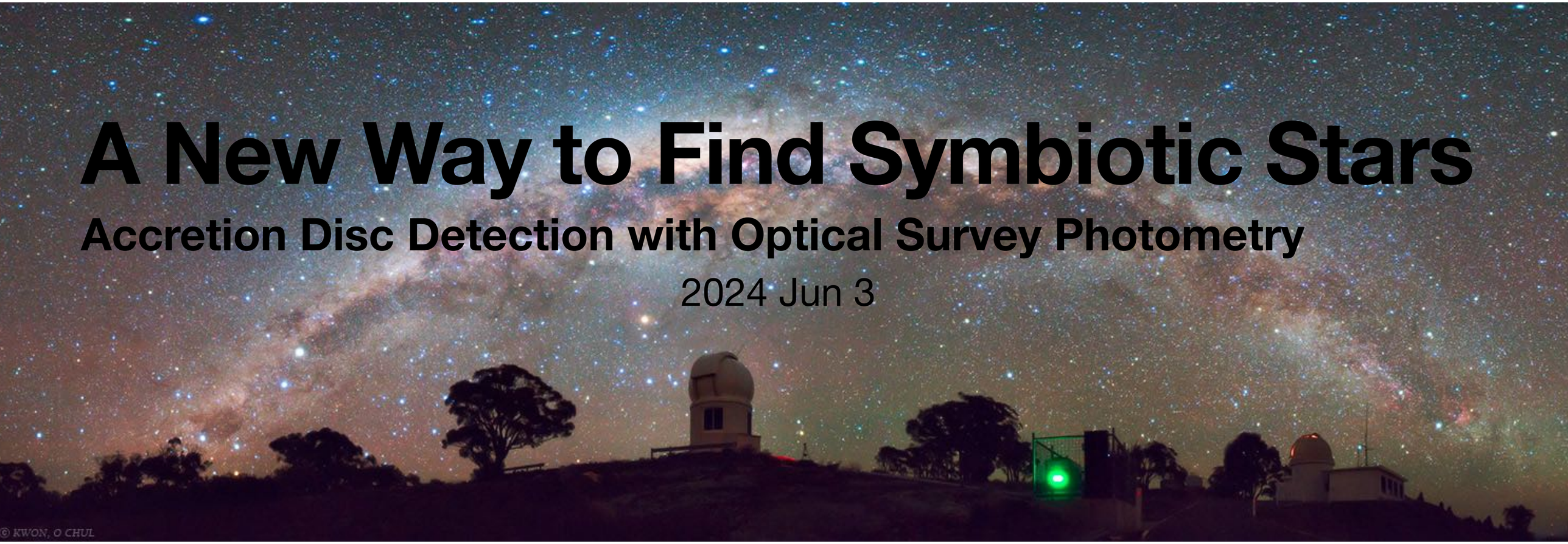

A New Way to Find Symbiotic Stars

Accretion Disc Detection with Optical Survey Photometry

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Jeno Sokoloski & Adrian Lucy
with G. J. M. Luna, K. Mukai, H. Breytenbach, D. Buckley, S. Potter, P. Woudt, P. Groot, B. Paul, N. Nuñez, A. Howell, C.Wolf, R. Manick, M. Shara, D. Zurek

Image credit: Kwon O Chul

Outline

I. The major role of WD shell burning in symbiotics

II. Finding accreting-only symbiotics with SkyMapper using optical colors and variability

WD shell burning affects everything

- Energetics:

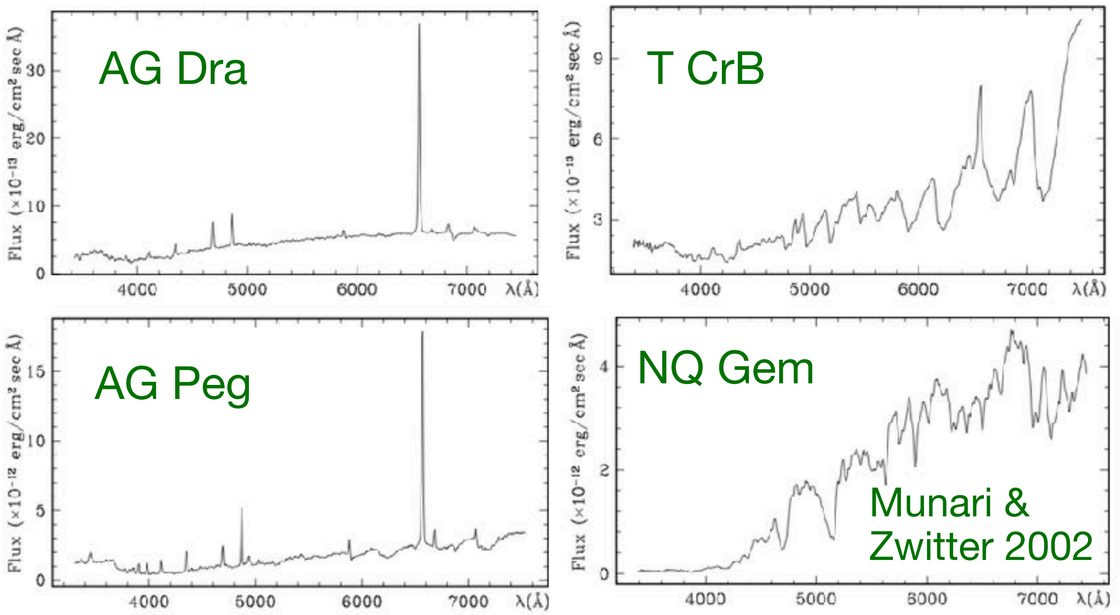
$$L_{\rm acc} = GM_{\rm WD}\dot{M}/R_{\rm WD} \approx 15\,L_\odot\,(\frac{M_{\rm WD}}{0.7M_\odot})\,(\frac{\dot{M}}{10^{-8}M_\odot/yr})$$

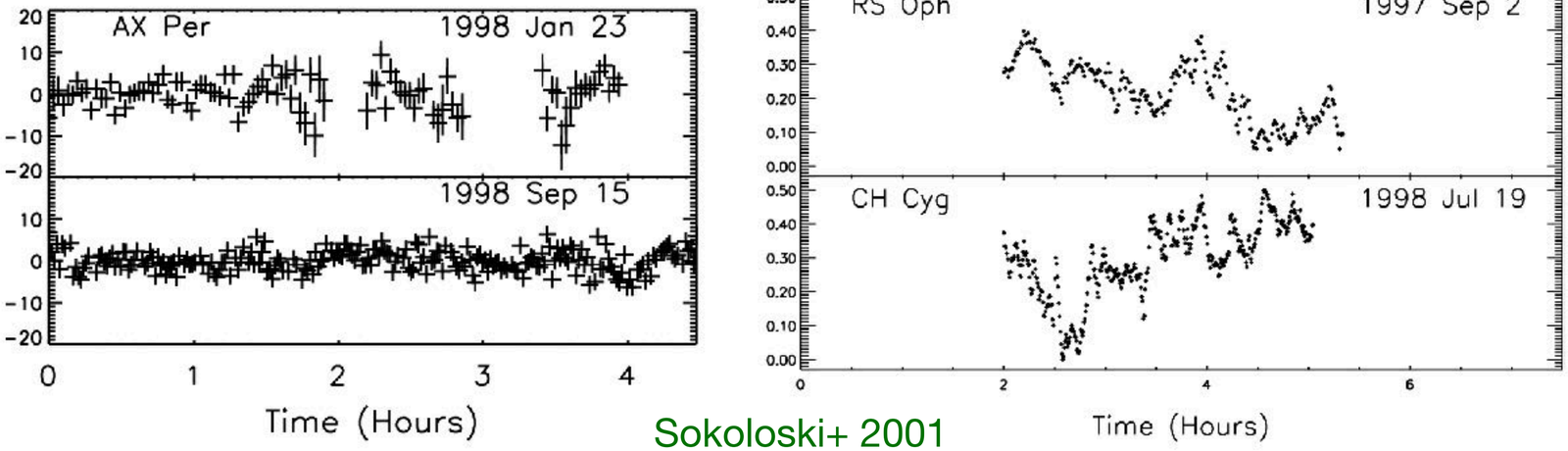
$$L_{\rm burn} \approx 50 \times L_{\rm acc} \sim 10^3\,L_\odot$$

- Optical spectra
- X-ray spectra
- Opt/UV flickering

Burning

Accreting Only





Sokoloski+ 2001

Proposed definition of symbiotic stars, based on modern, multi-wavelength data:

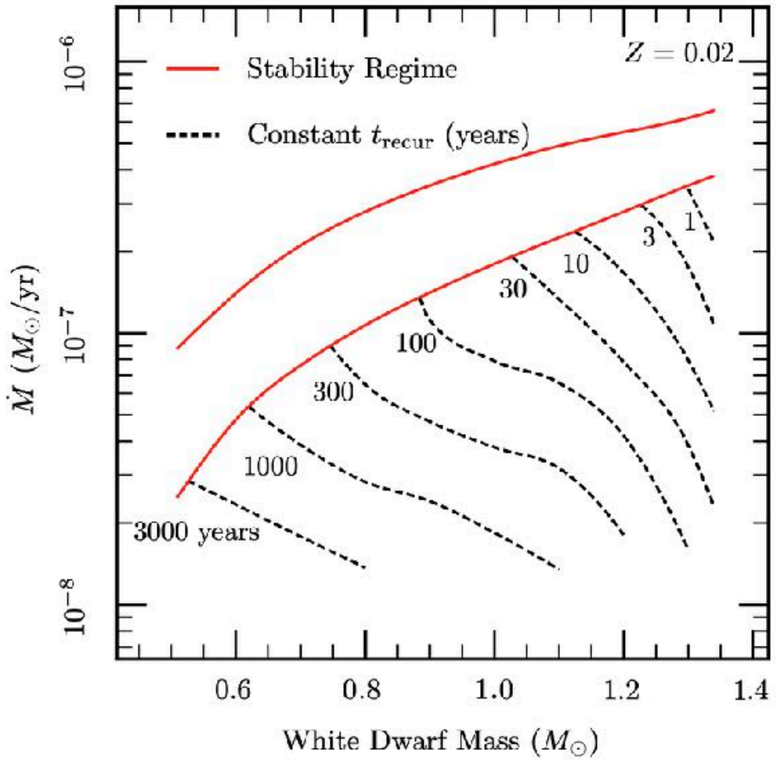
A binary in which a red giant transfers enough material to a smaller companion to produce an observable signal in one or more wavebands (Luna+13).

Notes: Magrini+ 03 already alluded to a similar definition by making the distinction between “symbiotic stars” and symbiotic stars “that can be observed in the ‘active’ phase, i.e., with a typical spectrum containing bright emission lines”. Also, this definition pushes the minimum Mdot for the symbiotic phenomenon down from $10^{-9}\,M_{\odot}/\mathrm{yr}$ (Kenyon 1986) by at least an order of magnitude.

Shell-burning vs accreting-only symbiotics

- Theory: Because of the narrow range of $M_{\odot}$ that produced it, persistent WD shell burning expected to be rare on accreting WDs (e.g., Wolf & Bildsten 2013; modulo extended post-nova burning?).
- Conundrum: it appears common among known symbiotics (e.g., Murset & Nussbaumer 94, Sokoloski+ 01, Mikolajewska 03).

Hypothesis: Most accreting-only symbiotics, **and therefore most symbiotics,** have not yet been discovered.



Wolf & Bildsten (2013)

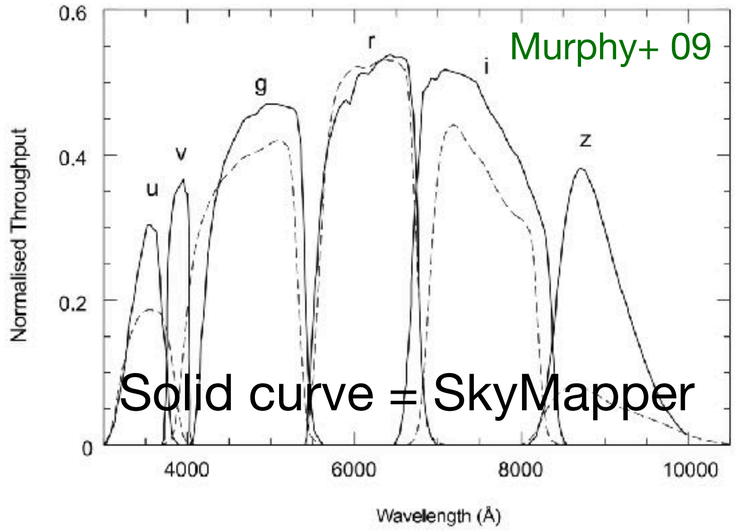
➡ What is the true population of symbiotics in the Galaxy? And how does including accreting-only symbiotics change our understanding of symbiotics' parameters?

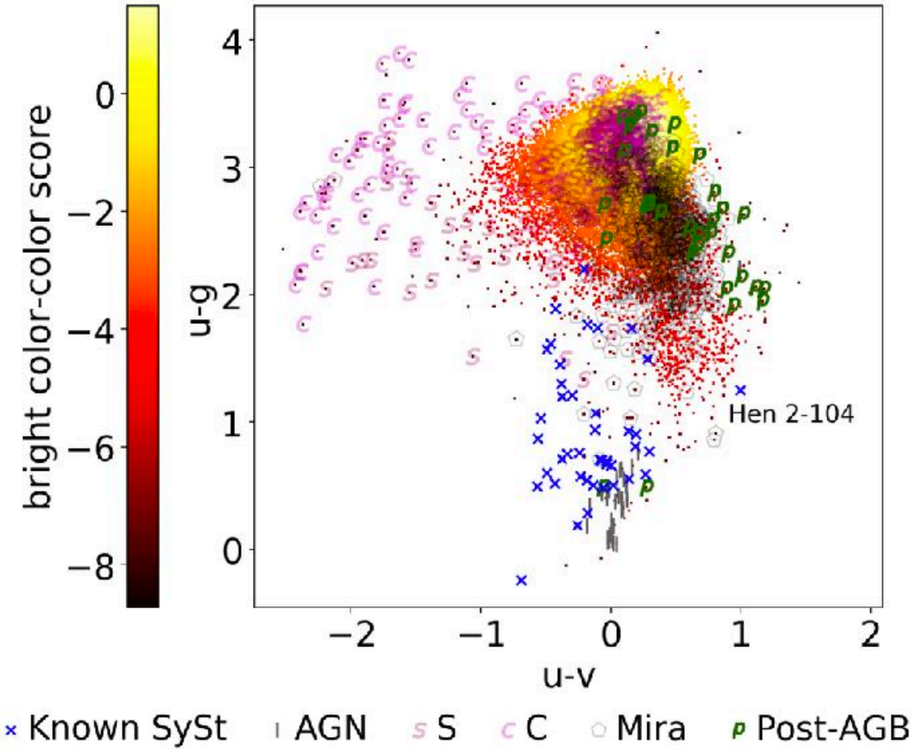
Binary stellar evolution & accretion

- Size and make up of the Galactic symbiotic population?
- Implications for binary stellar evolution? Physics of accretion and shell burning?
- Symbiotics w/ $P_{\rm orb} \sim$ years — between expected values for primaries that do vs don't experience CE evolution => physics needed in population synthesis calculations? (see, e.g., various papers by J. Mikolajewska and collaborators)?
- Finally, what can we learn from accreting-only symbiotics?

SkyMapper pilot survey

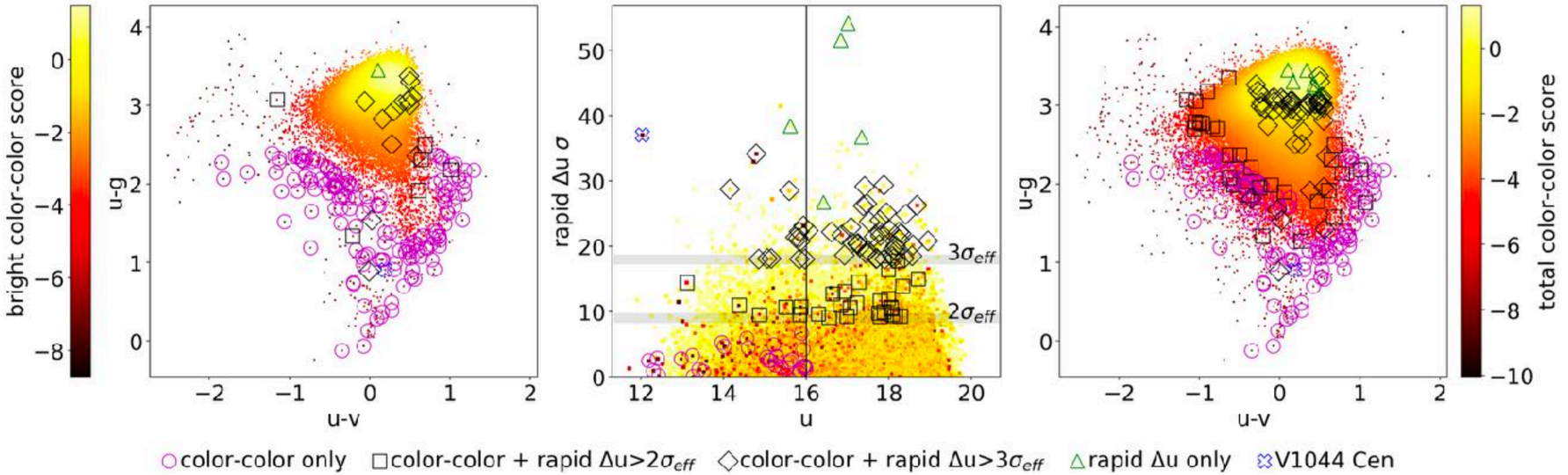
- SkyMapper Southern Sky Survey, 2014-2021
  - Custom 1.3m at Siding Spring; mosaic camera of 32 2k x 4k pix CCDs; >5 deg² fov
- Pilot search for symbiotics (Lucy 2021, PhD):
  1. Created catalog of luminous red objects w/ 2MASS+Gaia J-K_S > 0.85 and M_J < 0: 366,721candidate cool giants
  2. Computed average snapshot colors that isolated known SS (Merc+19) in distinct ways — *u-g* vs *u-v*
  3. Computed max($\Delta u/\sigma_{\Delta u}$) from 3 points within 20-min exposure sequences



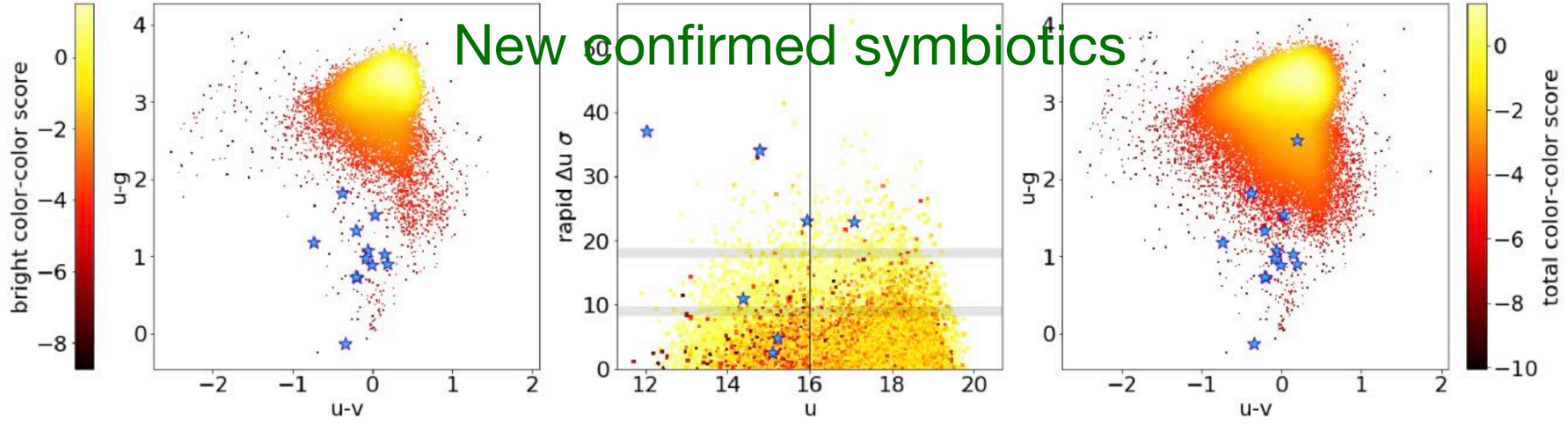


SkyMapper pilot survey results

See Lucy (2021)



New confirmed symbiotics



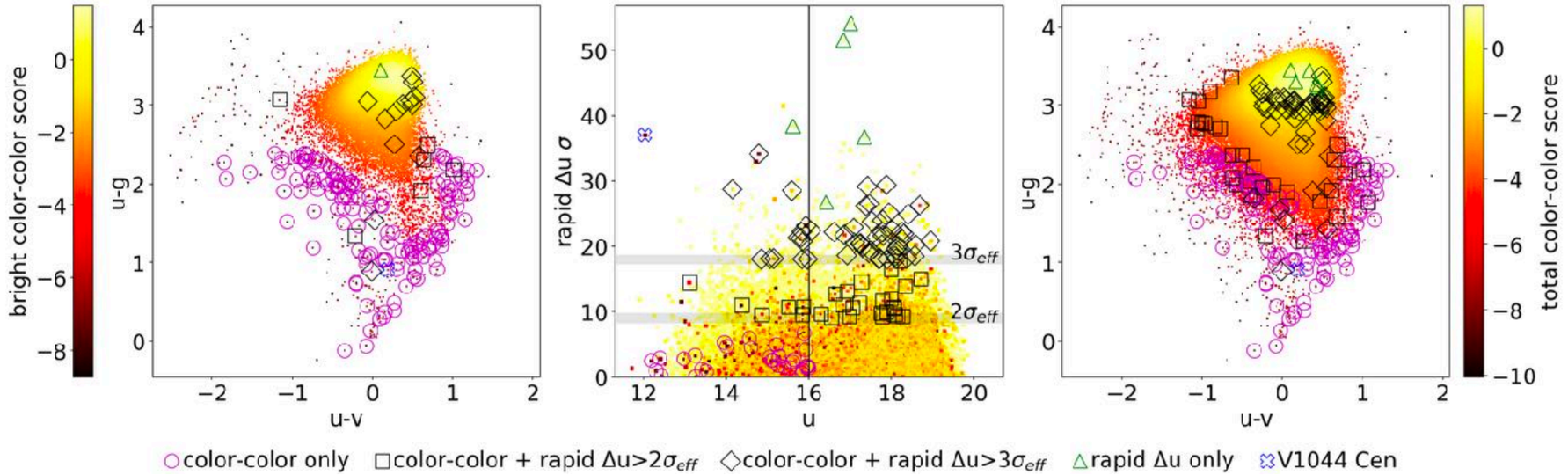
234 targets selected for follow-up optical spectroscopy w/ SAAO 1.9m

Discovered:

- 12 symbiotics (4 acc-only, 2 burning, 6 could be either)
- 10 additional candidates (likely acc-only if confirmed)

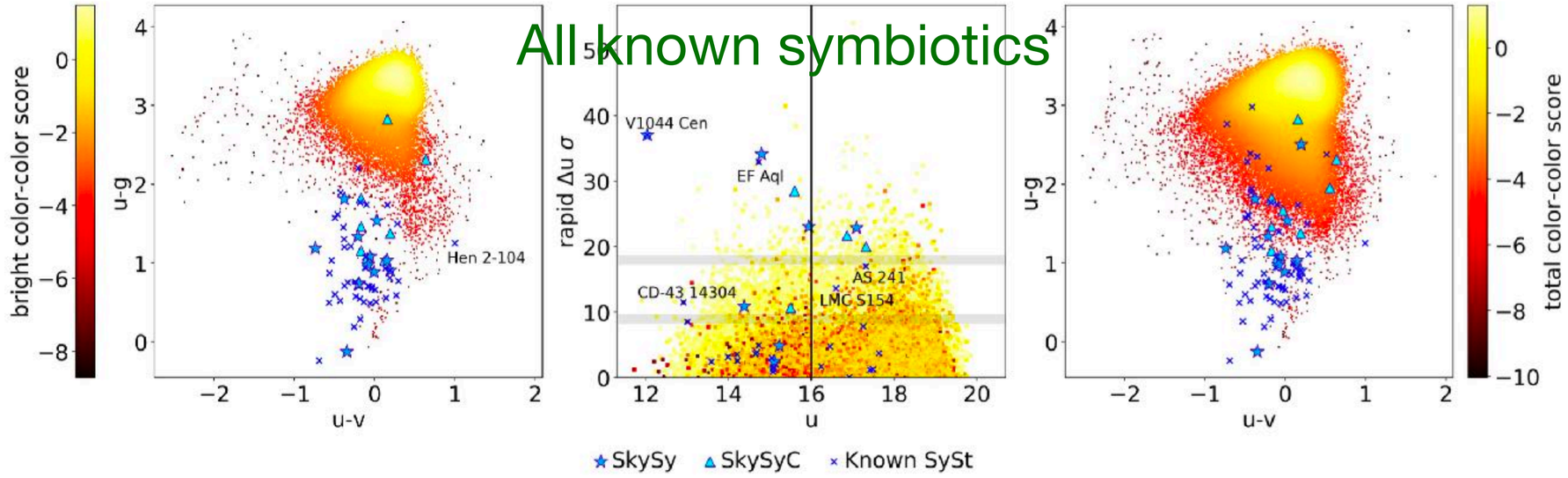
SkyMapper pilot survey results

See Lucy (2021)



234 targets selected for follow-up optical spectroscopy w/ SAAO 1.9m

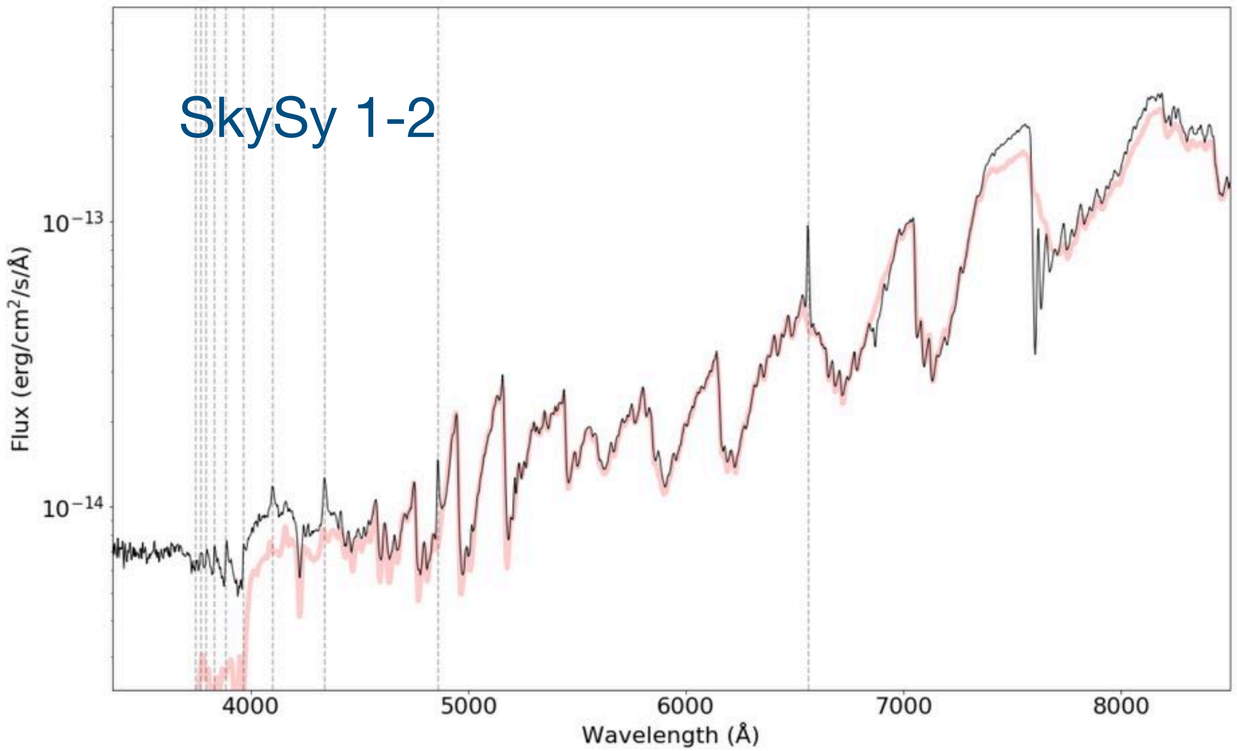
All known symbiotics

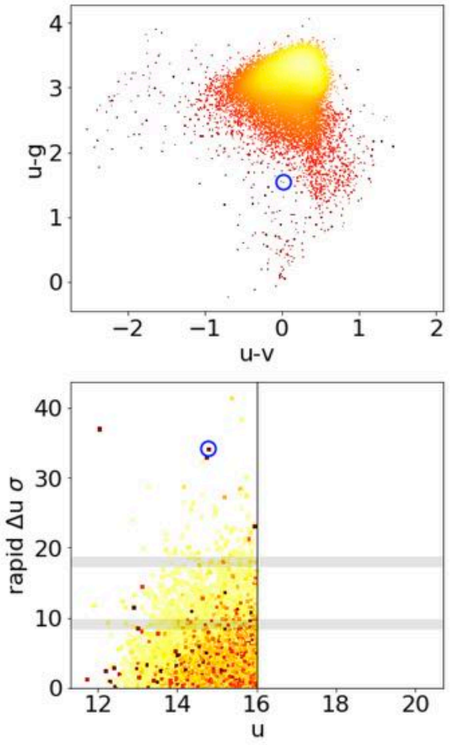


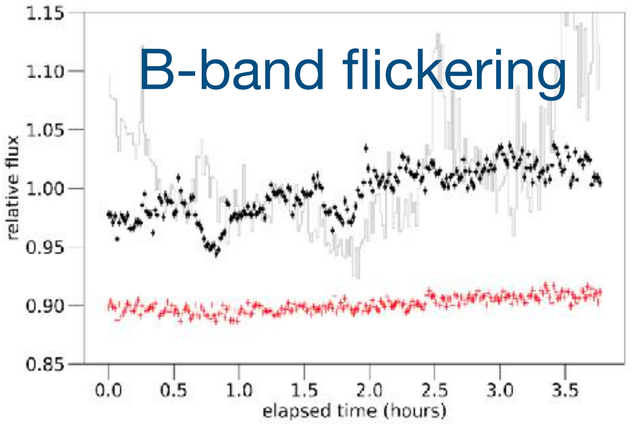
Discovered 12 previously unknown symbiotics and 10 additional candidates

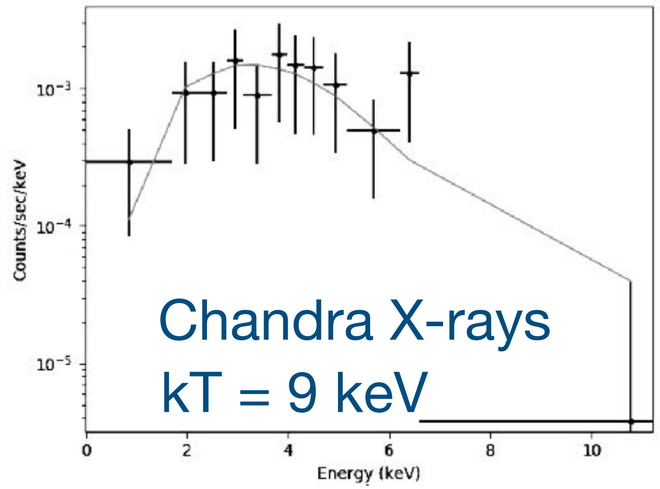
Confirming new symbiotics

➡ With optical spectroscopy & fast photometry, and X-rays









- B band LCs obtained for 11 targets; flickering confirmed for 5/7 w/ Δu excess
- UV & X-ray observations of 9 targets; 2-3 X-ray detections, all w/ hard counts

Context

- Statistics: Given our finding of 5 flickerers, the completeness of samples of previously known optically flickering symbiotics is <17%.
- Comparison to other surveys:
  - Akras+ (2019) — 10 / 12 SkySy and 4 / 10 SkySyC meet the A19 IR color selection criteria, suggesting an overlap in probed populations despite our focus on near-UV and A19's focus on IR. The A19 method would miss two SkyMapper non-flickering SS.
  - Munari+ (2021) — GALAH symbiotics from M21 reside in the densest part of SkyMapper *u-g u-v* parameter space and show no rapid Δu, suggesting we are probing different regimes.

Conclusions

https://ui.adsabs.harvard.edu/abs/2021PhDT.....17L/abstract

- The population of accreting-only symbiotics remains wildly uncertain.
- We used SkyMapper to demonstrate a search methodology designed for sensitivity to both burning and accreting-only objects.
- Combining snapshot *u-g u-v* colors and rapid Δu => the best candidates.
- We discovered 12 symbiotics & 10 strong candidates. This provides new targets for study of mass transfer in wide binaries, large disks, and jets.
- At least four, plus one previously-known symbiotic, are accreting-only. Comparing to other catalogs, a significant population of optically-flickering symbiotics is hidden within and beyond known catalogs of symbiotics.
- Surprisingly, our SkyMapper work probes distinct areas of parameter space from Munari+ 21and overlapping areas with Akras+ 19.