Characterising the Radio Properties of the AM CVn population

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National Astronomy Meeting 2025, Durham
Friday, 11.07.2025

- 5 min < P < 60 min
- **Ultracompact WD and evolved He star binary (CO-He, He-He)**
- **He-rich material accretion**
- Double degenerate/one semi-degenerate companion
- < 200 systems discovered to-date
- **Control sample for radio emissions in CVs** (WD+ low mass MS)
- CVs linked to Ia progenitors' evolution
- Local lab for **accretion physics**

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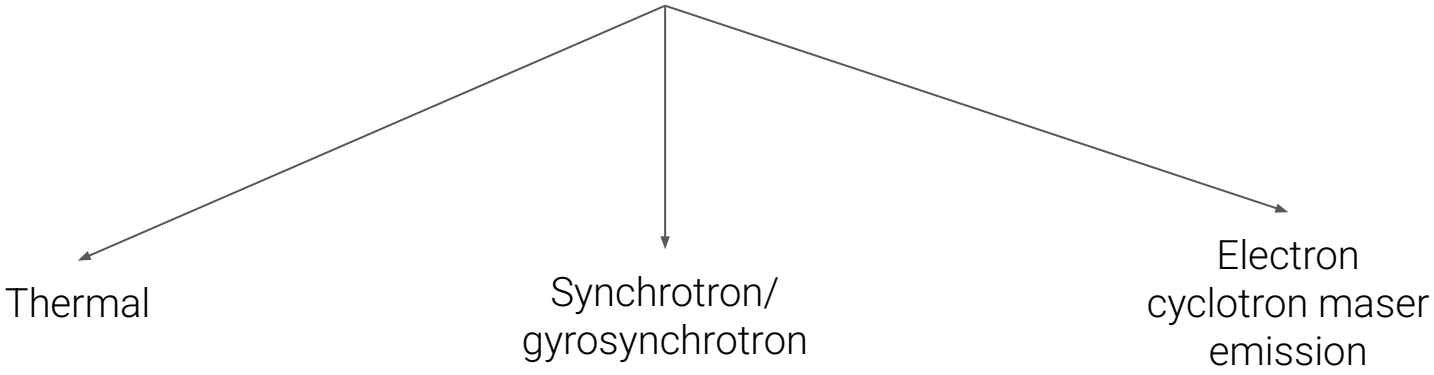

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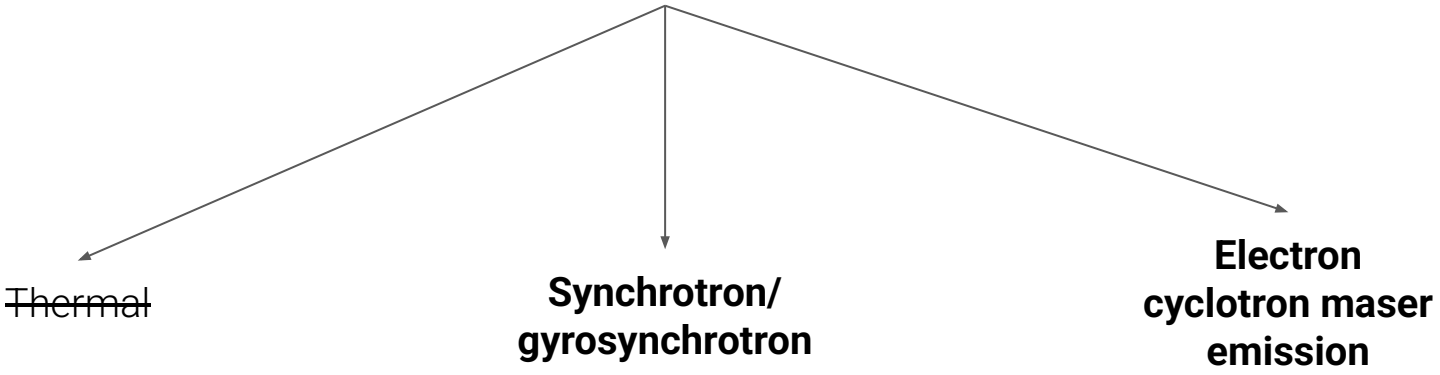
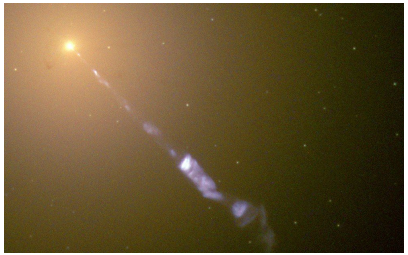


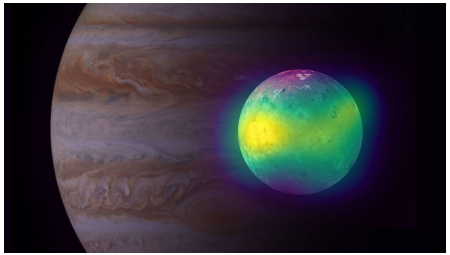
2 Possible Radio Emissions

Synchrotron/gyrosynchrotron



- ★ High energy electron moving in a B-field
- ★ Usually unpolarised

Electron cyclotron maser emission



- ★ Resonant interactions between gyrating/cyclotron motion of electrons (non-thermal) and low density magnetic field lines.
- ★ Results in coherent, polarised radiation

As defined in Zhang et al., 2020

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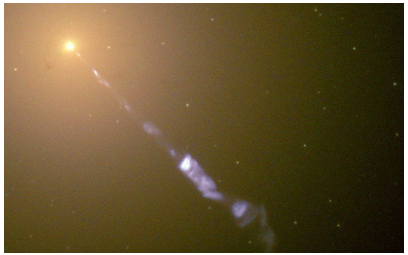

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- ★ Transient jets (CVs e.g. SS Cyg)
  Knigge et al. 2008, Coppejans & Knigge 2020
- ★ Magnetic reconnection in accretion disc
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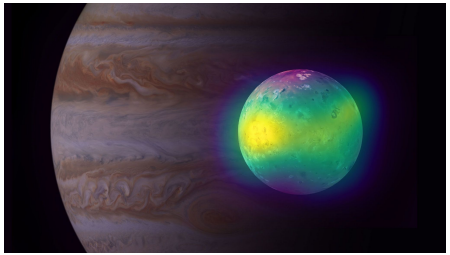

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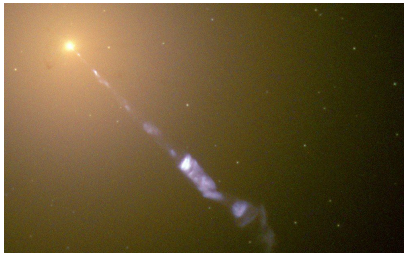

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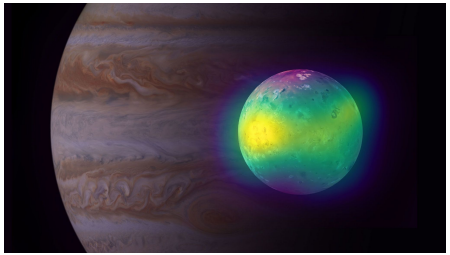

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- ★ Results in coherent, polarised radiation
  As defined in Zhang et al., 2023
- ★ Magnetic reconnection near donor
  Barrett et al., 2020
- ★ **Unipolar induction** (UI):
  - Conducting body moving in strong B-field in presence of low-density plasma → electric circuit
  - Circularly polarised

  Chanmugam & Dulk 1982, K. Wu 2009, Ramsay et al., 2007

This study:

Upper Limits on Radio Emissions from AM CVn type stars

(VLA May 2023, 4 - 8 GHz)

	AM CVn	HP Lib
Distance (pc)	**299.1**	**276**
Orbital period (mins)	17.1	18.4
Optical Magnitude (Gaia BP)	13.95	13.54
Disc state	High, optically thick	High, optically thick

CASA
Common Astronomy Software Applications

NRAO

Meet HM Cnc

- ★ Shortest period binary/AM CVn (5.36 mins)
- ★ Undergoing mass transfer
  (see Munday et al. 2022)

- ★ Polarised radio emission detected
- ★ UI leading contender
  (see Ramsay et al. 2007)

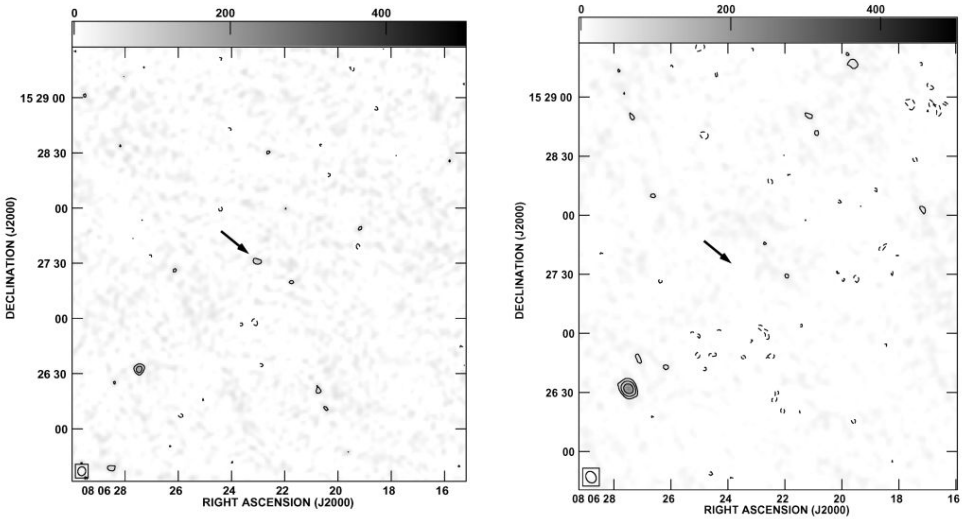


Figure 1. The radio (6 cm) maps of the field of RX J0806+15 made using the VLA in 2005 September (left-hand panel) and in 2006 December (right-hand panel). The arrow points to the optical position of RX J0806+15. In the left-hand panel, the position of the radio source is 0.3 arcsec distant from the optical

Ramsay et al. 2007

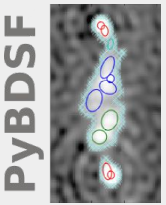
This work


CASA
Common Astronomy
Software Applications


NRAO


SKAO


LOFAR


PyBDSF

Targeted Radio Observations (AM CVns only)

Survey-based Radio Observations (CVs and AM CVns)

Targeted Radio Observations (AM CVns only)

AM CVn, HP Lib → VLA Priority A, 2023
6 GHz
0.33” resolution → 5400s integration time
(90 min) → 3σ upper limits
obtained from rms

HM Cnc *(2010/11, PI Gavin Ramsay)* → VLA, 2010/11
8.5 GHz
1.3” - 4” resolution
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Survey-based Radio Observations (CVs and AM CVns)

LOFAR (150 MHz, 2014 - 2020)

VLASS (3 GHz, 2017+)

RACS (900 MHz, 2019)

→ Cropped to same dimensions (5 synthesised beams a side) → Source location with PyBDSF → 3σ upper limits obtained from rms, detections from island peak flux (Gaussian images)

Results

& Implications

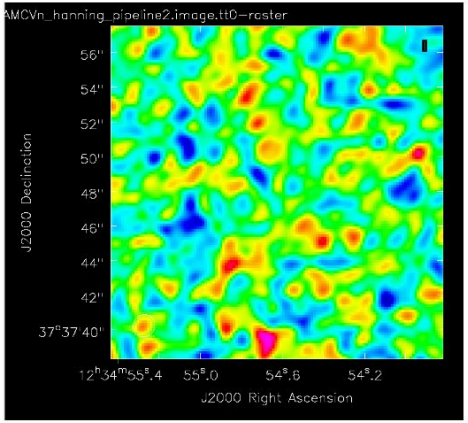


Figure 2. Final processed image of emission from AM CVn (centre) and surrounding region. The upper limit on flux density emission is 7.4 μJy.

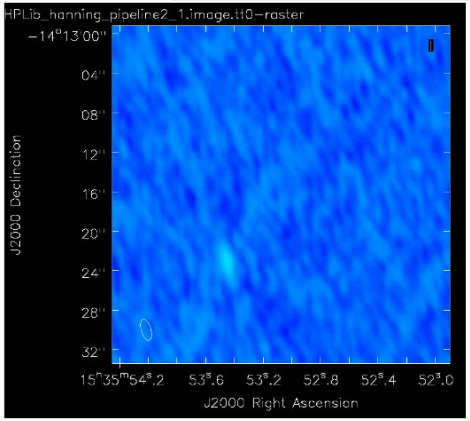
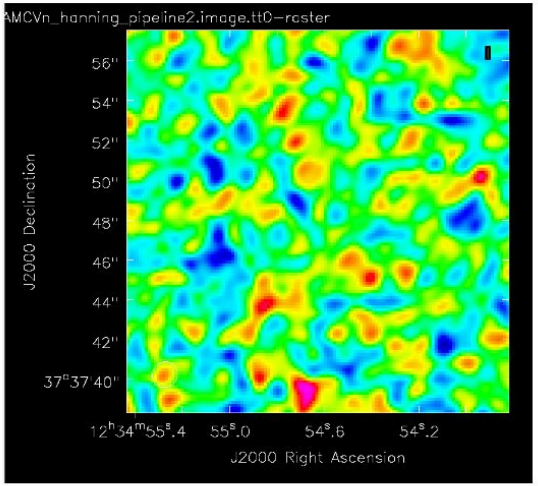
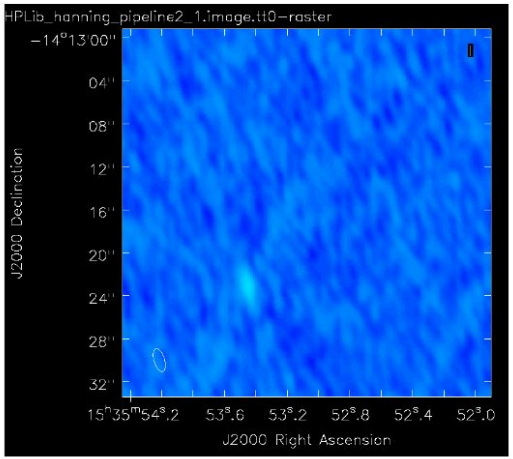


Figure 3. Final processed image of emission from HP Lib (centre) and surrounding region. The upper limit on flux density emission is 9.9 μJy. The bright region to the bottom left of HP Lib's location is a background radio galaxy.



AM CVn

HP Lib



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(Sahu et al., in prep)

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[b] For AM CVn, this corresponds to MJD 60087.27500000 - 60087.31173611. For HP Lib, this corresponds to MJD 60089.34003472 - 60089.37361111.

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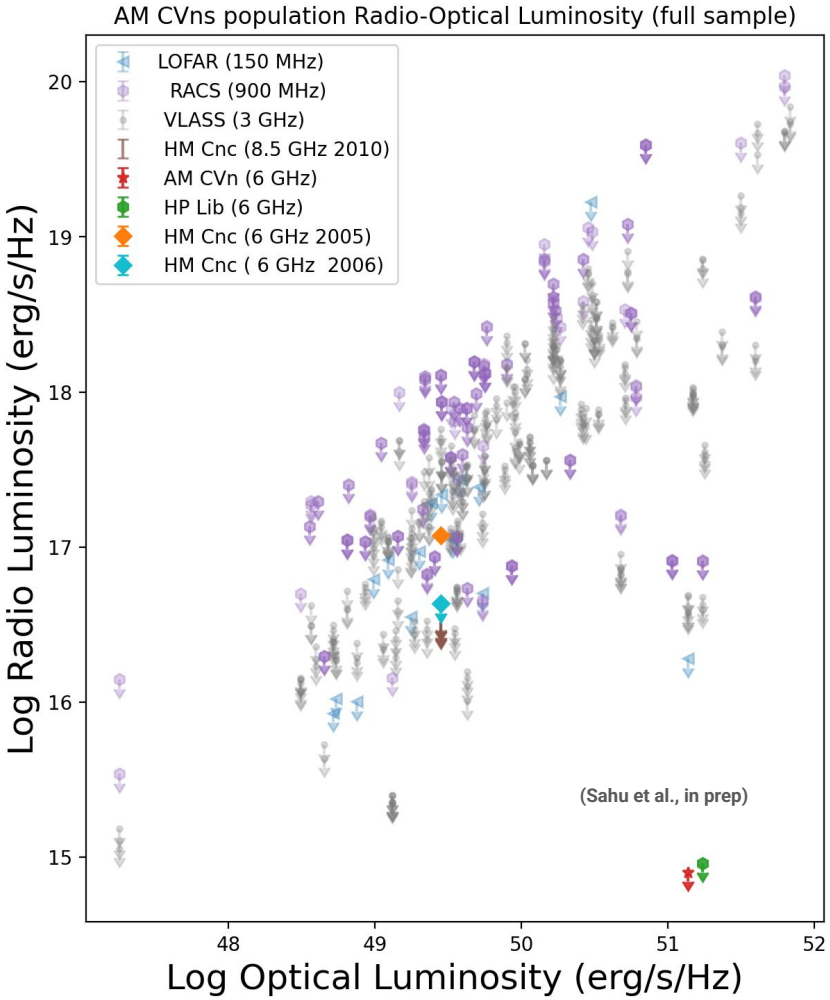
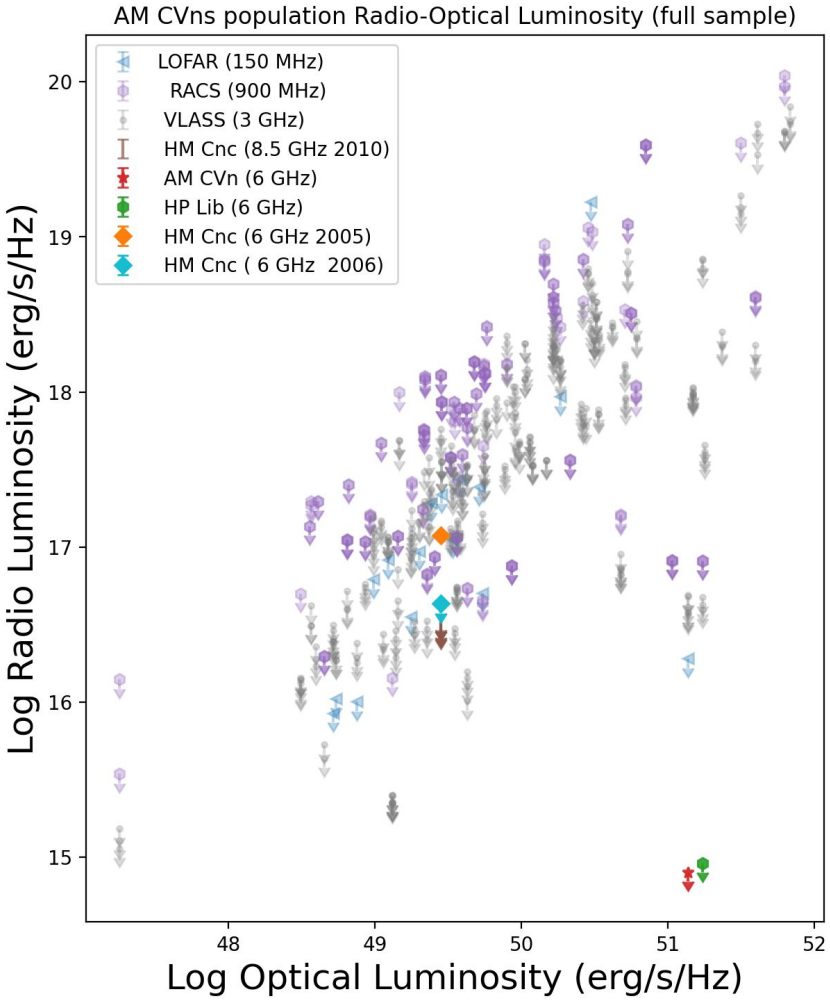
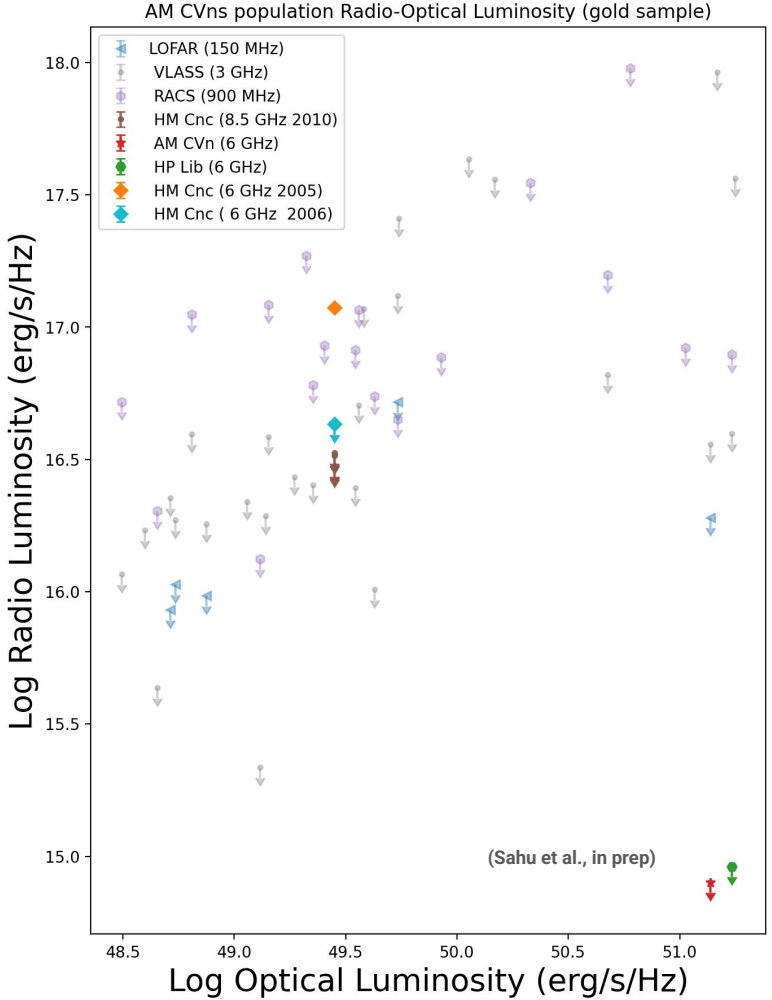


Apparent linear correlation due to distance effects


AM CVns population Radio-Optical Luminosity (full sample)
LOFAR (150 MHz)
RACS (900 MHz)
VLASS (3 GHz)
HM Cnc (8.5 GHz 2010)
AM CVn (6 GHz)
HP Lib (6 GHz)
HM Cnc (6 GHz 2005)
HM Cnc (6 GHz 2006)
Log Radio Luminosity (erg/s/Hz)
Log Optical Luminosity (erg/s/Hz)
15
16
17
18
19
20
48
49
50
51
52


AM CVns population Radio-Optical Luminosity (gold sample)
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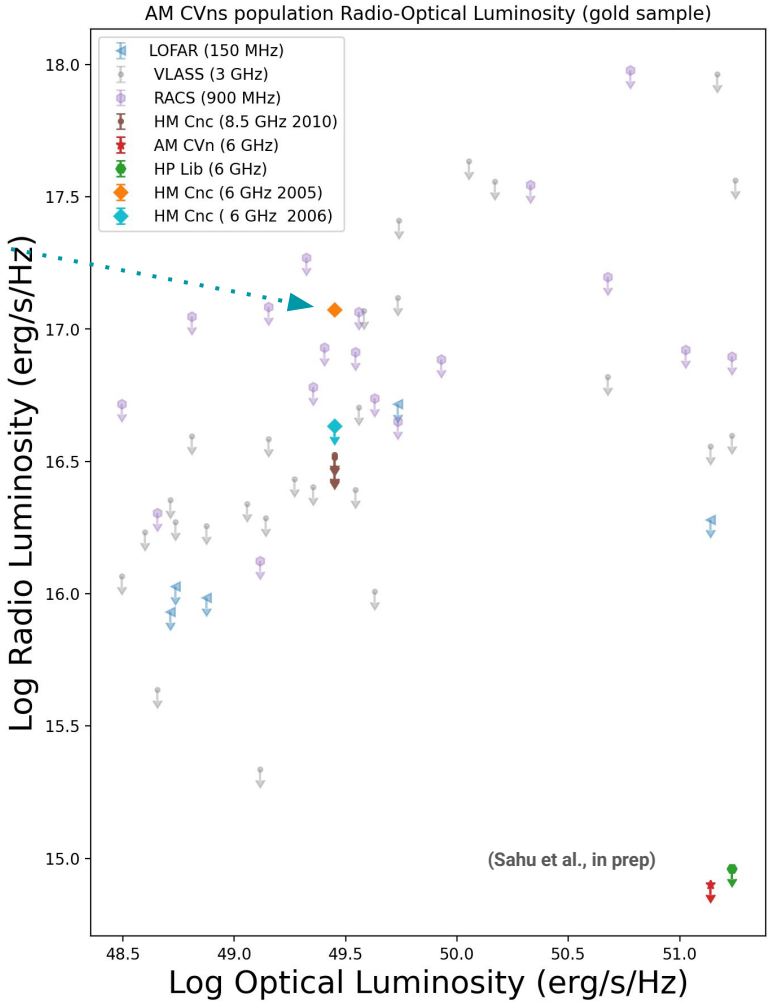
Log Radio Luminosity (erg/s/Hz)
Log Optical Luminosity (erg/s/Hz)
(Sahu et al., in prep)
15.0
15.5
16.0
16.5
17.0
17.5
18.0
48.5
49.0
49.5
50.0
50.5
51.0

HM Cnc detection 2005

Ramsay et al., 2007



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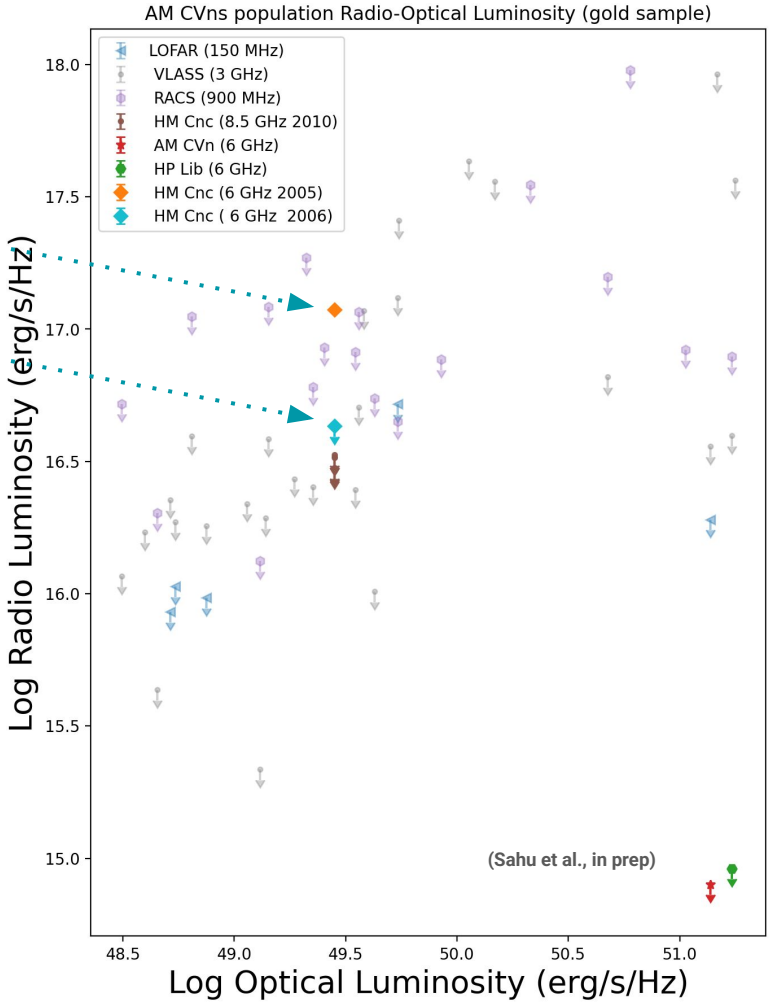

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Ramsay et al., 2007

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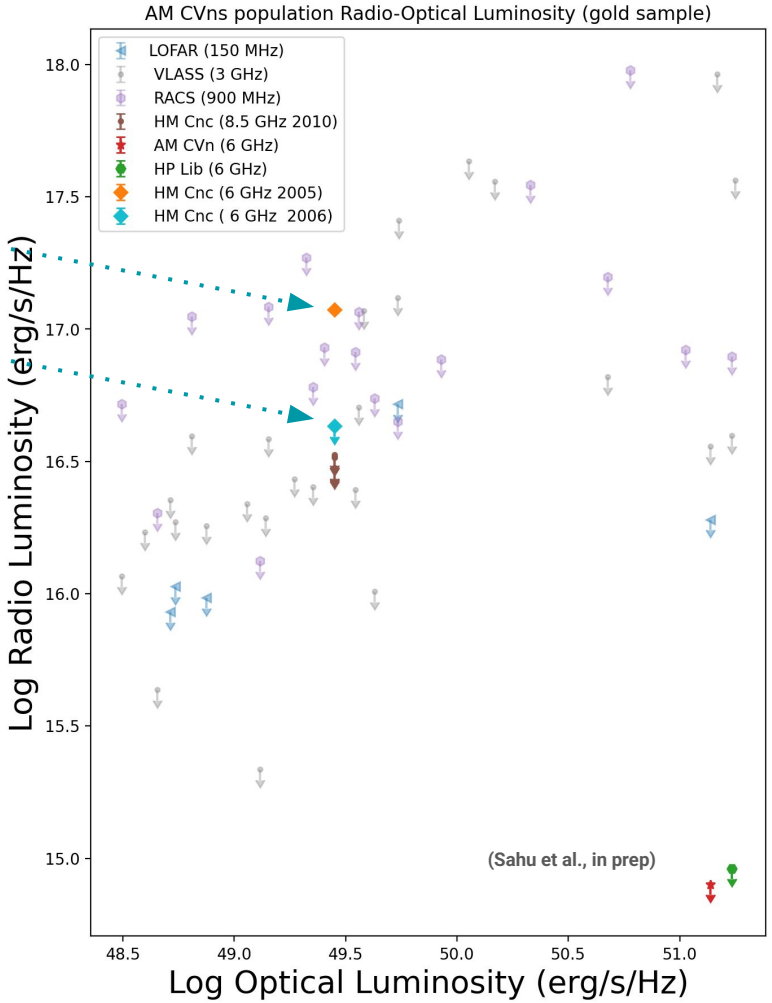
Is it unipolar induction?

- *Coherent and circularly polarised*



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Ramsay et al., 2007

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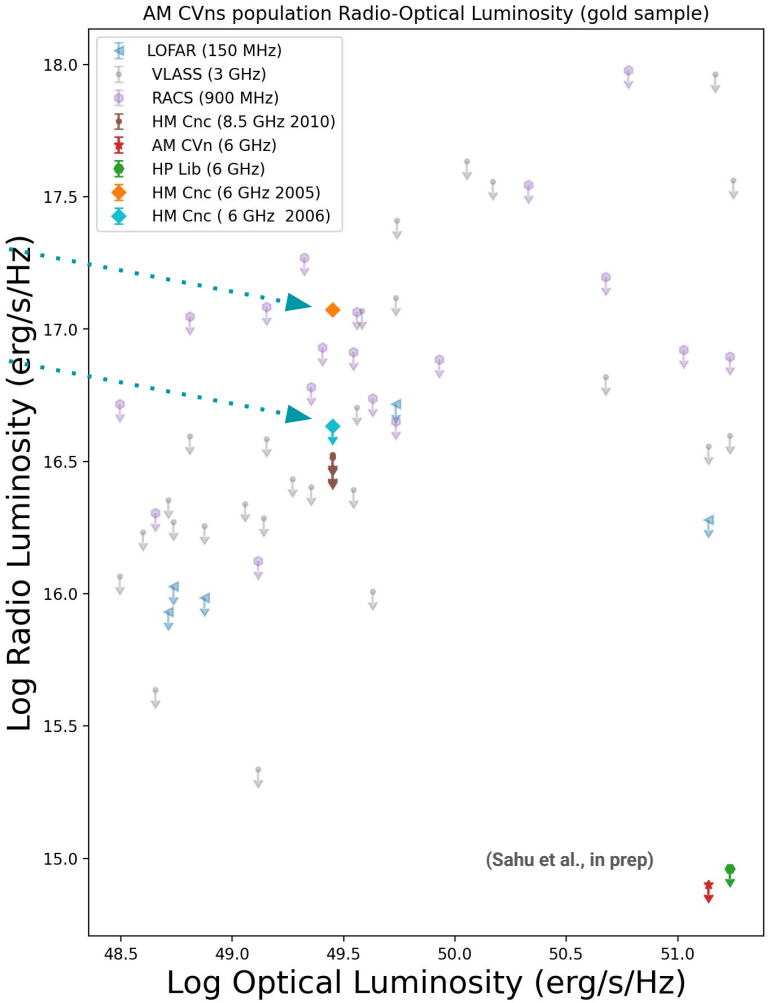
Unlikely - evidence for accretion stream observed

Munday et al. 2022



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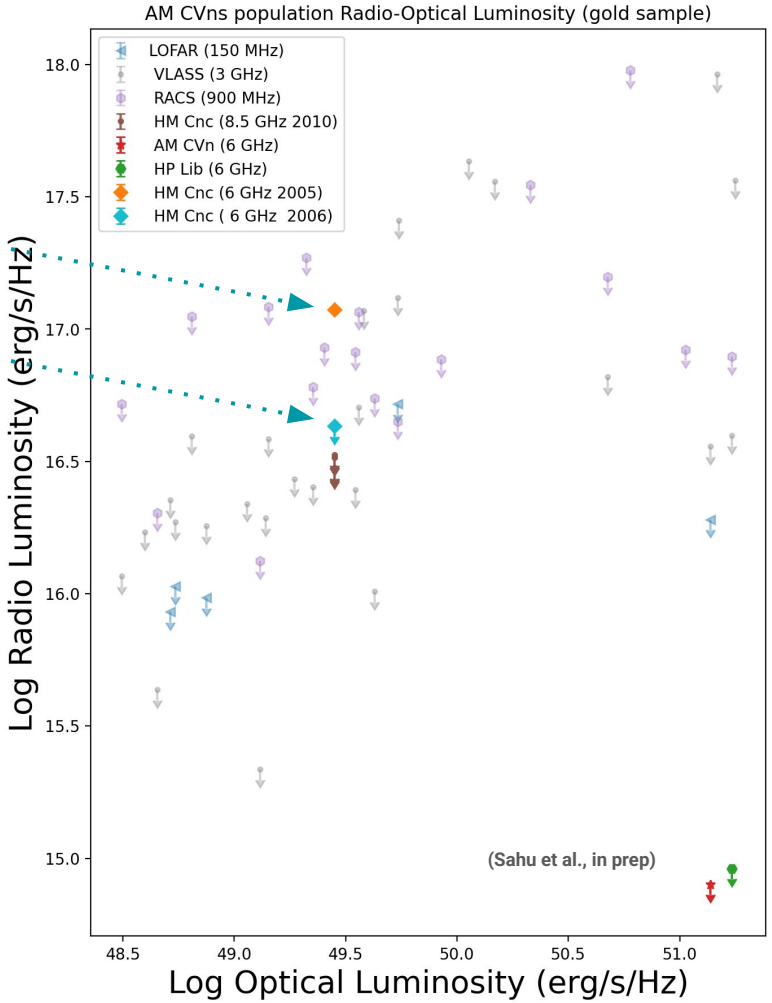
★ AM CVns are fainter analogues of CVs? → flaring behaviour at fluxes comparable to CVs (plus base luminosity unconfirmed)



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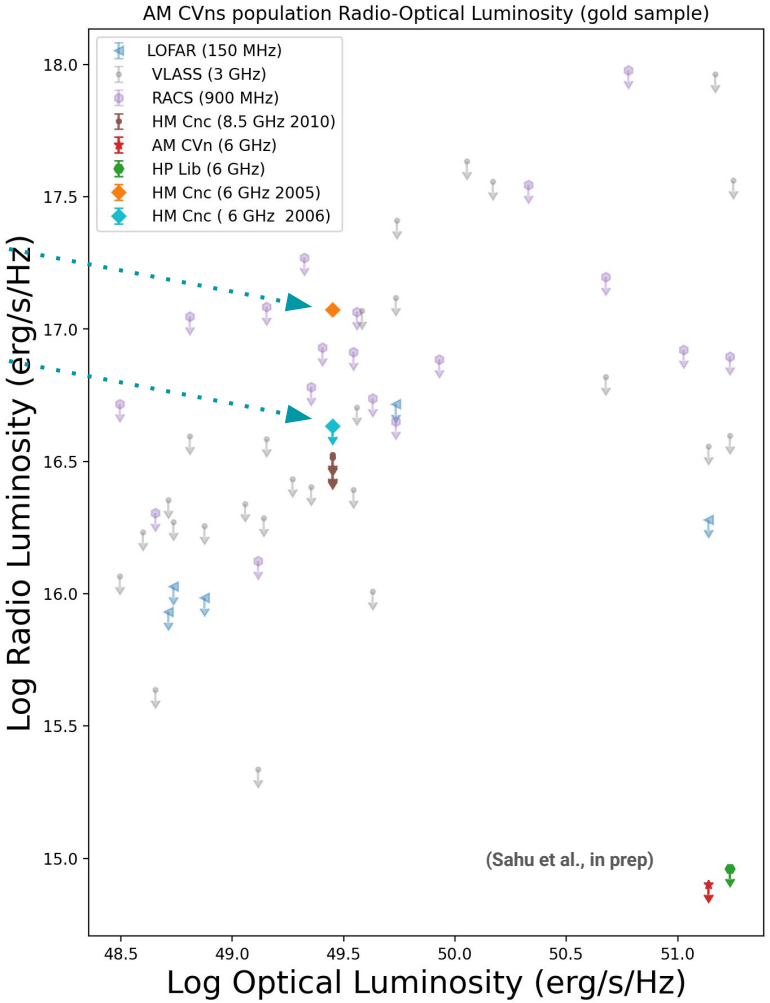
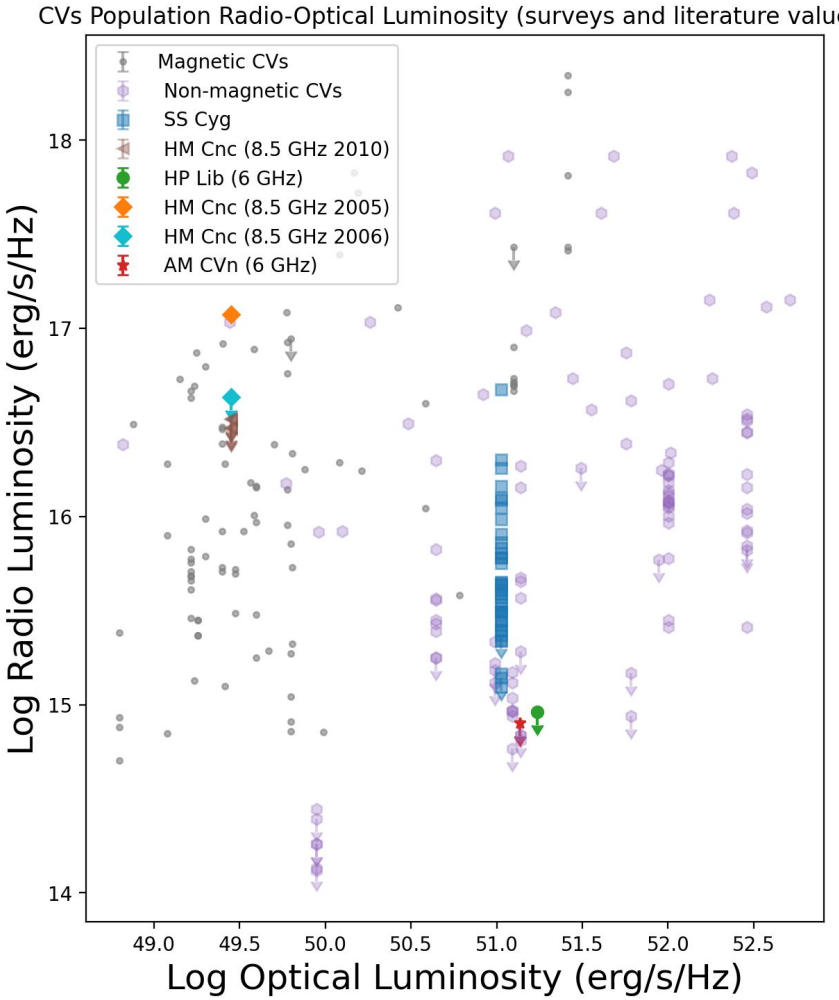
★ Caveat - based on one system only




CVs Population Radio-Optical Luminosity (surveys and literature values)
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Non-magnetic CVs
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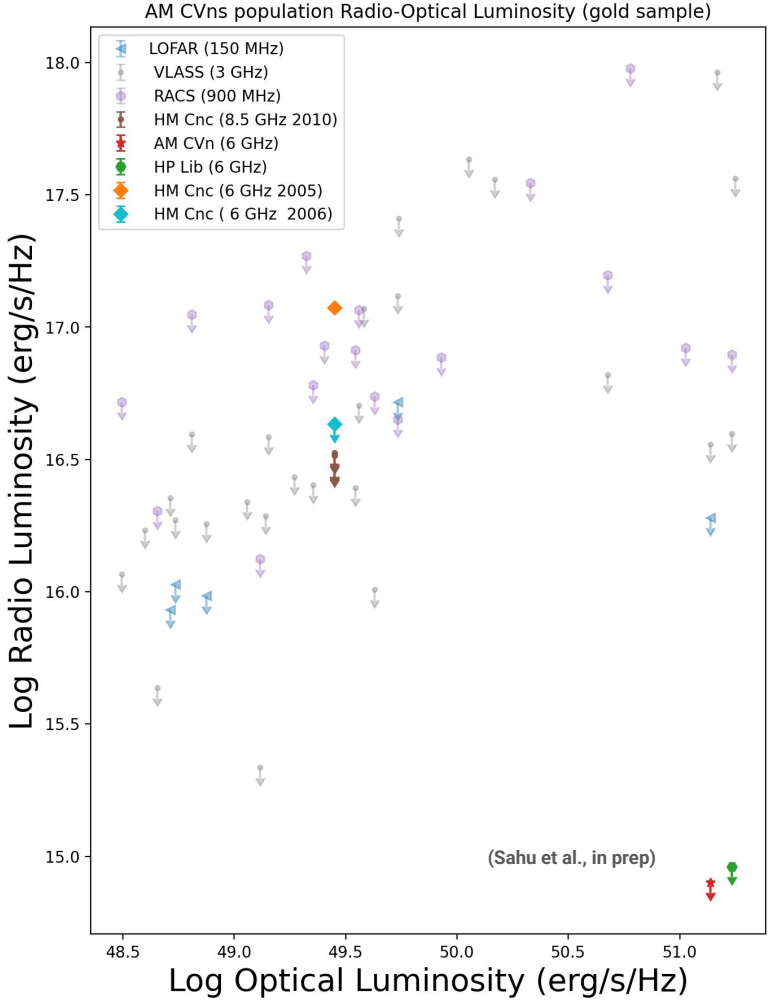
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(Sahu et al., in prep)
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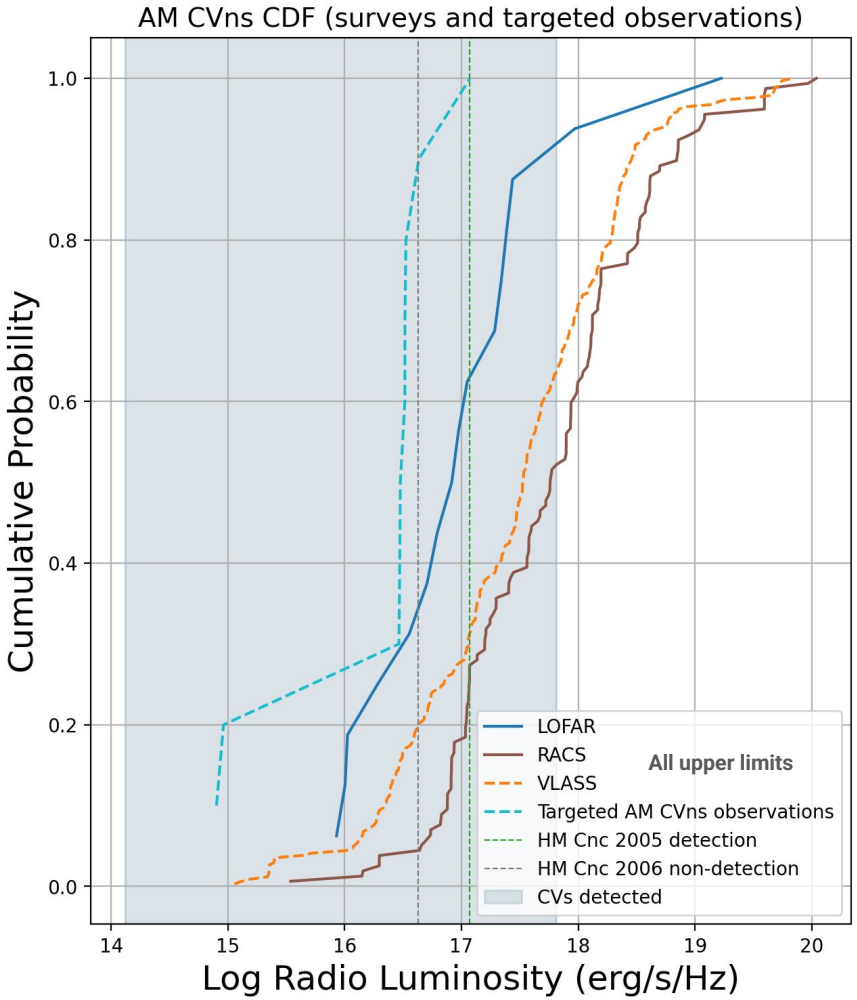

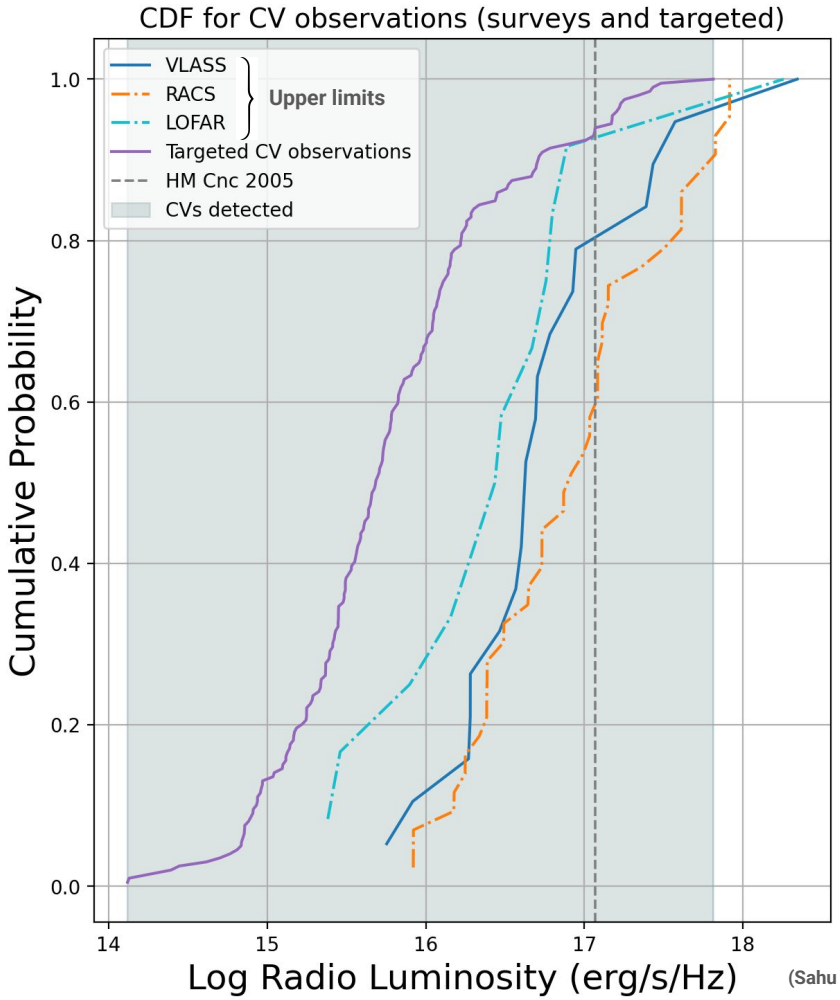

(Sahu et al., in prep)

Concluding Notes

★ Deepest-ever radio upper limits for AM CVns (HP Lib and AM CVn obtained with the VLA.

(Sahu et al., in prep)

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★ HM Cnc and UI - an unlikely match due to evidence of an accretion stream, as observed by *Munday et al. 2022*

★ Are AM CVns a fainter analog of CVs?

Collaborators:
Deanne Coppejans (supervisor), Danny Steeghs (supervisor), Wendy Williams (SKAO), Gavin Ramsay (Armagh), Jan van Roestel (Univ. Amsterdam), Patrick Thomas (Warwick)

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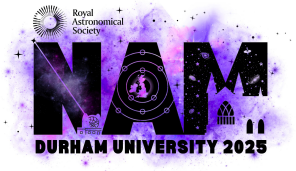

Data credits and sources:

Ritter, Hans, and Ulrich Kolb. "Catalogue of cataclysmic binaries, low–mass X-ray binaries and related objects." *Astronomy & Astrophysics* 404.1 (2003): 301-303.

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This research has made use of the CIRADA cutout service at URL cutouts.cirada.ca, operated by the Canadian Initiative for Radio Astronomy Data Analysis (CIRADA). CIRADA is funded by a grant from the Canada Foundation for Innovation 2017 Innovation Fund (Project 35999), as well as by the Provinces of Ontario, British Columbia, Alberta, Manitoba and Quebec, in collaboration with the National Research Council of Canada, the US National Radio Astronomy Observatory and Australia's Commonwealth Scientific and Industrial Research Organisation.

Lacy, M. et al. (2020). The Karl G. Jansky Very Large Array Sky Survey (VLASS). Publications of the Astronomical Society of the Pacific, 132(1010), 035001. ADS states

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Shimwell et al. (2022), A&A, 659, A1: The LOFAR Two-metre Sky Survey. V. Second data release