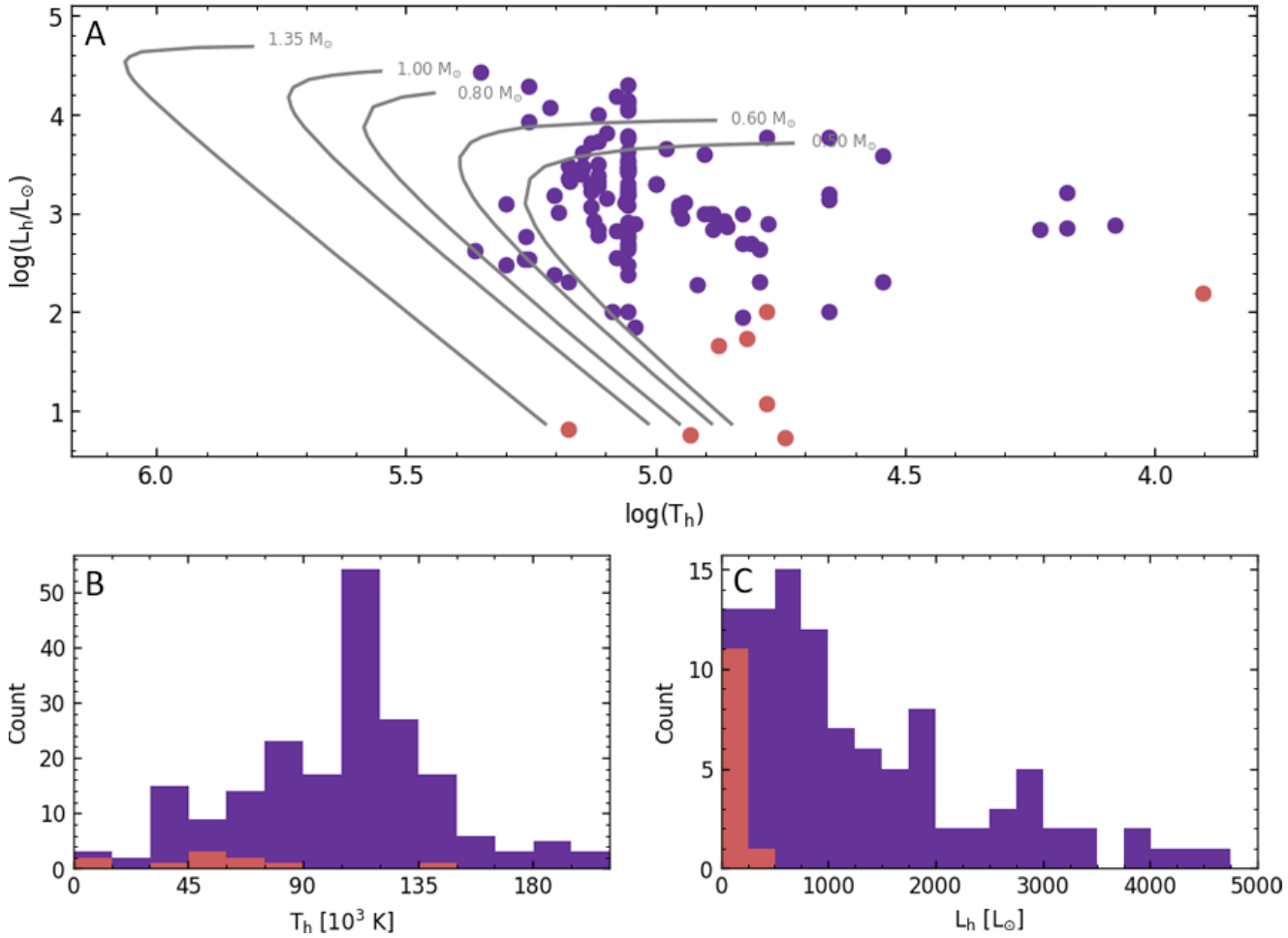


Figure: Temperatures and luminosities of the symbiotic white dwarfs.

Hot components

References:
Merc et al., in preparation

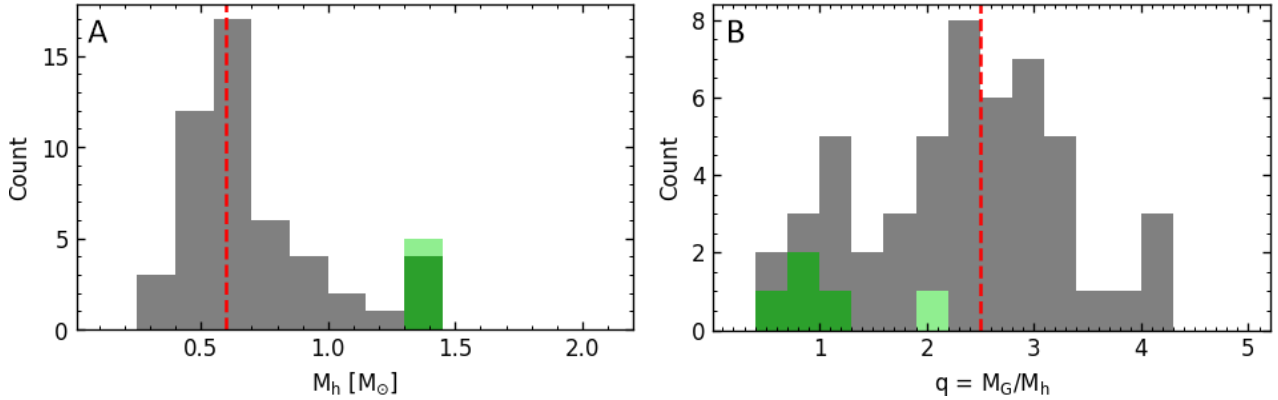


Figure: Masses of the hot components and the mass ratio.

Symbiotic population

References:
Merc et al., in preparation

- **expected numbers** in the Milky Way
  - 1 200 – 15 000 (Lü, Yungelson & Han, 2006)
  - 3 000 (Allen, 1984)
  - 3 000 – 30 000 (Yungelson et al., 1995)
  - 30 000 (Kenyon et al., 1993)
  - 300 000 (Munari & Renzini, 1992)
  - 400 000 (Magrini, Corradi & Munari, 2003)

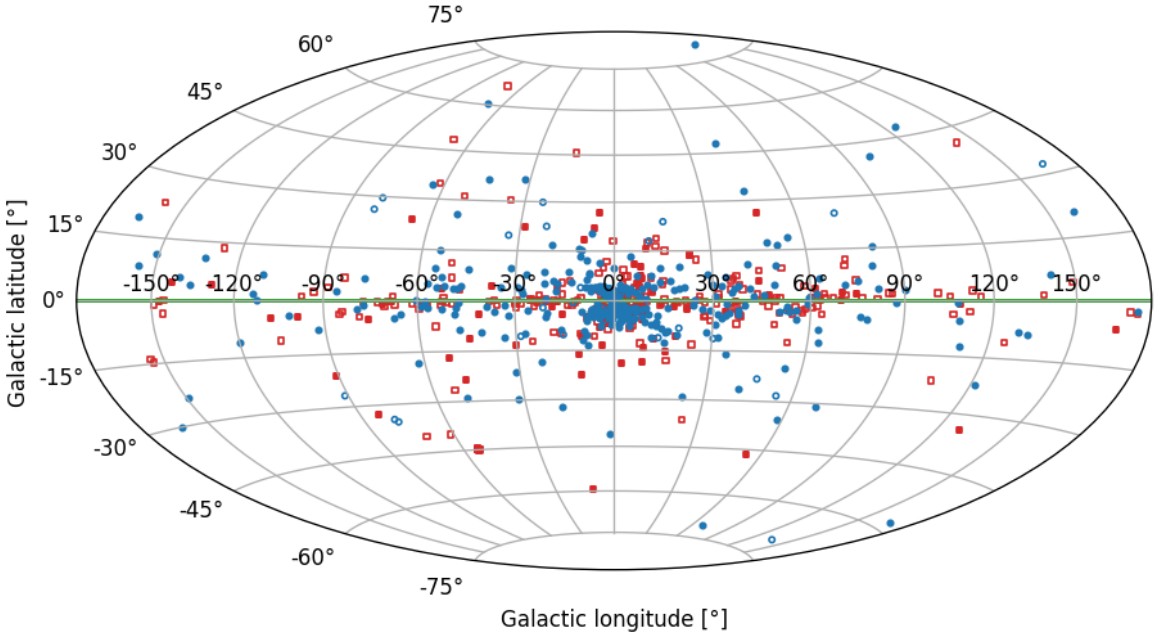


Figure: Galactic symbiotic stars.

Symbiotic candidates

- **New Online Database of Symbiotic Variables**
  - many of the known symbiotic stars are only **poorly studied**
  - several **candidates** from recent surveys
- **observing campaign** on the selected objects from our Database
  - **objects with no or limited spectroscopic information**
  - **multi-frequency** photometric data
  - spectra in cooperation **ARAS & 2SPOT,** from archives and newly acquired data

References:
Merc et al., 2019, RNAAS
doi: 10.3847/2515-5172/ab0429
Merc et al., 2020, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/staa3063
Merc et al., 2021, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stab2034

Symbiotic candidates

- photometric and spectroscopic analysis of **poorly studied symbiotic candidates**
  - **„cleaning“** the database
  - input for statistical research

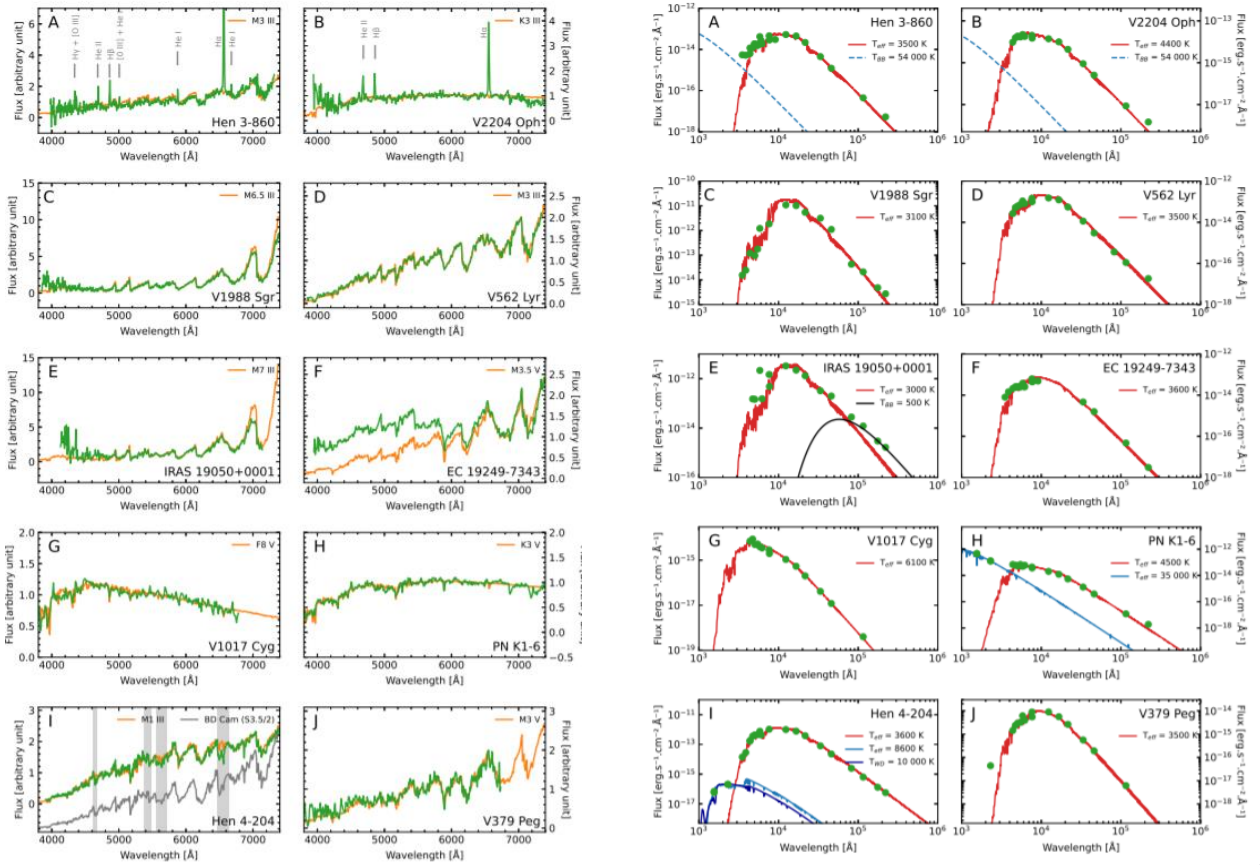


Figure: Optical spectra and multi-frequency SEDs of candidates.

References:

Merc et al., 2020, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/staa3063

Merc et al., 2021, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stab2034

Symbiotic candidates

- photometric and spectroscopic analysis of **poorly studied symbiotic candidates**
  - **„cleaning“** the database
  - input for statistical research

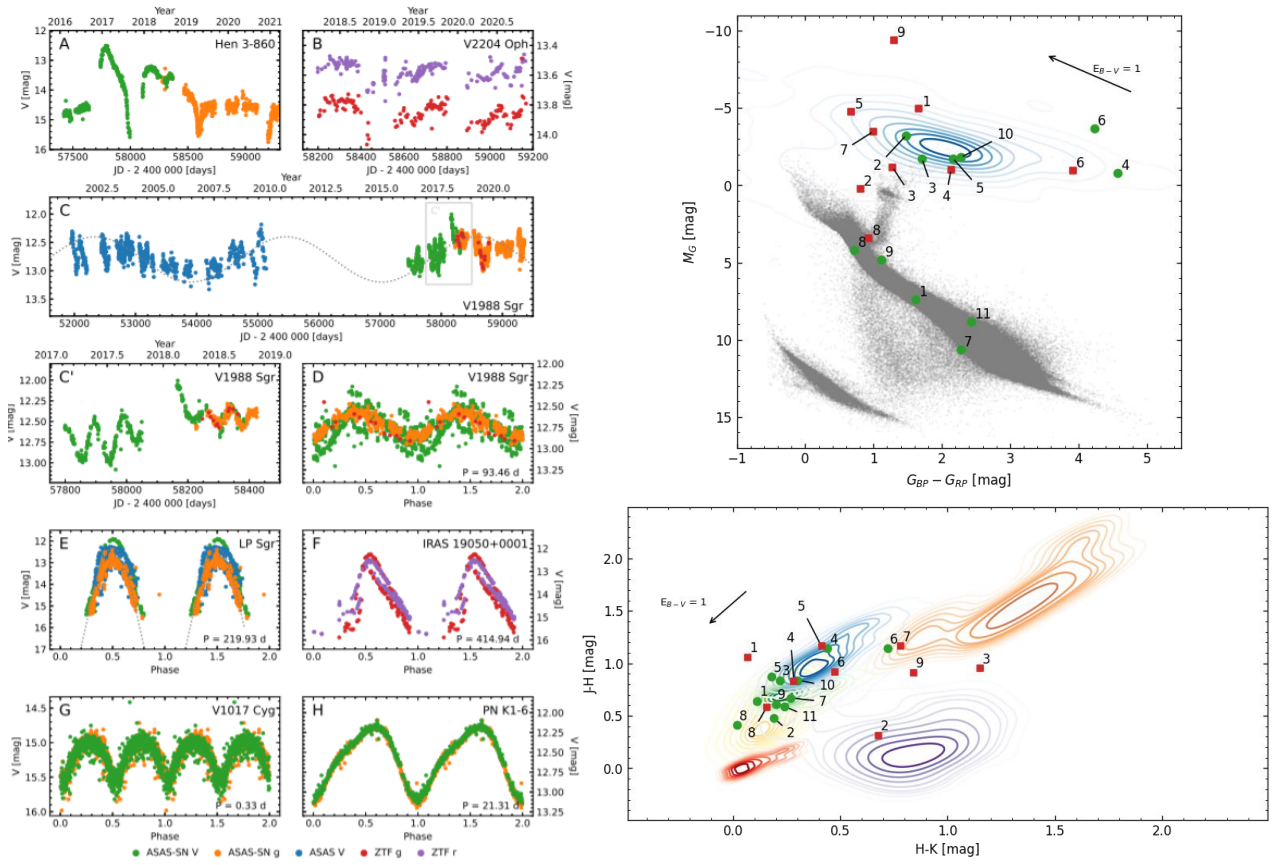


Figure: Light curves, HR diagram and IR color-color diagram.

References:

Merc et al., 2020, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/staa3063

Merc et al., 2021, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stab2034

Symbiotic candidates

- almost **100 „literature“ candidates** already analyzed
  - candidates on classical symbiotic stars
  - symbiotic nova candidates
  - all 27 candidates in the LMC
  - candidates in globular cluster 47 Tuc
  - Gaia DR3 symbiotic candidates

References:
Merc et al., 2019, RNAAS
doi: 10.3847/2515-5172/ab0429
Merc et al., 2020, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/staa3063
Merc et al., 2021, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stab2034

V2204 Oph

- at least two **outbursts** (1926, 1983)
  - possible **symbiotic binary**
- **never** observed spectroscopically
- spectrum of **K5 giant**, strong **emission lines**
  - excess in blue and **UV region**
  - **yellow** symbiotic star

Spectrum:
P. Velez, ARAS Group

References:
Ross, 1926, Astronomical Journal
doi: 10.1086/104698
Samus', 1983, Mitt. Verand. Sterne
Merc et al., 2021, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stab2034

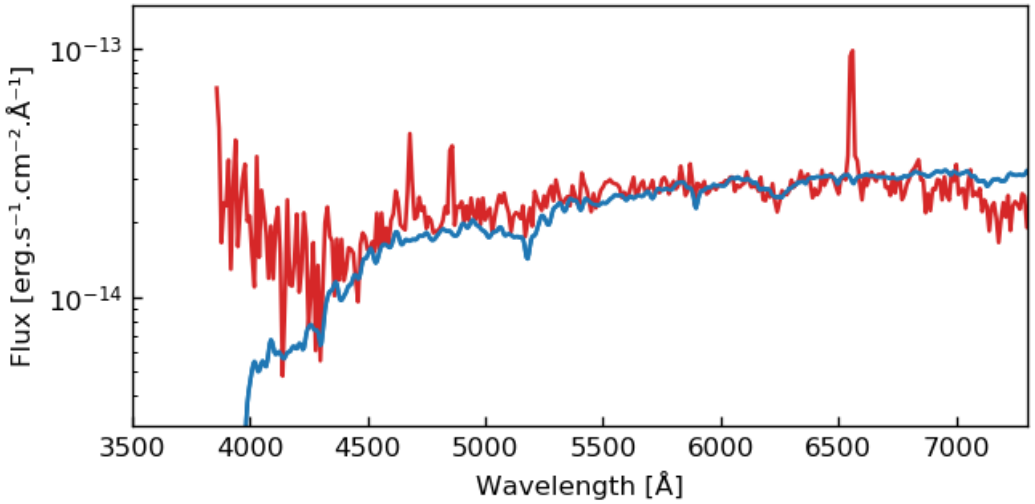


Figure: Spectrum of V2204 Oph.

Hen 3-860

- 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, [Fe VII]

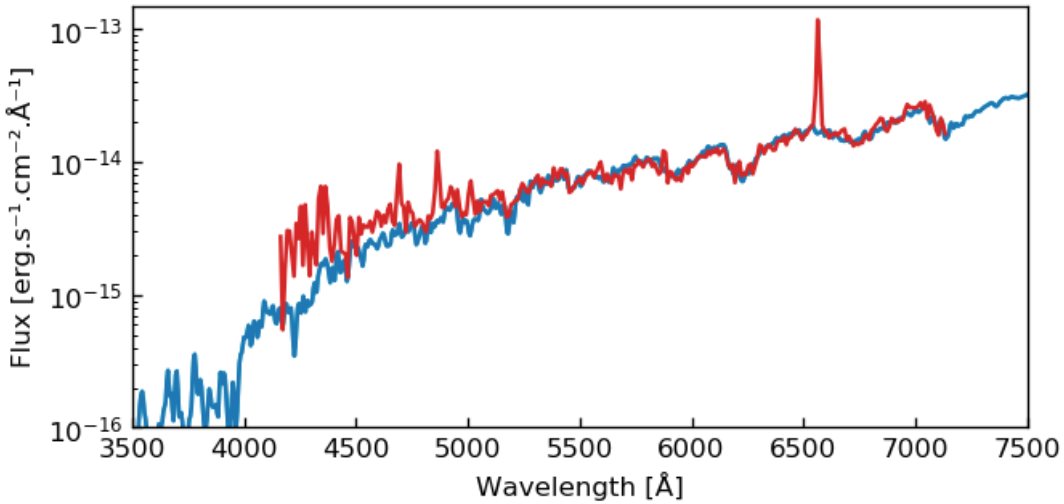


Figure: Spectrum of Hen 3-860.

References:

Merc et al., 2021, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stab2034

Merc et al., 2022, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stab3512

Hen 3-860

- 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, [Fe VII]
- orbital period of **602 days**
- **two** or three **outbursts** in past

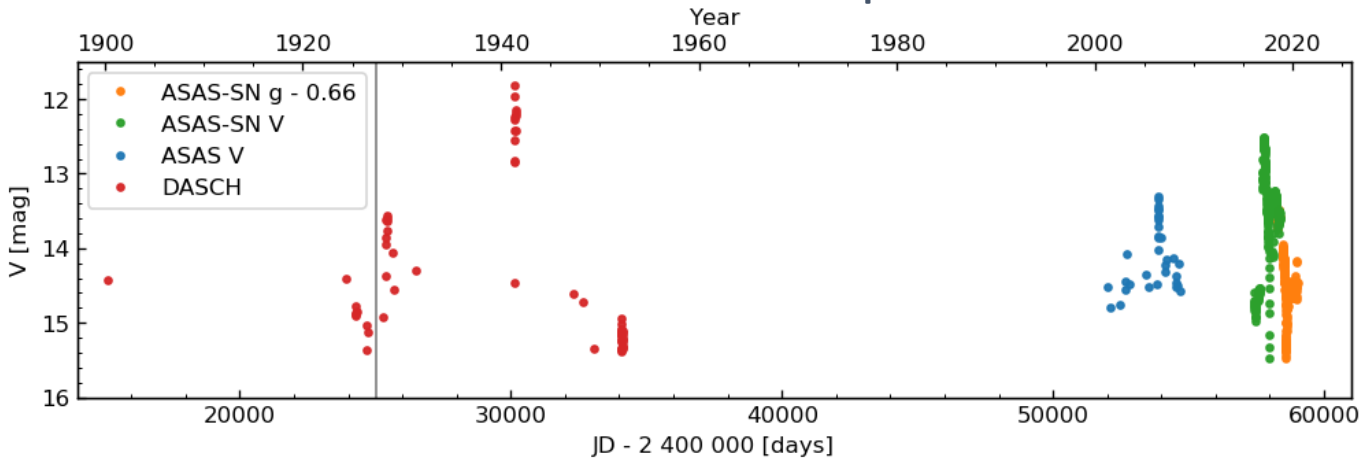


Figure: Historical light curve of Hen 3-860.

References:

Merc et al., 2021, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stab2034

Merc et al., 2022, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stab3512

V618 Sgr

References:
Swope & Shapley, 1940, Annals of the Astronomical Observatory of Harvard College
Kilkenny, 1989, The Observatory
Merc et al., in preparation

- initially classified as **R CrB-type variable** based on the light curve
- **hydrogen lines** in emission -> symbiotic star?
  - no emission lines of **high ionization potential**

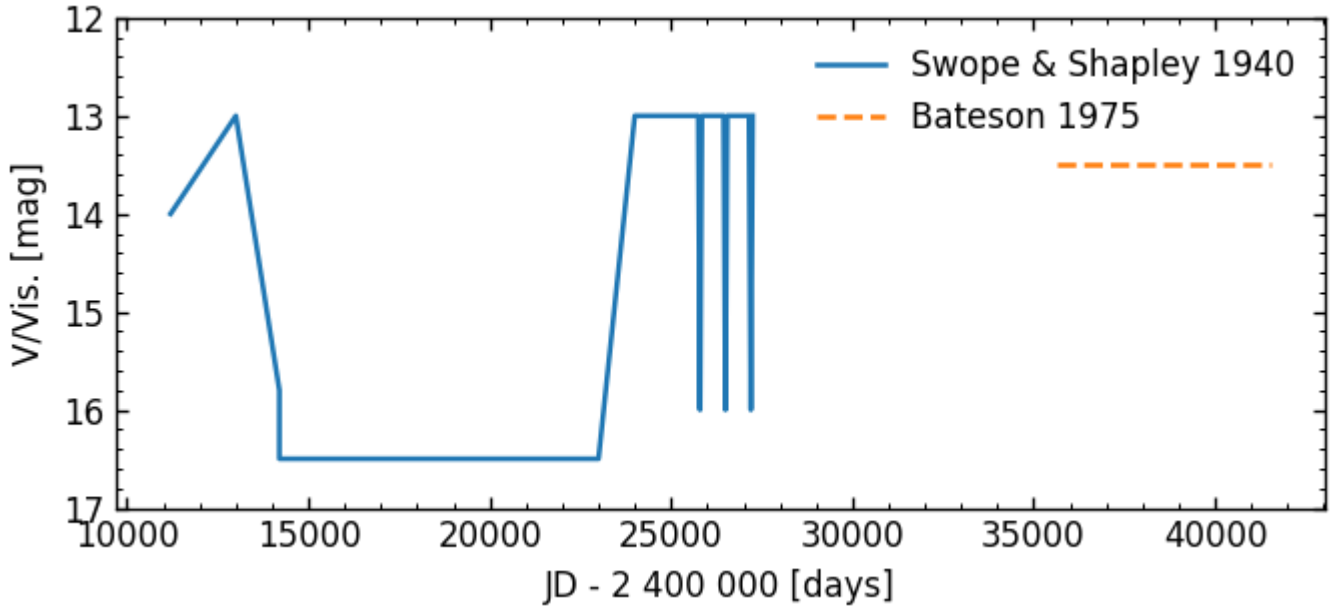


Figure: Reconstructed light curve of V618 Sgr.

V618 Sgr

References:
Swope & Shapley, 1940, Annals of the Astronomical Observatory of Harvard College
Kilkenny, 1989, The Observatory
Merc et al., in preparation

- initially classified as **R CrB-type variable** based on the light curve
- **hydrogen lines** in emission -> symbiotic star?
  - no emission lines of **high ionization potential**

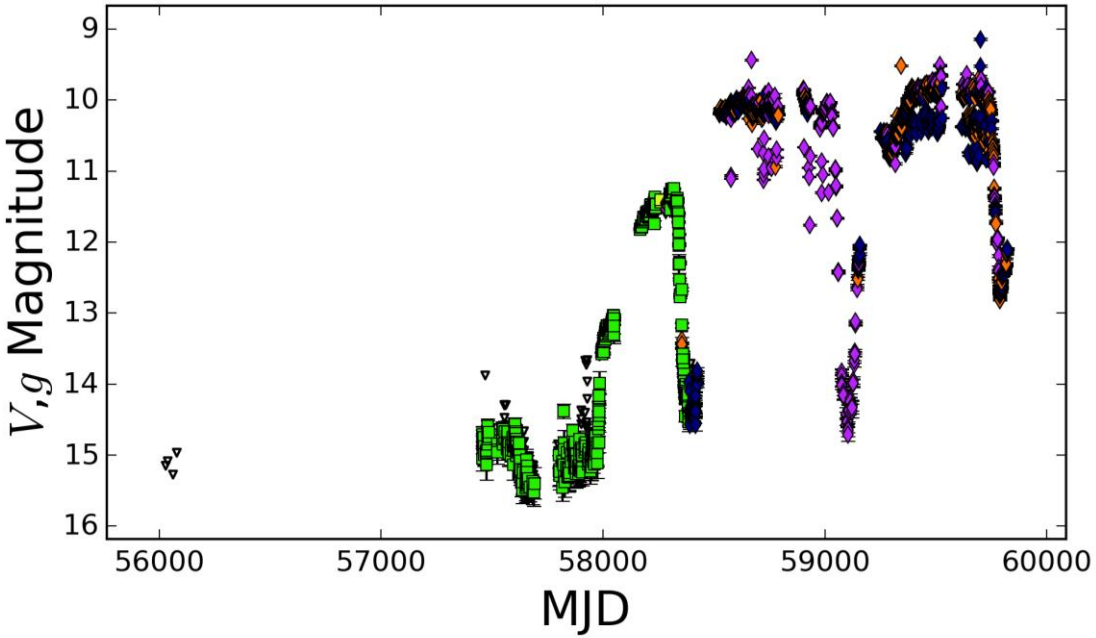


Figure: Recent ASAS-SN light curve of V618 Sgr.

V618 Sgr

First recurrent ‘slow’ symbiotic nova?

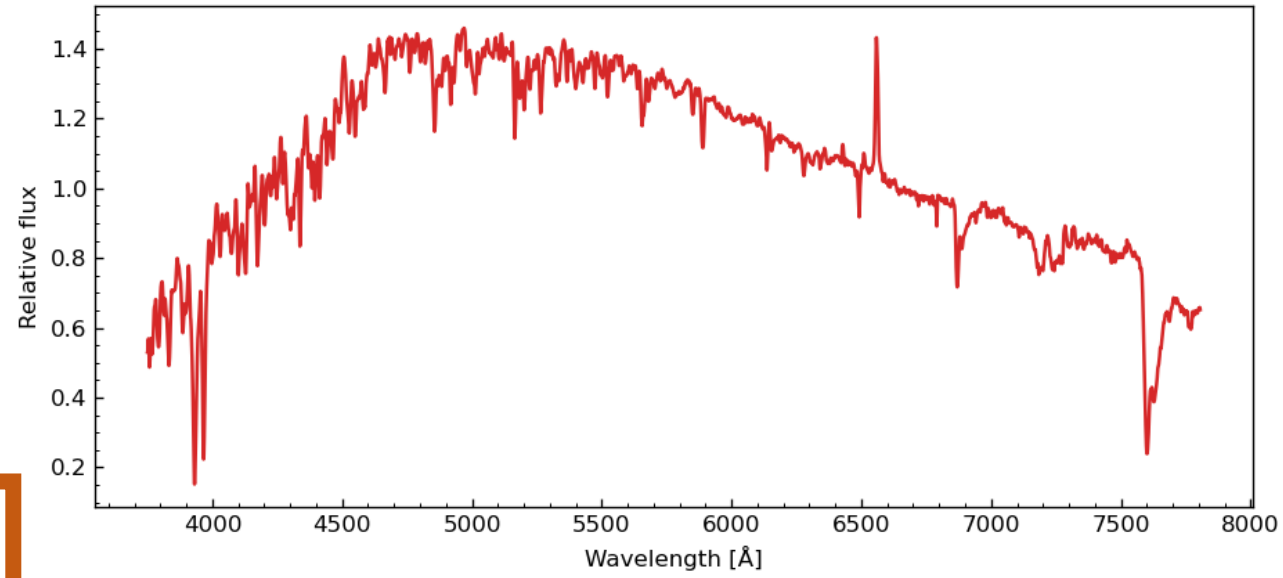


Figure: Optical spectrum of V618 Sgr (April 9, 2022).

Spectrum:
S. Charbonnel, O. Garde, P. Le Dû, L. Mulato
T. Petit; 2SPOT

References:
Swope & Shapley, 1940, Annals of the Astronomical Observatory of Harvard College
Kilkenny, 1989, The Observatory
Merc et al., in preparation

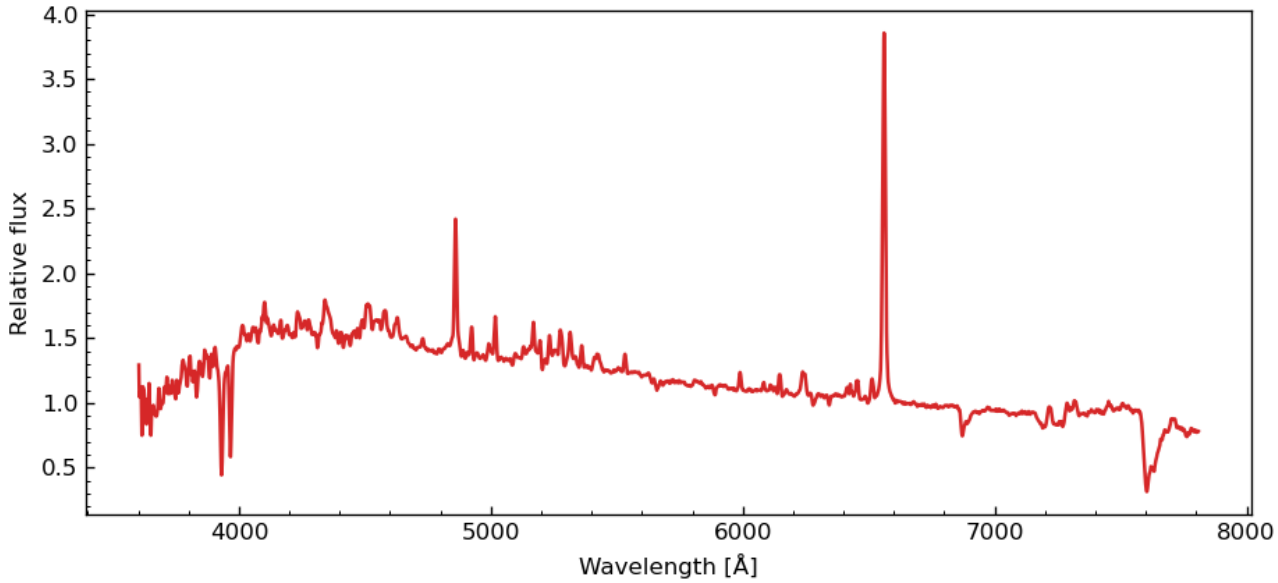
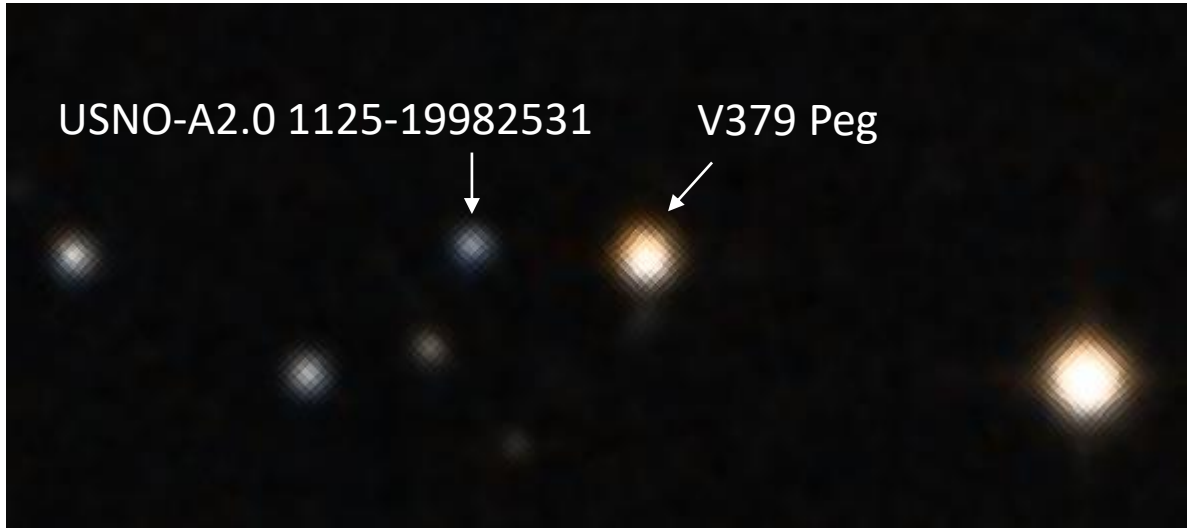


Figure: Optical spectrum of V618 Sgr (May 20, 2022).

V379 Peg

- object **detected in outburst** (1981)
  - UV-excess star with a blue continuum
- spectrum of **cool star** (1988)
  - symbiotic binary?
- not the same object?



Spectrum:
C. Buil, ARAS Group

References:
Lipovetsky & Stepanian, 1981, Astrofizika
Kopylov, Lipovetsky et al., 1988, Astrofizika
Merc et al., 2021, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stab2034

V379 Peg

- object **detected in outburst** (1981)
  - UV-excess star with a blue continuum
- spectrum of **cool star** (1988)
  - symbiotic binary?
- not the same object?
- spectrum of M3V star, distance 106 pc

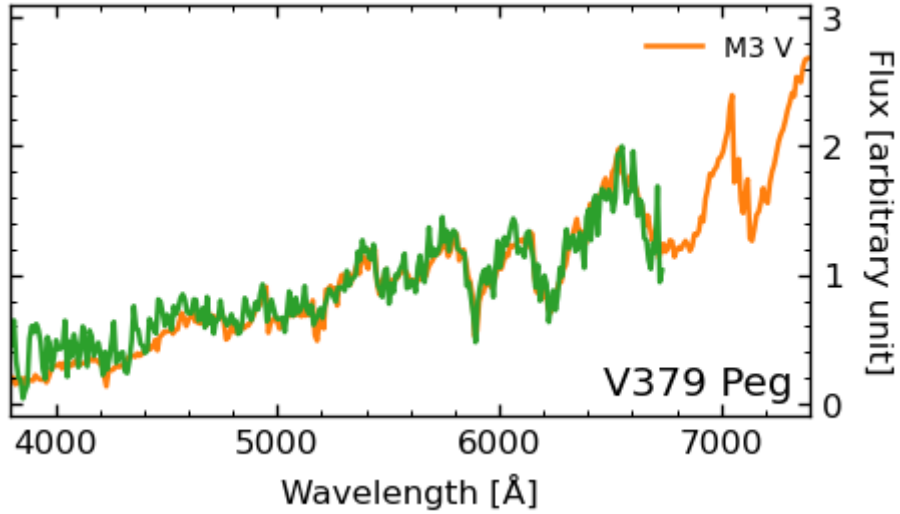


Figure: Spectrum of V379 Peg.

Spectrum:
C. Buil, ARAS Group

References:
Lipovetsky & Stepanian, 1981, Astrofizika
Kopylov, Lipovetsky et al., 1988, Astrofizika
Merc et al., 2021, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stab2034

V1017 Cyg

- classified as a **symbiotic star** during the analysis of post-AGB stars
  - based on the **photometric** appearance
  - **no spectrum**
- also in **RR Lyr** catalog
- spectrum of **G1 V star**, distance of 1100 pc

Spectrum:
C. Buil, ARAS Group

References:
Szczerba et al., 2007, Astronomy and Astrophysics
doi: 10.1051/0004-6361:20067035

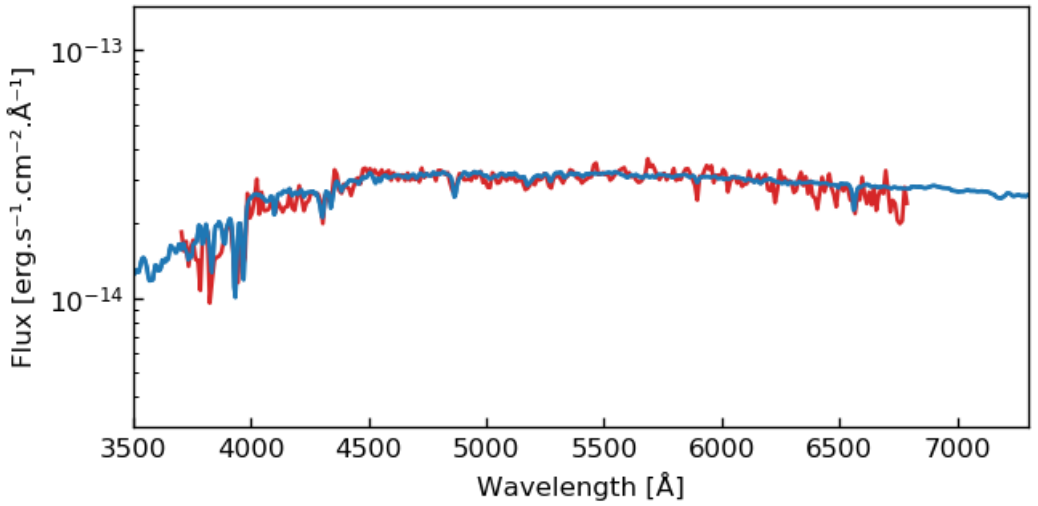


Figure: Spectrum of V1017 Cyg.

V1017 Cyg

Spectrum:
C. Buil, ARAS Group

References:
Szczerba et al., 2007, Astronomy and Astrophysics
doi: 10.1051/0004-6361:20067035

- classified as a **symbiotic star** during the analysis of post-AGB stars
  - based on the **photometric** appearance
  - **no spectrum**
- also in **RR Lyr** catalog
- spectrum of **G1 V star**, distance of 1100 pc
- variability with period of **0.33 days – W UMa**

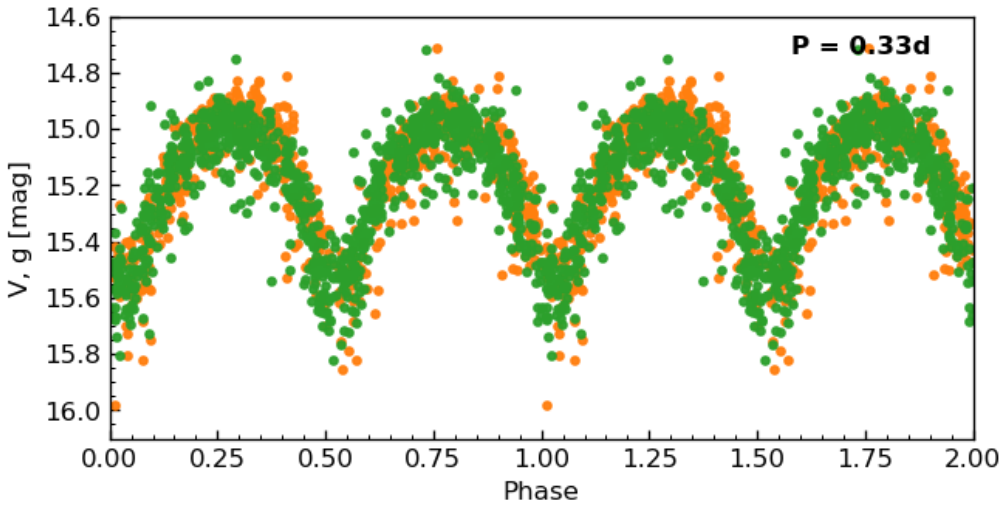
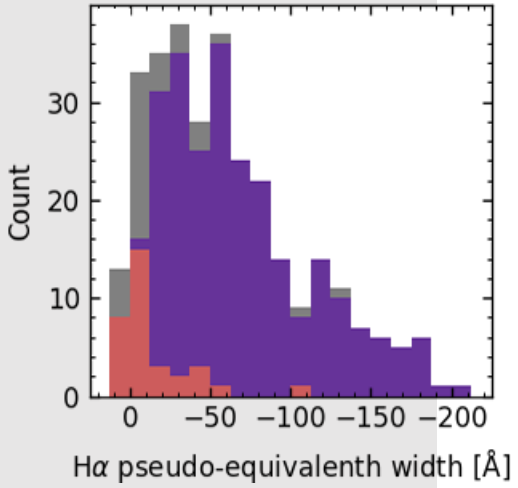


Figure: Phased light curve of V1017 Cyg.

Symbiotic candidates

- Gaia DR3 published on June 13, 2022
  - **340 new** symbiotic candidates
  - machine-learning
  - based on low-res RP spectra, astrometric data, and Gaia photometry

References:
Gaia Collaboration, 2022, A&A 2022arXiv220800211G
Eyer et al., 2022, A&A 2022arXiv220606416E
Merc et al., in preparation



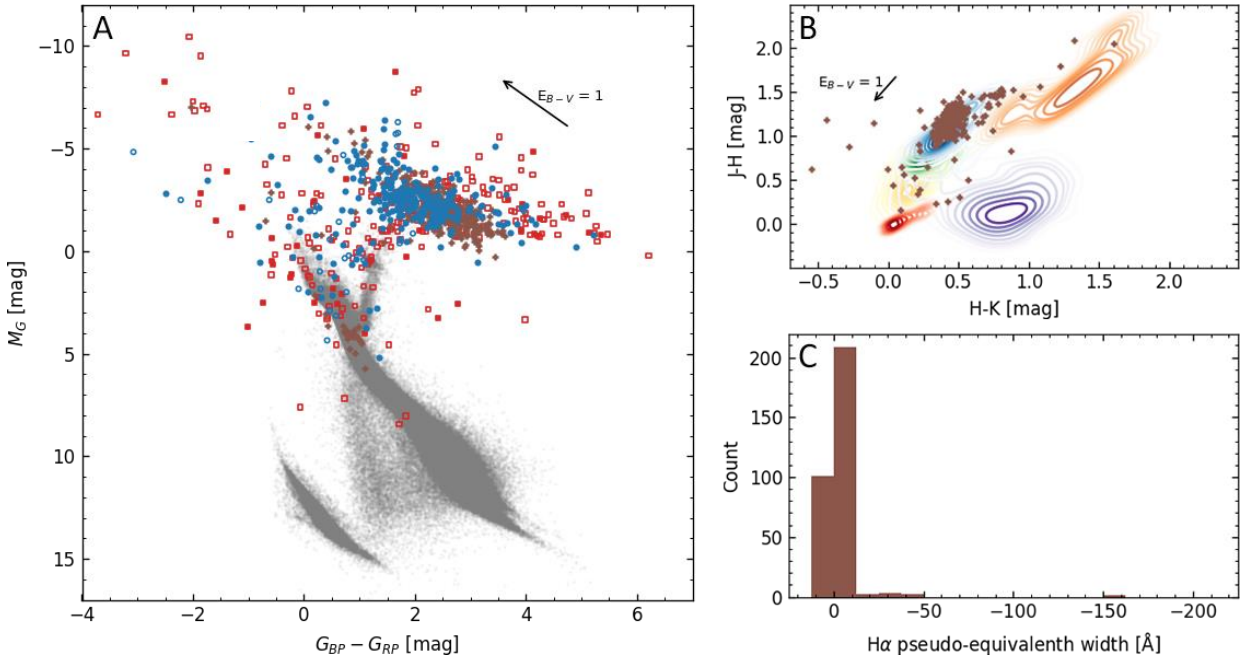


Figure: Gaia DR3 symbiotic candidates.

Symbiotic candidates

References:
Gaia Collaboration, 2022, A&A 2022arXiv220800211G
Eyer et al., 2022, A&A 2022arXiv220606416E
Merc et al., in preparation

- **only 7** out of 340 sources have **Hα in emission** according to Gaia
  - measured from low-res BP/RP spectrum (R ~ 30 – 60)
  - all already observed, all have strong Hα
  - 3 new shell-burning symbiotics, 2 likely acc-only, 2 are M-type with Hα only
  - randomly selected stars without Hα according to Gaia → spectra of single giants
- Hα from Gaia can be used **to identify promising** symbiotic candidates
  - Wray, Henize emission-line stars
  - Gaia LPVs
  - 19 confirmed shell-burning or 11 likely acc-only symbiotic stars
  - including 2 yellow, 1 carbon (only 10 known in Galaxy)

Gaia18aen

References:
Merc et al., 2020, Astronomy & Astrophysics
doi: 10.1051/0004-6361/202039132

- 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*
  - radius of the giant 230 $R_\odot$, **luminosity 7400 $L_\odot$**

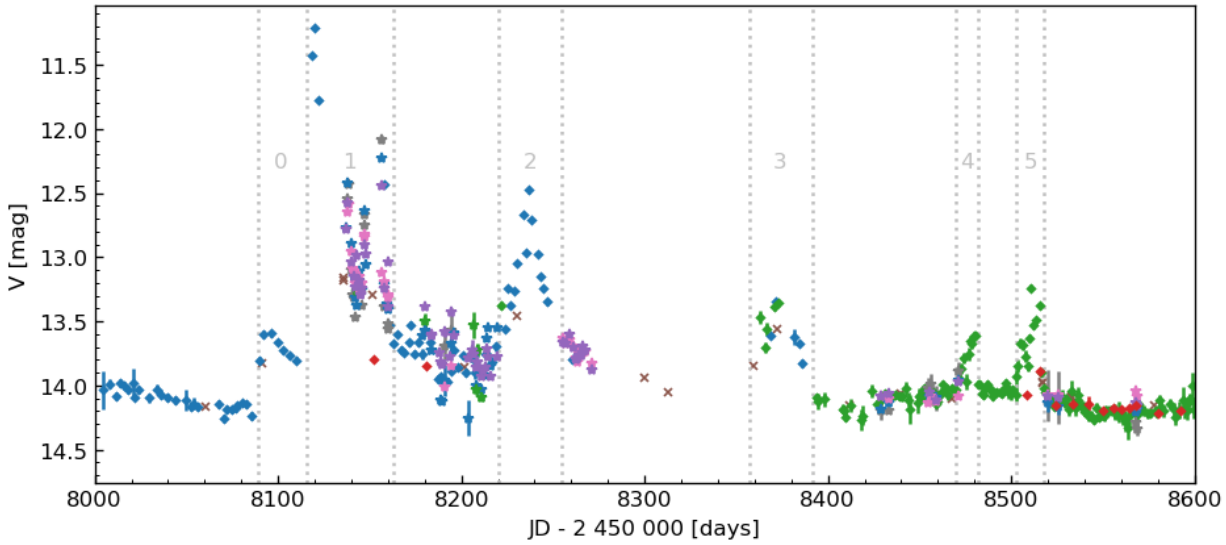


Figure: The light curve of Gaia18aen.

Gaia18aen

References:
Merc et al., 2020, Astronomy & Astrophysics
doi: 10.1051/0004-6361/202039132

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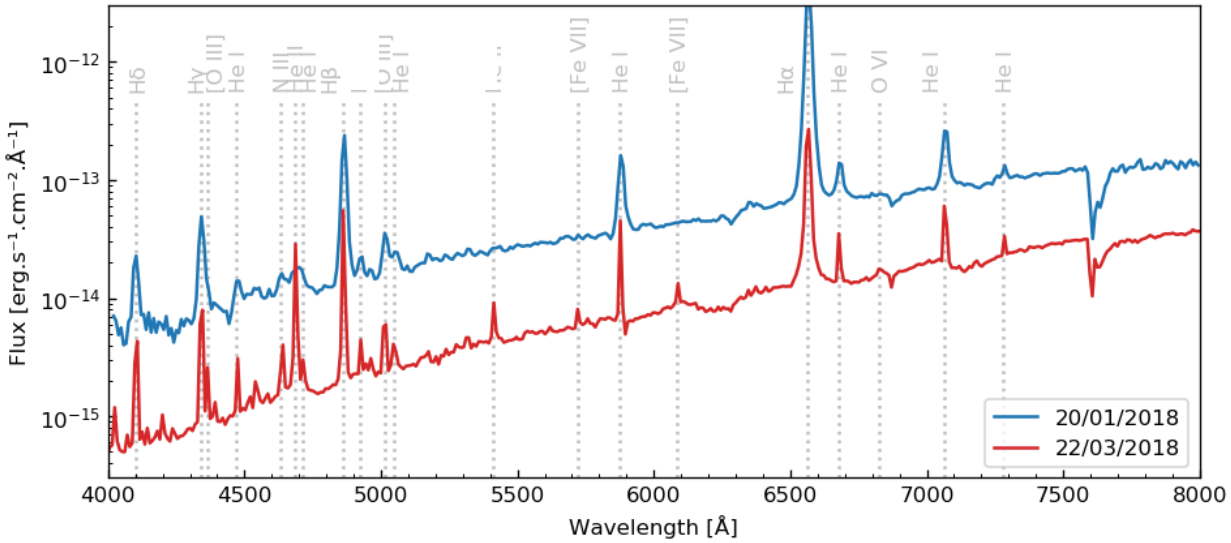

Figure: The optical spectra of Gaia18aen.

Gaia22bou

Spectrum:
S. Charbonnel, O. Garde, P. Le Dû, L. Mulato
T. Petit; 2SPOT

References:
Merc et al., 2022, The Astronomer's Telegram, No. 15340
Miszalski & Mikołajewska, 2014, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stu292

- detected in brightnening by **Gaia** (April 2022)
  - ongoing since September?
- coincident with **known symbiotic** WRAY 15-1167
  - **no outbursts** recorded before
- two low-resolution spectra
  - highly ionized lines **disappeared**
  - TiO bands **weakened** in comparison with the quiescence

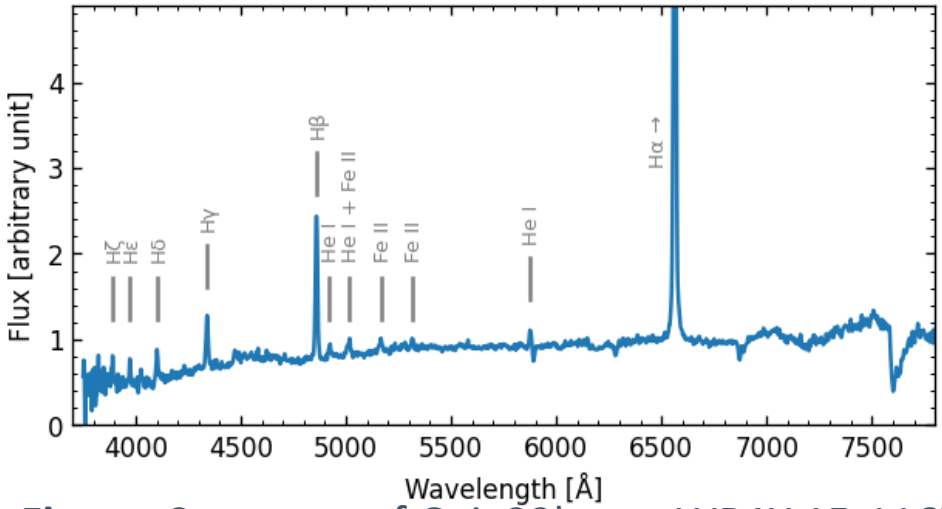

Figure: Spectrum of Gaia22bou = WRAY 15-1167.

TCP J18224935 -2408280

Spectrum:
S. Charbonnel, O. Garde, P. Le Dû, L. Mulato
T. Petit; 2SPOT

References:
Merc et al., 2021, The Astronomer's Telegram, No. 14691
Aydi et al., 2021, The Astronomer's Telegram, No. 14692
Taguchi et al., 2021, The Astronomer's Telegram, No. 14699

- **brightening** discovered by **amateur** observer Tadashi Kojima
- coincident with **Gaia DR2 LPV** with a period of roughly **800 days**
- **strong emission lines** of H I, He I, [O III], and He II in addition to the **K5-M0 continuum**
  - Alpy600 spectrograph mounted at a remotely controlled **30-cm Ritchey-Chretien telescope**

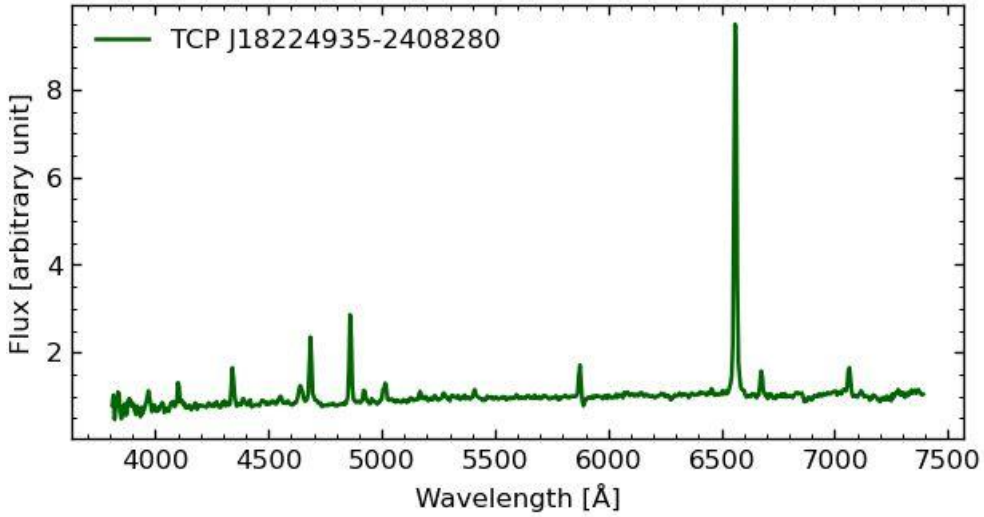

Figure: Spectrum of TCP J18224935-2408280.

TCP J18224935 -2408280

Spectrum:
S. Charbonnel, O. Garde, P. Le Dû, L. Mulato
T. Petit; 2SPOT

References:
Merc et al., 2021, The Astronomer's Telegram, No. 14691
Aydi et al., 2021, The Astronomer's Telegram, No. 14692
Taguchi et al., 2021, The Astronomer's Telegram, No. 14699

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- coincident with **Gaia DR2 LPV** with a period of roughly **800 days**
- **strong emission lines** of H I, He I, [O III], and He II in addition to the **K5-M0 continuum**
  - Alpy600 spectrograph mounted at a remotely controlled **30-cm Ritchey-Chretien telescope**
- **independent confirmation** later with the 4.1-m SOAR telescope (Chile) and 3.8-m Seimei telescope (Japan)
  - our ATel published **1h 12m** before ATel with SOAR results

DeGaPe 35

- detected as conspicuous object during **amateur survey** searching for new Pne
- spectrum obtained at **amateur remote-controlled observatory** in Chile
- spectrum **confirmed** the symbiotic nature
  - **M5 III continuum**, emission lines of H I, He I, He II, [Fe VII], O VI

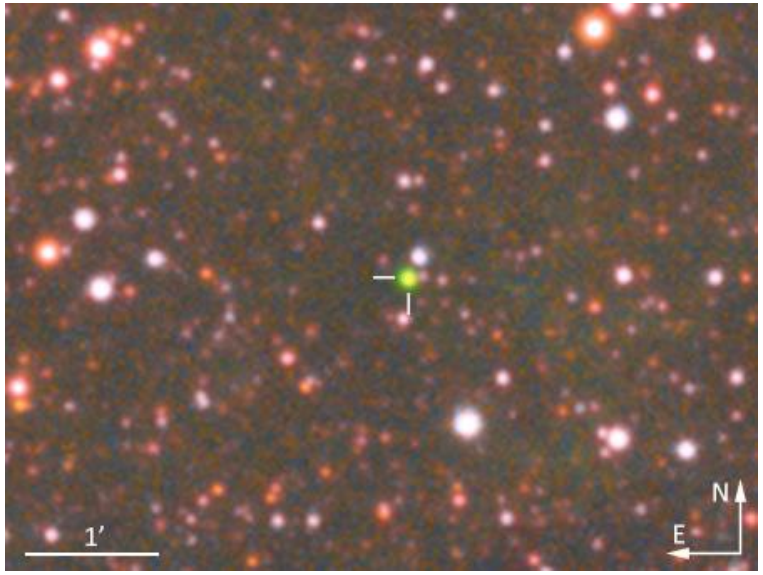

Figure: Discovery image of DeGaPe 35.

References:
Petit, Merc & Gális, submitted to New Astronomy

DeGaPe 35

- detected as conspicuous object during **amateur survey** searching for new Pne
- spectrum obtained at **amateur remote-controlled observatory** in Chile
- spectrum **confirmed** the symbiotic nature
  - **M5 III continuum**, emission lines of H I, He I, He II, [Fe VII], O VI

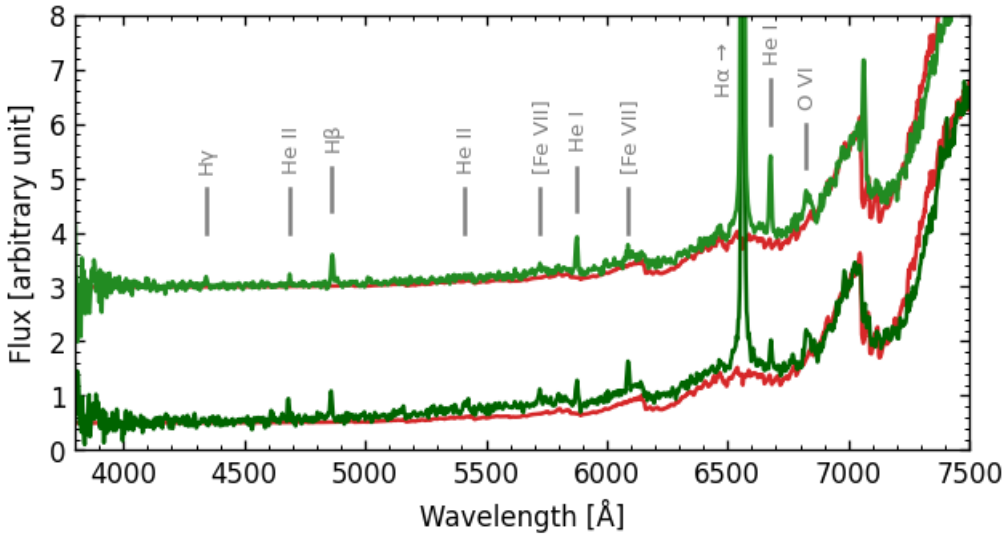

Figure: Spectrum of DeGaPe 35.

References:
Petit, Merc & Gális, submitted to New Astronomy

Summary

Thank you for your attention.

- symbiotics are **unique** astrophysical laboratories
- even after 100 years of research, many **questions remain open**

- **New Online Database of Symbiotic Variables**
  - new, **modern, complex**, online database
  - **most comprehensive collection** of orbital, stellar, other observational parameters of the symbiotic stars ever published
  - **tool** for studies of symbiotic population
- **classification of candidates**
- **search for new symbiotics**
  - **new approach** to searching symbiotics