New Online Database of Symbiotic Variables

Spectroscopic and photometric analysis of symbiotic candidates

Lessons learned from the ongoing campaign

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Outline

- **Symbiotic binaries**
  - Very short introduction
  - Importance
- **New Online Database of Symbiotic Variables**
- **Symbiotic candidates**
- **Conclusions**

Symbiotic stars
Very short introduction

- **interacting binaries**
  - **cool giant** (M, K), hot and luminous **white dwarf**
  - among the **widest** interacting systems
  - orbital periods **of hundreds of days – tens of years**

- significant photometric **variability**
  - **outbursts** (Z And-type, SyN, SyRN)
  - **quiescent** variability
  - **pulsation** (SR, Mira)

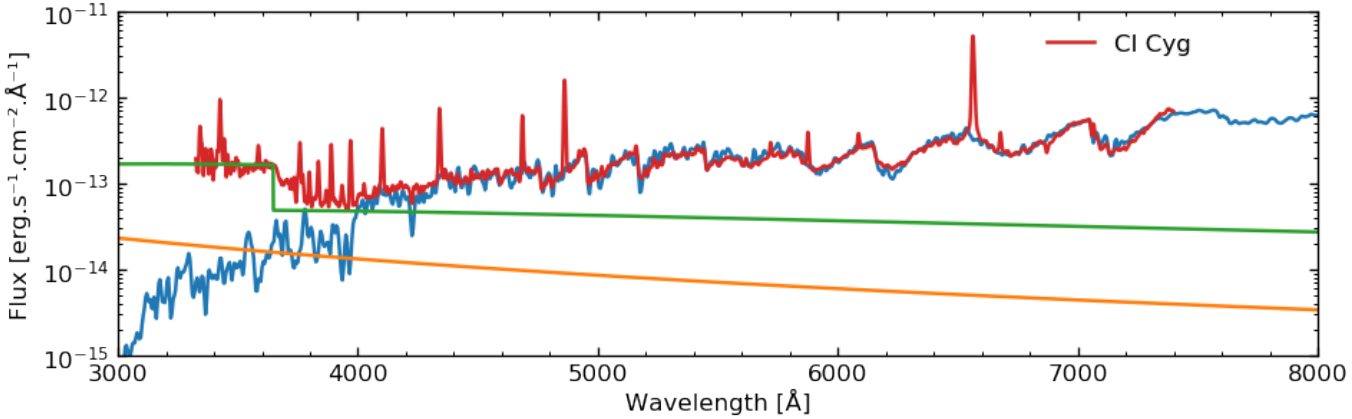

Figure: Optical and near-UV spectrum of CI Cyg.

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

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

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

- **New Online Database of Symbiotic Variables**
  - http://astronomy.science.upjs.sk/symbiotics/
  - **496** (276 + 220) objects in our Galaxy
  - 161 (73 + 88) in 14 external galaxies
  - >50 misclassified objects

- many objects presented in the literature are **very poor candidates** ☹
  - into the databases (SIMBAD, ASAS-SN...)
  - subsequently used in research

Symbiotic candidates

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

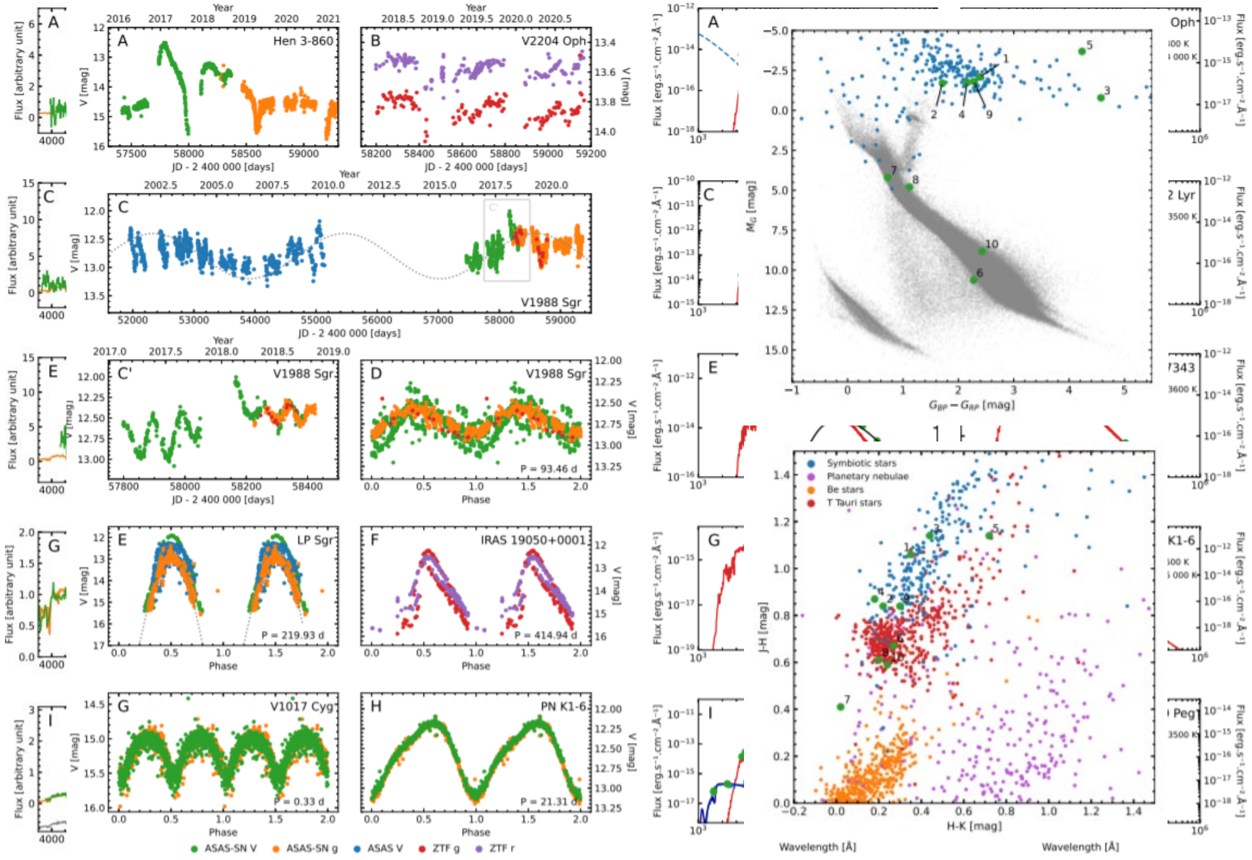

Figure: Light curves and multi-frequency SEDs of candidates. / Figure: Optical spectra, HR diagram and IR color diagram.

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

Hen 3-860

Spectrum:
P. Velez, ARAS Group

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

- 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 **600 days**
- **two** or three **outbursts** in past

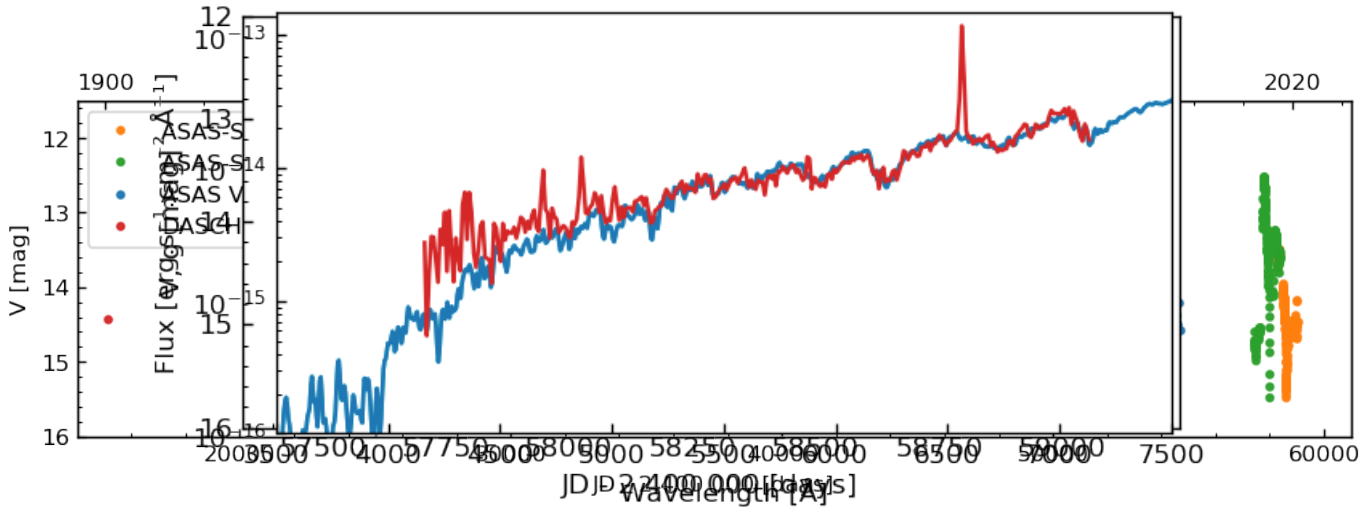

Figure: Historic light curve of Hen 3-860 from ASAS-SN survey.

V2204 Oph

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

- at least two **outbursts** (1926, 1983)
  - possible **symbiotic binary**
- **never** observed spectroscopically
- spectrum of **K3 giant**, strong **emission lines**
  - excess in blue and **UV region**
  - **yellow** symbiotic star

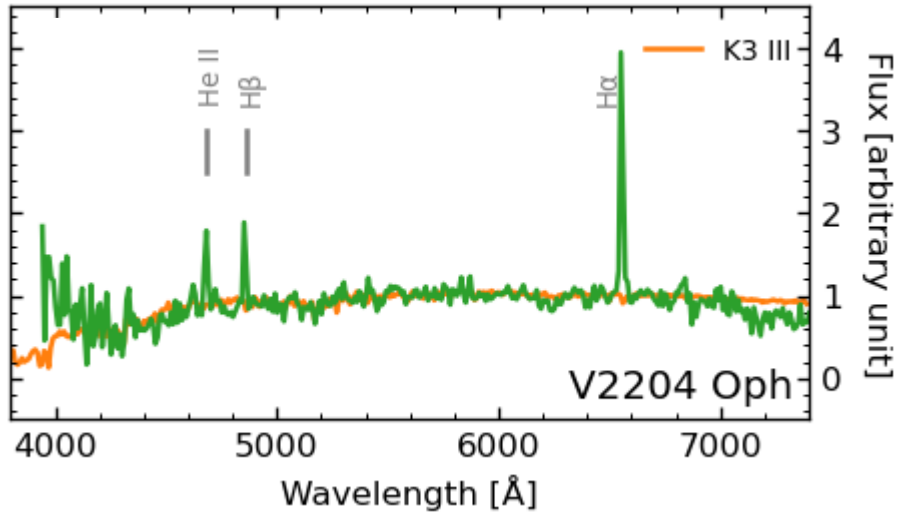

Figure: Spectrum of V2204 Oph.

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

Rule 1: Not everything observed in the brightening is a symbiotic star!

- not the same object?

Do check (at least):
- duration of the brightening
- its amplitude
- changes of colors
- other variability
- (spectrum)

Figure: Spectrum of V379 Peg.

EC 19249-7343

Spectrum:
P. Velez, ARAS Group

References:
O'Donoghue et al., 2013, MNRAS
doi: 10.1093/mnras/stt158
Merc et al., 2021, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stab2034

Rule 2: Not every red star is a symbiotic star!

- **M dwarf**, distance **19 pc**, high proper motion

Do check (at least):
- (spectrum)
- presence of emission lines
- variability
- IR colors
- distance

Figure: Spectrum of EC 19249-7343.

[RP2006] 295
+ other in LMC

Spectrum:
W. Reid, private communication

References:
Reid, 2014, MNRAS
doi: 10.1093/mnras/stt2385

Rule 3: Not every emission-line object is a symbiotic star!

Do check (at least):
- late-type absorption features
- ionization potential of emission lines

Figure: Spectrum of [RP2006] 295.

NGC 2403 SySt-1

References:

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

Rule 4: Not every X-ray source with a red counterpart is a symbiotic binary!

Do check (at least):

- (spectrum)
- variability
- distance

Phase

Figure 1. Red light curve of NGC 2403 SySt-1.

V503 Her

Rule 5: If you observe a long-lasting eclipse, it doesn't have to be a symbiotic binary!

Do check (at least):

- IR colors
- multi-frequency SED
- (spectrum)

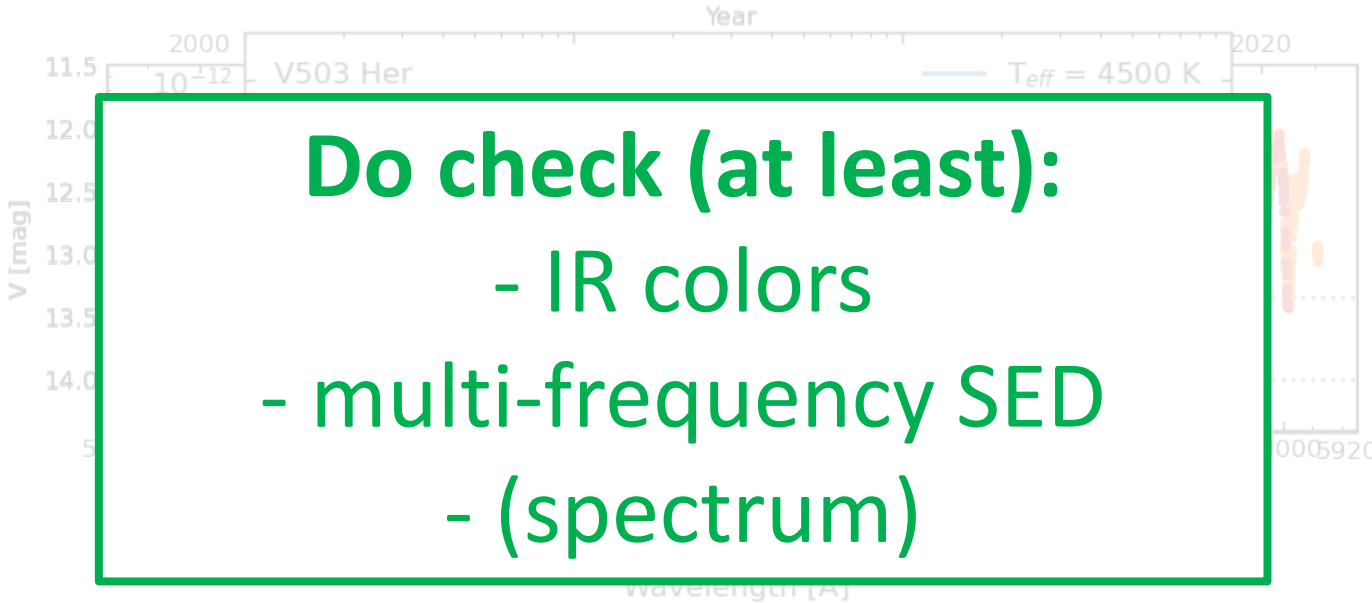

Figure 5: Multi-frequency SED of V503 Her.

References:

Kenyon, 1986, The Symbiotic Stars
ISBN: 978-0521093316
Gromadzki et al., 2013, Acta Astronomica

V1017 Cyg

Spectrum:
C. Buil, ARAS Group

References:
Szczerba et al., 2007, Astronomy and Astrophysics
doi: 10.1051/0004-6361:20067035
Merc et al., 2021, Monthly Notices of the Royal Astronomical Society
doi: 10.1093/mnras/stab2034

Rule 6: If it doesn't fit your sample, it doesn't mean it's a symbiotic binary!

- spectrum of **G1 V star**, distance of 1100 pc
- variability with period of **0.33 days – W UMa**

Do check (at least):
- IR colors
- multi-frequency SED
- distance
- variability
- (spectrum)

Conclusions

Thank you for your attention.

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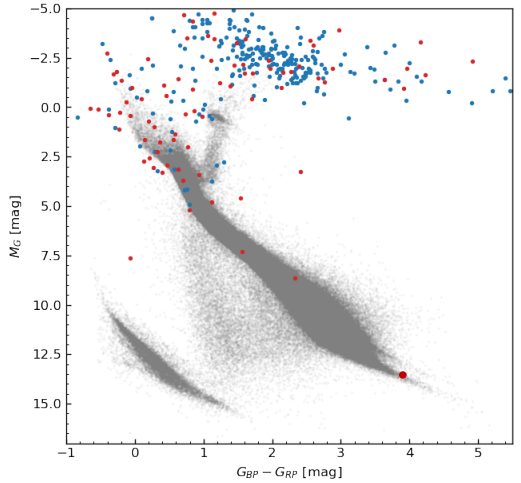

Figure: Position of known (blue) and suspected (red) symbiotic stars in the Gaia color-magnitude diagram.

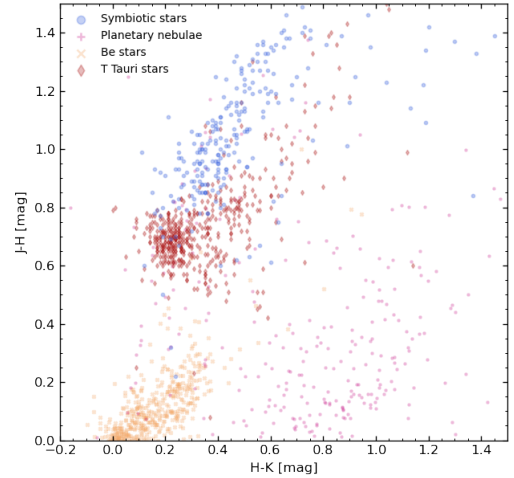

Figure: Symbiotic stars and other objects in NIR color-color diagram.

- analyze all available information
  - **spectroscopic** surveys (APOGEE, LAMOST...)
  - all-sky **photometric** surveys (ASAS-SN, ZTF...)
  - **Gaia** DR2, EDR3+
  - **2MASS**, **WISE**
  - **GALEX**...