Sub-millimeter photometry of the magnetic cataclysmic variable AR Sco

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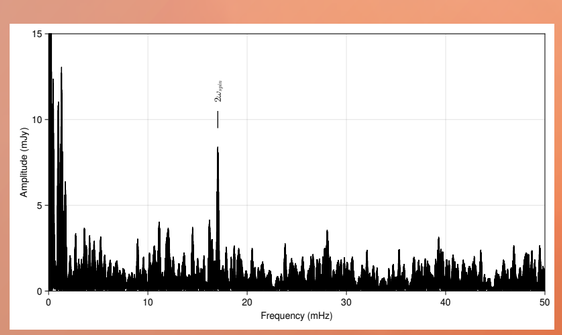
AR Sco System Parameters

- AR Sco is magnetic cataclysmic variable (MCV)
  - Discovered by Marsh *et al.* 2016 [1]
  - D = 117.05 ± 0.15 pc, V = 14.75
- Binary: white dwarf (WD) + red dwarf (RD)
- Rapidly rotating magnetic WD:
  - P_{orb} = 3.56 hr, P_{spin} = 117.20 s
- Roche lobe overflow: WD accretes material from RD
- Radio emission (2-1000 GHz): $\alpha \propto 0.5$, ($S_\nu \propto \nu^\alpha$)
  - Implies synchrotron emission
- B = ~500 MG estimated, based on spin down power
  - Suggest high magnetic field caused by WD crystallization generating a strong dynamo

AR Sco Photometry

- Submillimeter Array (SMA), Mauna Kea, HI
- One ≈1 hr observations at 210 GHz
  - 2022 April 9
- One ≈1 hr observations at 354 GHz
  - 2022 May 16
- Periodogram: signal at $2\nu_{spin}$
- Frequency: 0.01705 mHz (58.65 s)
- Amplitude: 8.5 mJy (7%)



Synchrotron Model Parameters

Parameter	Fast-cooling	Slow-cooling
ν_a (Hz)	$< 10^{10}$	$< 10^{10}$
ν_m (Hz)	$< 10^{14}$	1.5×10^{11}
ν_c (Hz)	4×10^{11}	10^{15}
n_e (cm^{-3})	3.3×10^{12}	1.9×10^{13}
p	1.0	1.3
ε	-0.7	-0.9
B (G)	1	1
R (cm)	10^{12}	10^{12}
L (cm)	10^{1}	10^{3}

Conclusions

- The 1st harmonic of the spin frequency shows the synchrotron emission is associated with the dipolar magnetic field of the WD
- The fast timescale of the flares indicates that magnetic reconnection is the likely primary injection mechanism for electron acceleration
- The lack of synchrotron self absorption constrains the magnetic field to be <1 G
- The low magnetic field of the emission region implies a low magnetic moment (~10^{33}) for the WD
- AR Sco is a magnetic propeller, like AE Aqr

Future Work

- Use VLBI to localize and constrain the emission region
- Develop more detailed models of the synchrotron emission to explain the steep spectral slope between 22 – 210 GHz

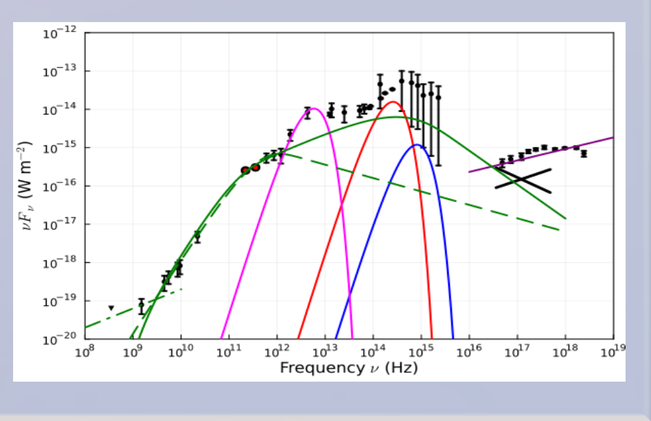
References

[1] Marsh, T. et al. 2016, Nature, 537, 374

[2] Barrett, P. & Gurwell, M. 2024, in prep.

AR Sco Spectral Energy Distribution

- SMA
- Four ≈1 hr observations at 210 GHz
  - $\langle f_\nu \rangle$ = 113.6 ± 1.2 mJy/beam (🔴)
- One ≈70 min observation at 345 GHz
  - $\langle f_\nu \rangle$ = 88 ± 11 mJy/beam (🔴)
- VLA
- One 4 hr K band observation at 22 GHz
  - $\langle f_\nu \rangle$ = 12—22 ± 0.3 mJy/beam (🟥)
- Fitted synchrotron spectral energy distribution
  - Slow-cooling model (solid)
  - Fast-cooling model (dashed)
  - 50 K blackbody (solid)
  - RD blackbody (solid)
  - WC blackbody (solid)



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