The Sydney Radio Star Catalogue

A new catalogue of radio stars

Laura Driessen
Postdoctoral research fellow and joint VAST project scientist
Laura.Driessen@Sydney.edu.au

THE UNIVERSITY OF SYDNEY

Why do we need a new radio star catalogue?

- The Catalogue of Radio stars was most recently updated in 2001
  (Wendker 1987, A&A Suppl. Ser., 69)
- To investigate the properties of the radio star population
  - The overall number of radio stars
  - Stellar types
  - Variability / flare rates
  - Rotation rates
  - Magnetic fields
- Impact on exoplanet habitability
- Tying the radio and optical reference frames
- Galactic foreground removal for cosmology
- Star removal for AGN / QSO investigation

What's in the Sydney Radio Star Catalogue (SRSC)?

- Radio stars found in searches using SKA precursor instruments (< 3 GHz)
- Published radio stars
    - V-LoTSS circular polarisation searches
      (Callingham et al. 2023, A&A 670, A124)
    - V-LoTSS, LoTSS and VLASS cross-matches with the *Gaia* Catalogue of Nearby Stars (GCNS)
      (Yiu et al. 2024, A&A, 684, id.A3)
    - ThunderKAT variable source searches
      (Driessen et al. 2020, MNRAS, 491, 1; Driessen et al. 2022, 10, 1; Andersson et al. 2022, MNRAS, 513, 3)
    - ASKAP short-timescale variable source searches
      (Wang et al. 2023, MNRAS, 523, 4)
    - Proper motion searches
      (Driessen et al. 2023, PASA, 40, e036)
- Radio stars found in circular polarisation searches using ASKAP
- Radio stars found in cross-matching using ASKAP

What's in the Sydney Radio Star Catalogue (SRSC)?

- Radio stars found in searches using SKA pathfinder/precursor instruments
- Published radio stars
- Radio stars found in circular polarisation searches using ASKAP
    - RACS-low (Pritchard et al. 2021, MNRAS, Volume 502, Issue 4)
    - VASTP (Pritchard et al. 2024, MNRAS, Volume 529, Issue 2)
    - RACS-mid and RACS-high
- Radio stars found in cross-matching using ASKAP

ASKAP catalogue cross-matching

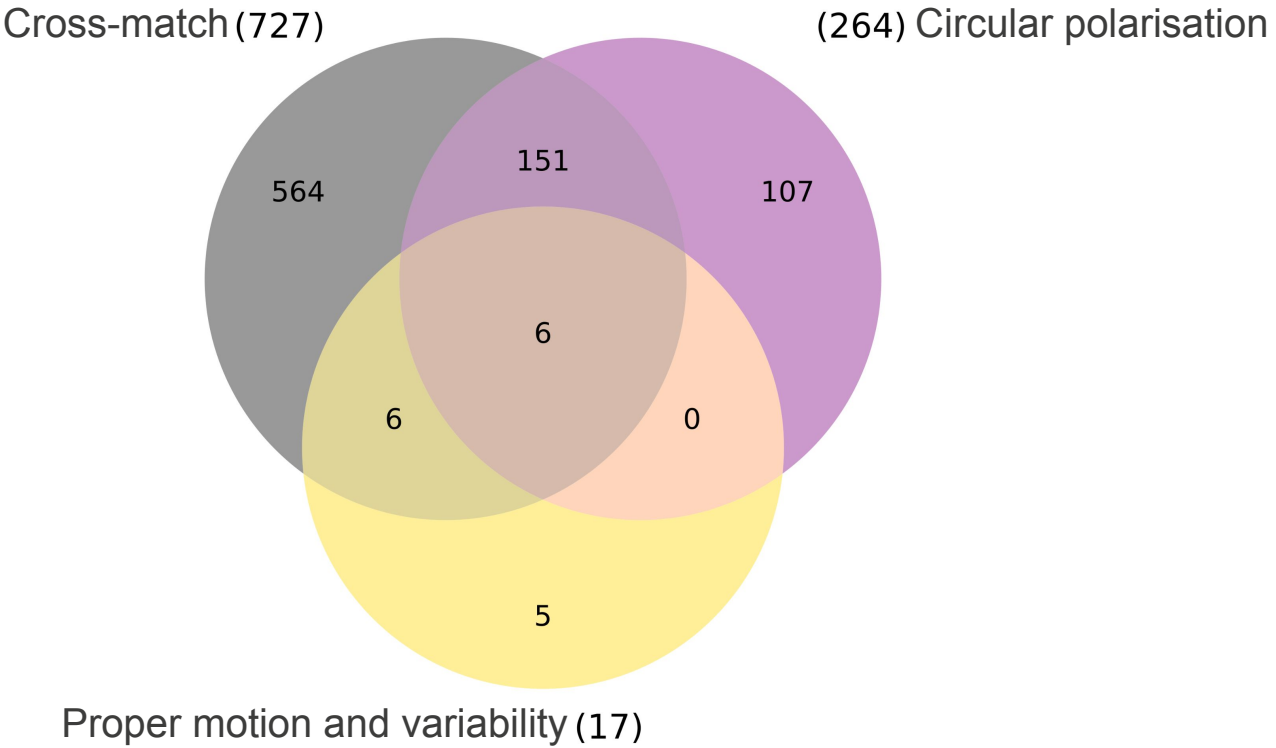
- Position cross-matching between ASKAP point sources and star catalogues

Sample name	N_{ASKAP}	$N_{ASKAP,!G}$	$N_{ASKAP,!G,PS}$
RACS-LOW	2,665,933	2,617,851	1,733,301
RACS-MID	3,107,143	3,038,033	2,118,761
RACS-HIGH	3,204,704	3,131,871	2,455,364
00-01hour	2,201,419	2,170,113	2,169,828
01-02hour	119,463	117,924	117,907
02-03hour	1,200,003	1,180,784	1,180,561
03-04hour	478,887	467,810	467,762
04-05hour	137,416	134,691	134,681
05-06hour	573,419	563,380	563,211
06-07hour	1,346,916	1,318,819	1,318,689
07-08hour	190,507	187,600	187,555
08-09hour	734,965	725,826	725,477
09-10hour	229,746	225,730	225,655
10-11hour	2,151,104	2,142,785	2,141,799
11-12hour	91,946	88,258	88,244
12-13hour	105,013	103,614	103,588
13-14hour	38,802	38,627	38,613

Star catalogue	N_{star}	N_{star} (Dec < +50°)
CNS5	5 908	5 193
ROSAT Stellar	27 881	23 017
XMM-Newton Stellar	5 042	4 400
Wolf-Rayet	669	653

- The Fifth Catalogue of Nearby Stars
  (CNS5; Golovin et al. 2023, A&A, Volume 670, id.A19)
- The Stellar Content of the *ROSAT* All-Sky Survey Catalogue
  ("ROSAT Stellar"; Freund et al. 2022, A&A, Volume 664, id.A105)
- The stellar content of the *XMM-Newton* slew survey
  ("XMM-Newton Stellar"; Freund et al. 2018, A&A, Volume 614, id.A125)
- The Galactic Wolf-Rayet Catalogue
  ("Wolf-Rayet"; Rosslowe & Crowther 2015, MNRAS, Volume 447, Issue 3)

What's in the Sydney Radio Star Catalogue (SRSC)?



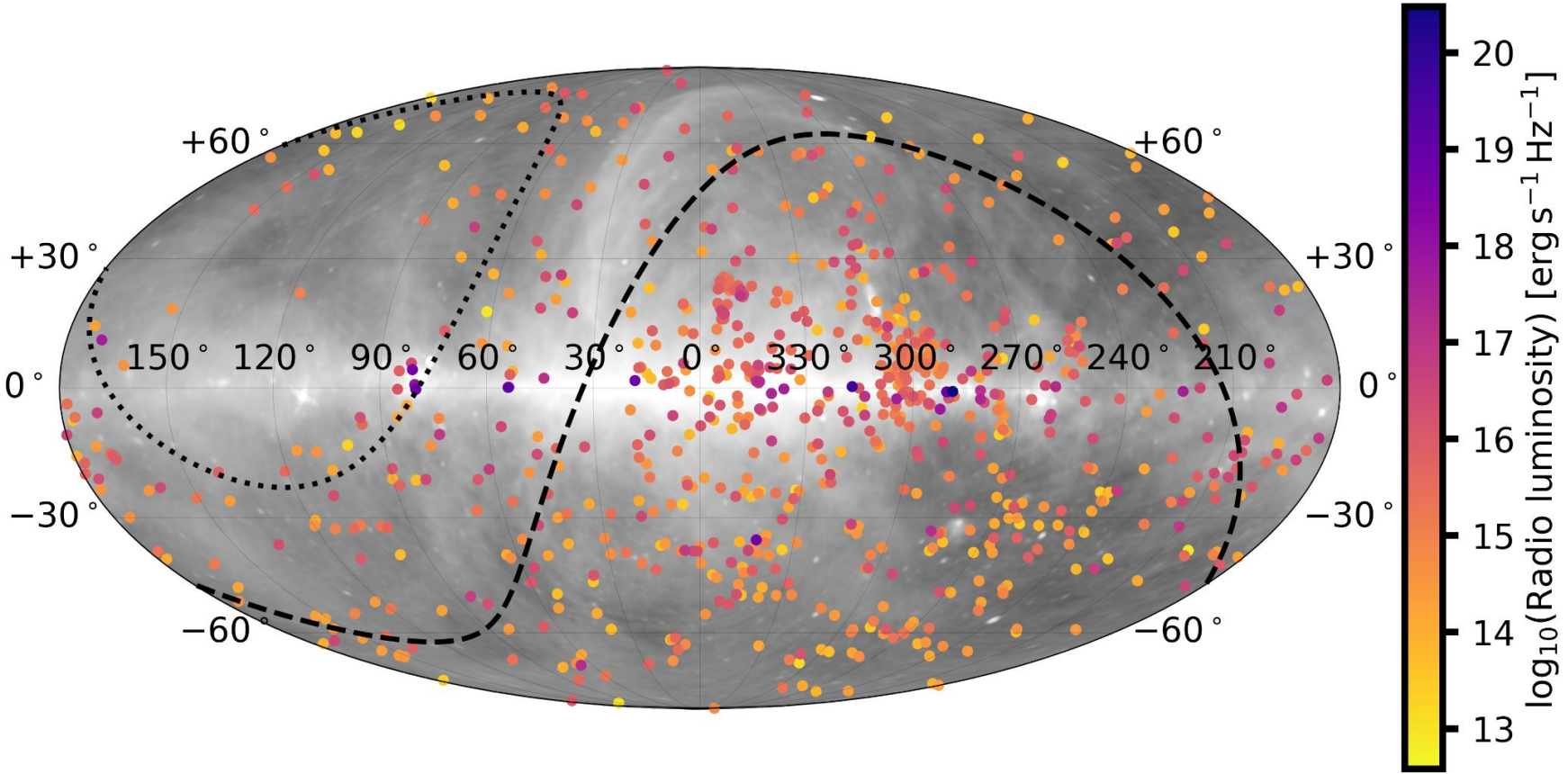
What will be added to the SRSC in the future?

- A detailed literature search to include radio stars found using other telescopes and in targeted searches
- Reliable radio stars from the Catalogue of Radio Stars
  (Wendker 1987, A&A Suppl. Ser., 69)
- A similar cross-match to stars found in the SRG/eROSITA all-sky survey
  (Freund et al 2024, eprint arXiv:2401.17282)
- Radio stars found in future searches, email me if you have stars that you'd like to have added to the SRSC (Laura.Driessen@Sydney.edu.au)

- We do not plan to include mm-band detections of stars

Properties of the Sydney Radio Star Catalogue

Skymap of the SRSC stars



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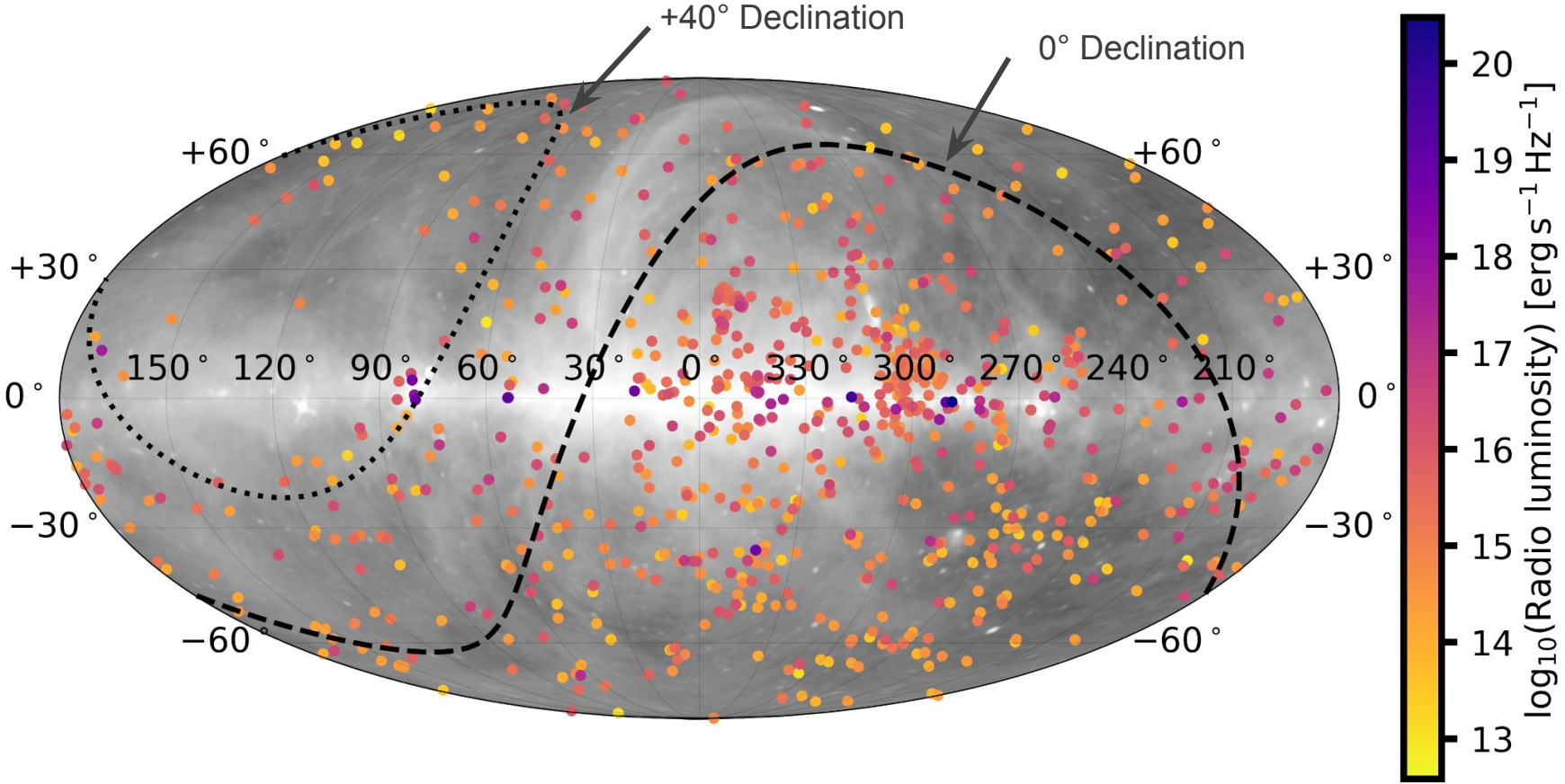
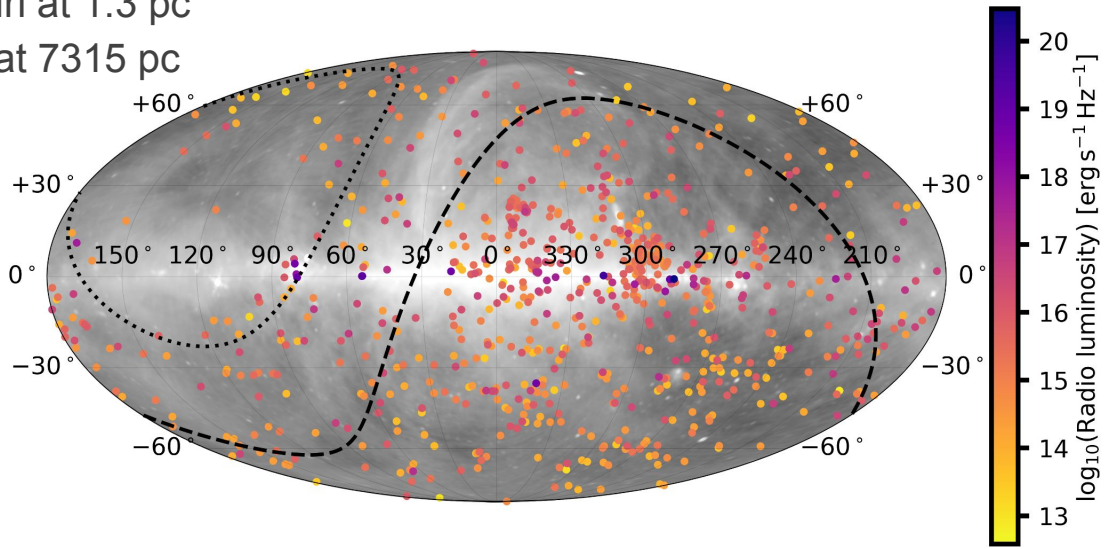


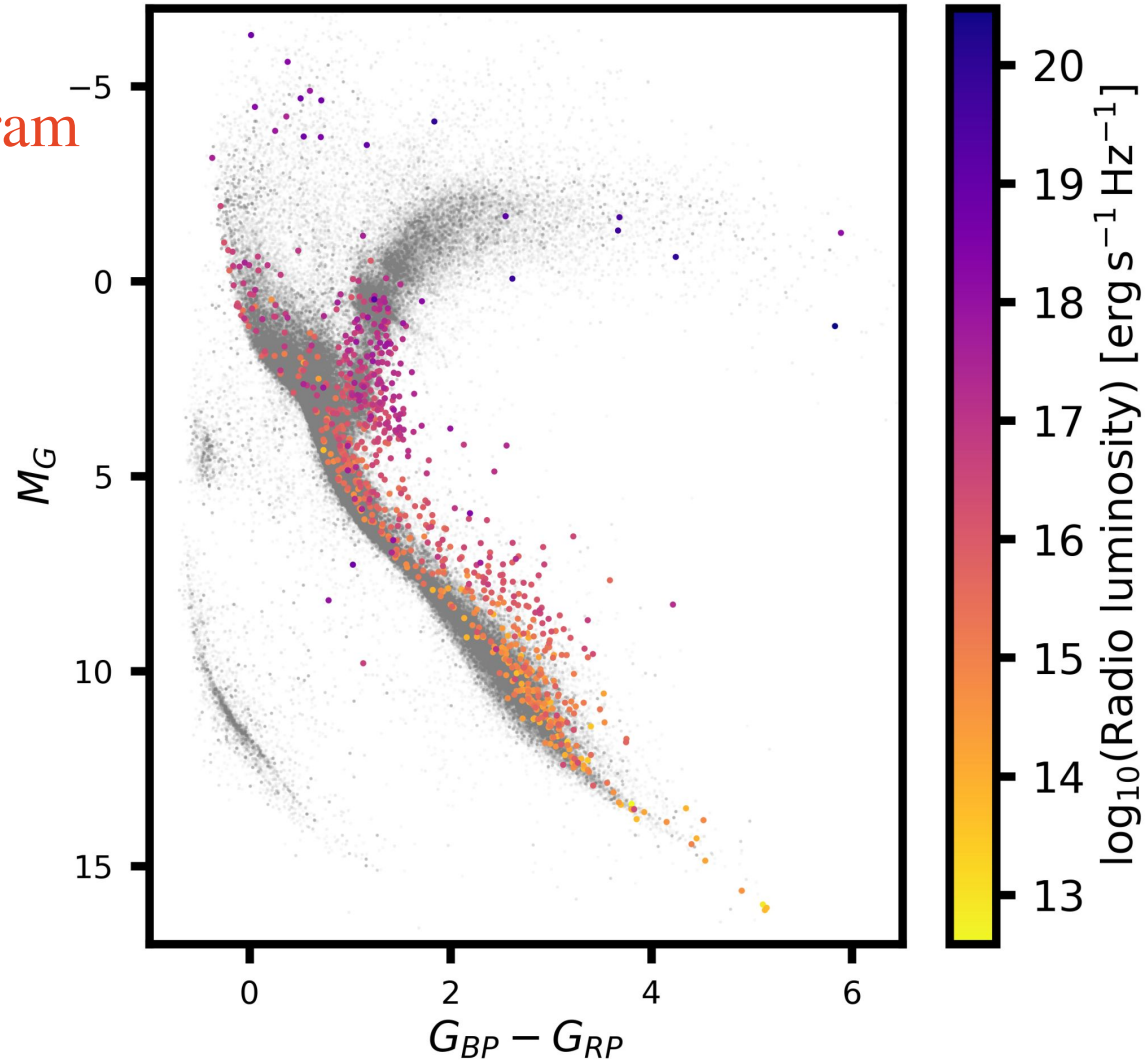
Skymap of the SRSC stars

- 839 unique stars
- 3405 radio detections
    - 398 stars with a single detection
    - 441 stars with more than one detection
- Radio flux densities between 0.02 mJy (EXO 040830–7134.7) and 199.4 mJy (Apep)
- 800 of the stars have an rgeo distance (Bailer-Jones et al. 2021, ApJ, Volume 161, Issue 3, id.147)
    - Closest star is Proxima Centauri at 1.3 pc
    - Furthest star is WRAY 15-682 at 7315 pc



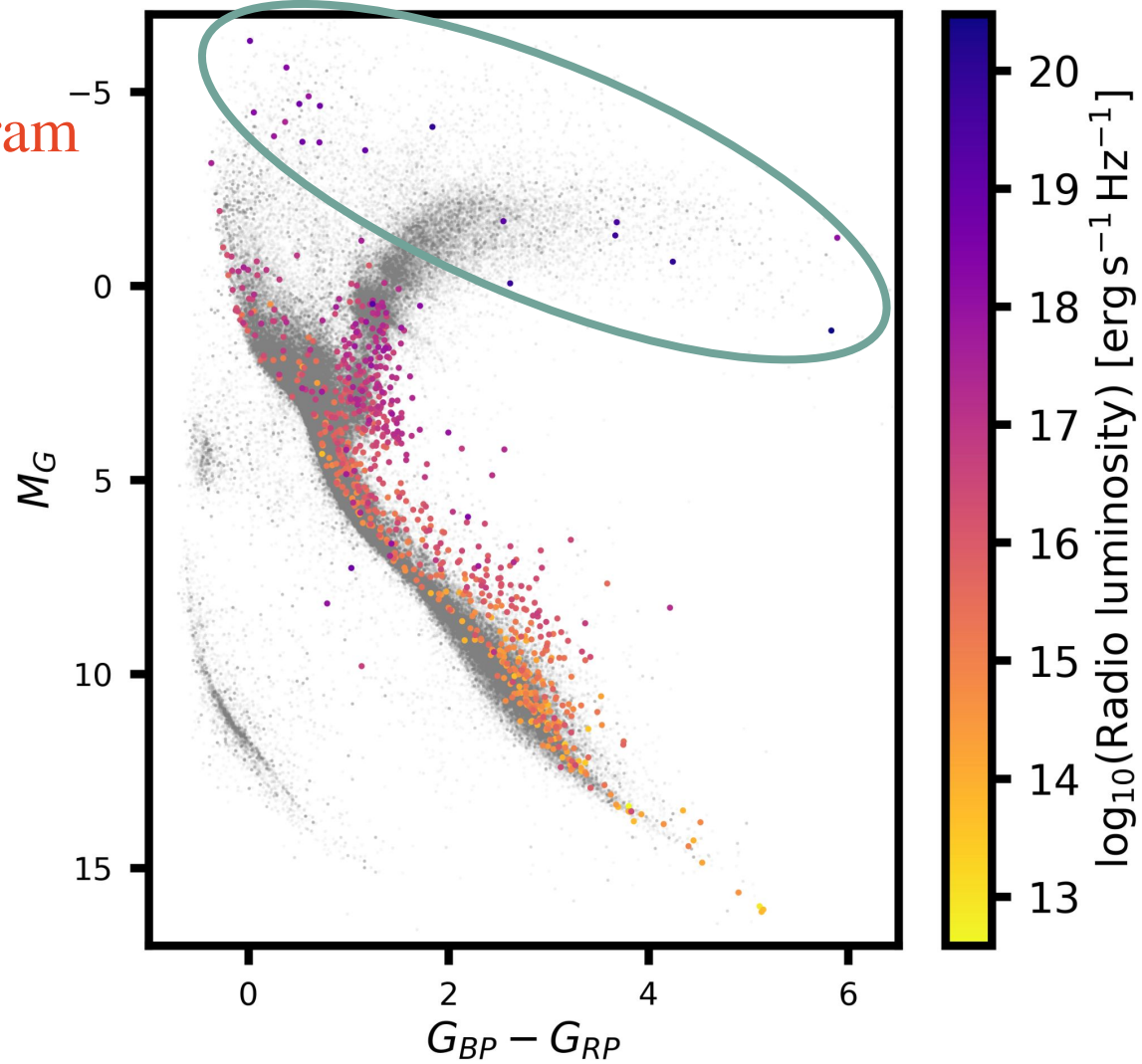
Colour-magnitude diagram

- *Gaia* colour-magnitude diagram (CMD)
  - M_G is the absolute G-band magnitude (330 - 1050 nm)
  - G_{BP} and G_{RP} are the *Gaia* blue (330 - 680 nm) and red (640 - 1050 nm) apparent magnitudes
  - The radio luminosity uses the rgeo distance and the maximum radio luminosity for each star



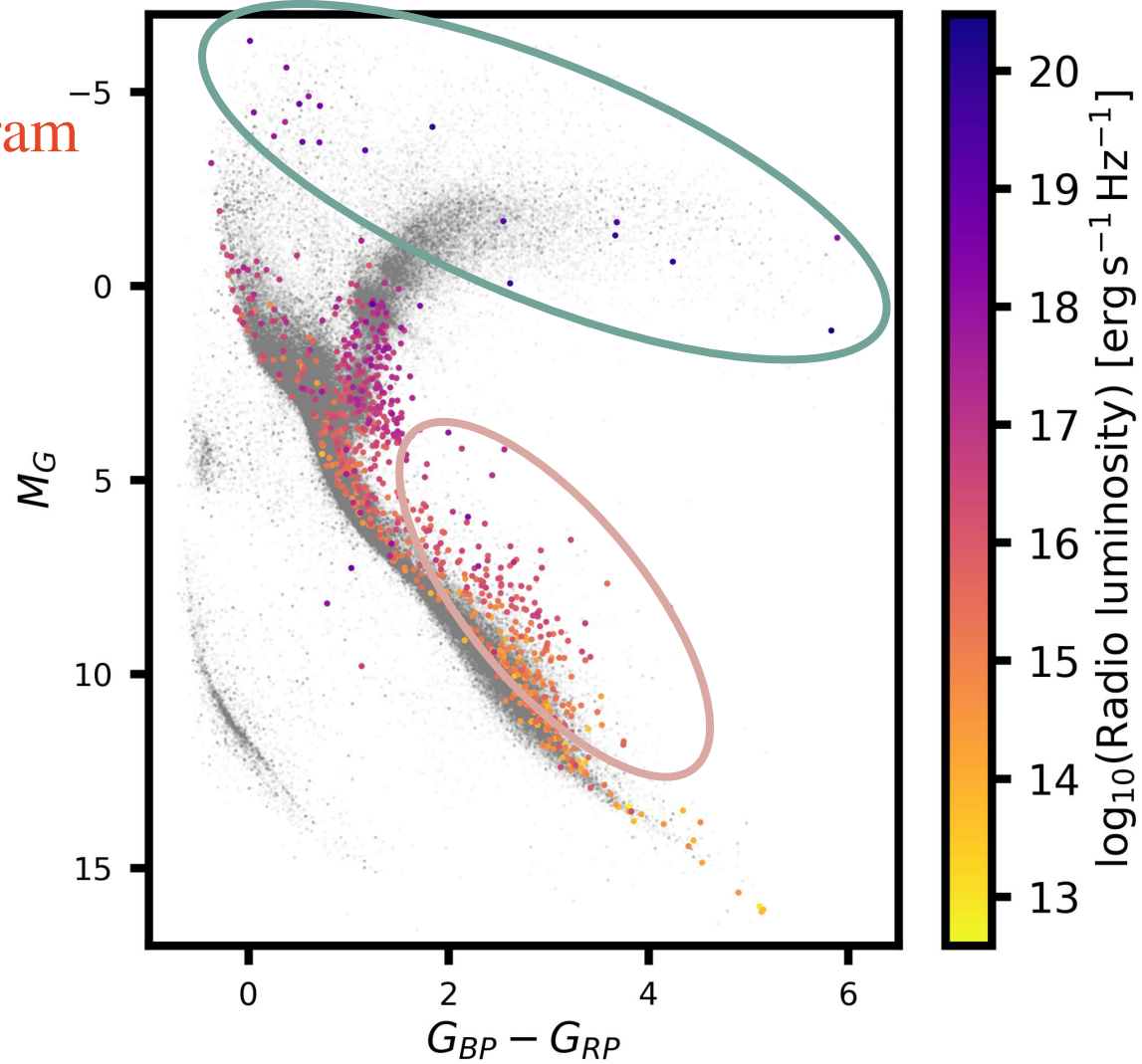
Colour-magnitude diagram

- Wolf-Rayet stars, symbiotic binaries and blue supergiants



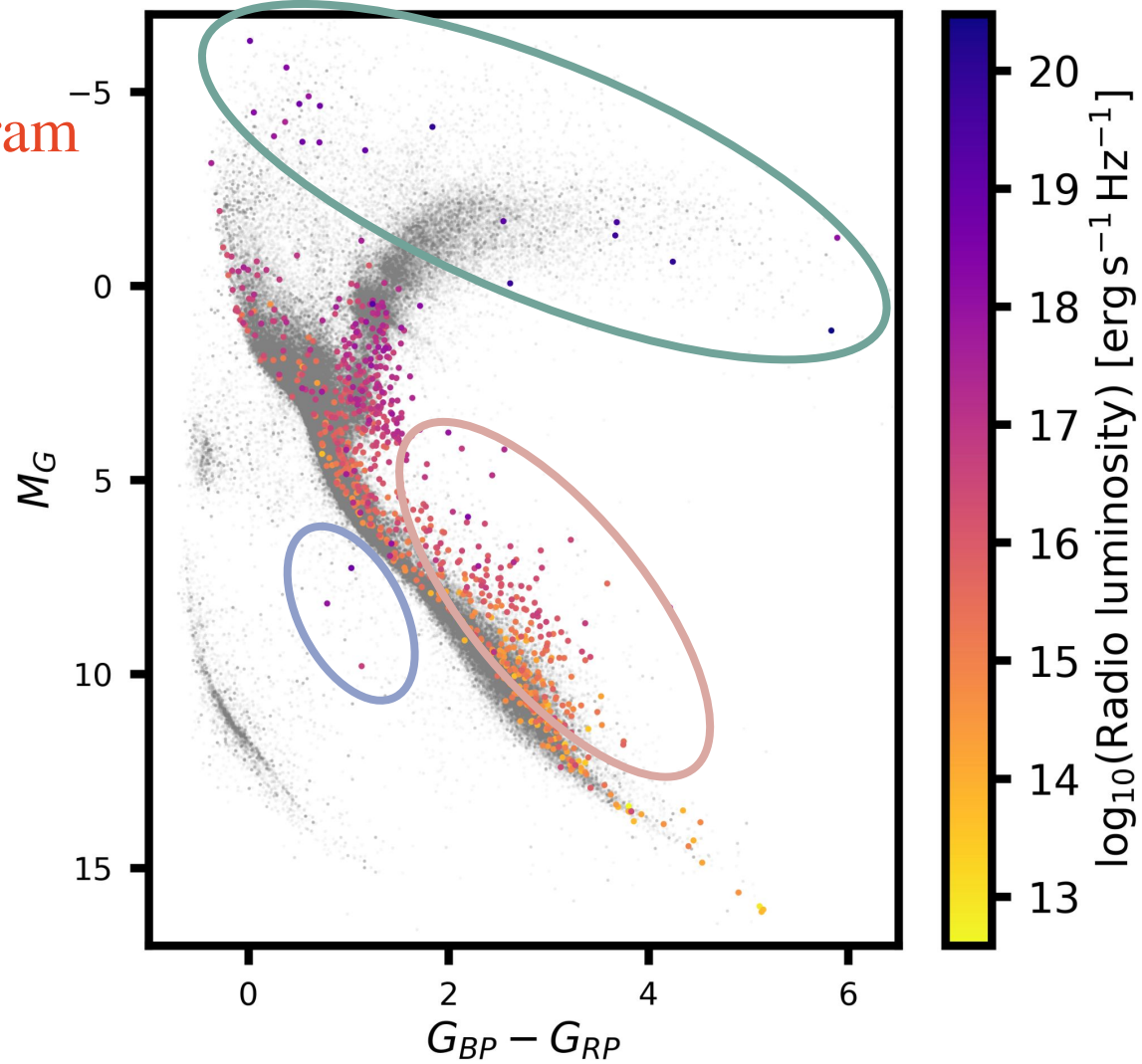
Colour-magnitude diagram

- Wolf-Rayet stars, symbiotic binaries and blue supergiants
- Young stars, e.g. T Tauri stars, Orion variables, YSOs



Colour-magnitude diagram

- Wolf-Rayet stars, symbiotic binaries and blue supergiants
- Young stars, e.g. T Tauri stars, Orion variables, YSOs
- A magnetic CV and two *Gaia* stars that we don't know much about



The Güdel – Benz relation

- Güdel-Benz relation is the correlation between the X-ray and radio luminosity of coronally active stars: $\log_{10}L_X \lesssim \log_{10}L_R + 15.5$ (Güdel & Benz 1993, ApJL v.405, p.L63)
- X-ray measurements using ROSAT and Einstein, radio measurements (mostly at ~5 GHz, some at ~9 GHz)

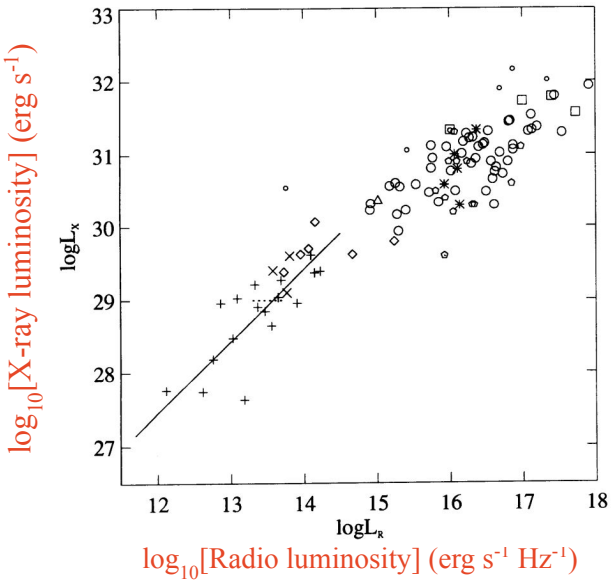


FIG. 1.—L_X vs. L_R for radio and X-ray detected stars of different classes. Key to the symbols and references: (*pluses*) dM(e) stars (Güdel et al. 1993a, b); (*crosses*) dK(e) stars (Güdel 1992); (*diamonds*) BY Dra binaries (Güdel 1992; Güdel 1993a, b); (*large circles*) RS CVn binaries (Drake et al. 1989, 1992); (*small circles*) RS CVn binaries with two giants (Drake et al. 1989, 1992); (*triangles*) AB Dor (Kürster, Schmitt, & Fleming 1992; Lim 1992); (*asterisks*) Algols (Wade & Hjellming 1972; Umana, Catalano, & Rodonò 1991; White & Marshall 1983; McCluskey & Kondo 1984); (*squares*) FK Com stars (Slee et al. 1987; Bedford, Elliot, & Eyles 1985; Ambruster, Fekel, & Guinan 1992; Phillips 1992; Hughes & McLean 1987, and references therein; Drake, Walter, & Florkowski 1990) (*pentagons*) PTTS (White et al. 1992, and references therein). The solid line is a fit to the M dwarfs.

Güdel & Benz 1993, ApJL v.405, p.L63

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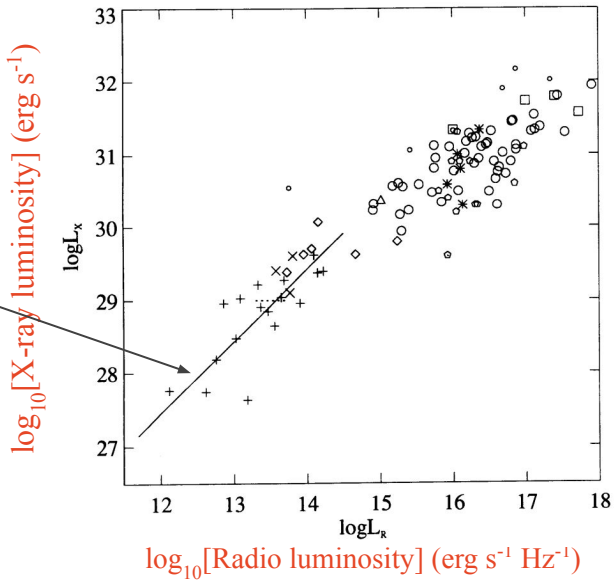
$\log_{10}L_X = \log_{10}L_R + 15.5$



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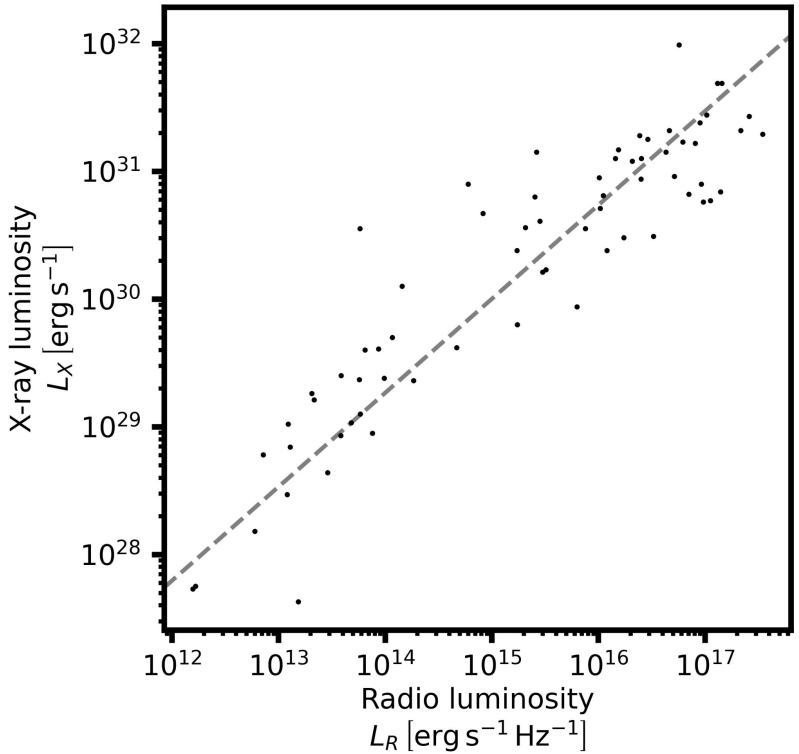
The Güdel – Benz relation

- New version of the Güdel-Benz relation: $\log_{10}L_R = 1.36(\log_{10}L_X - 18.97)$
  (Williams et al. 2014, ApJ, 785, 1)

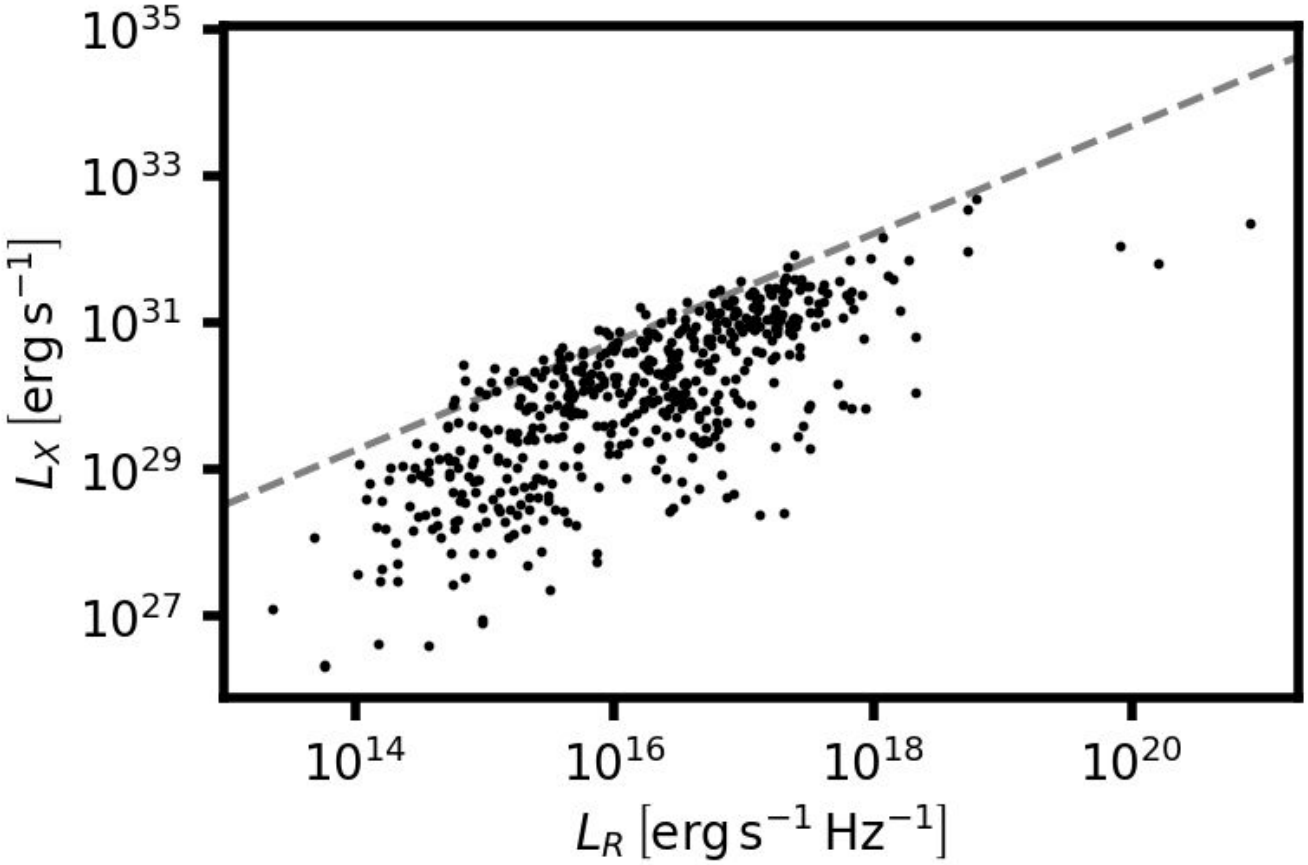


Stars from: Güdel & Benz 1993, ApJL v.405, p.L63

The SRSC Güdel – Benz relation

- eROSITA is the soft X-ray instrument on board the SRG spacecraft
- It performs all-sky surveys in the 0.2 – 10.0 keV energy range
- eRASS:4 is the eROSITA all-sky survey including 2 years of data covering Galactic latitude ≥ 180°
- 800 stars in the SRSC have rgeo distances, 530 of those have eRASS:4 detections

The SRSC Güdel – Benz relation



Future work

- Do a detailed literature search to add known radio stars
- More searching for new radio stars, e.g. cross-matching to eROSITA stars and expanding ASKAP circular polarisation searches
- Add in your stars, email me if you have stars that you'd like to have added to the SRSC (Laura.Driessen@Sydney.edu.au)
- We will regularly update the website version
- We will update the Vizier version when we have larger changes/additions to make

- Science using the SRSC!

Summary

- The Sydney Radio Star Catalogue is a new catalogue
- This first version contains 839 unique radio stars and 3,405 radio detections
- We will maintain and update the website version

Radio star website
www.RadioStars.org

Catalogue Paper
arXiv:2404.07418

Laura.Driessen@Sydney.edu.au | www.AstroLaura.com | Twitter.com/AstroLauraD | https://github.com/AstroLaura