Brown Dwarfs: Keep their cool
4 September 2025

Probing magnetic activity and atmospheric dynamics in the L3.5 dwarf LSPM J0036+1821

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LSPM J0036+1821

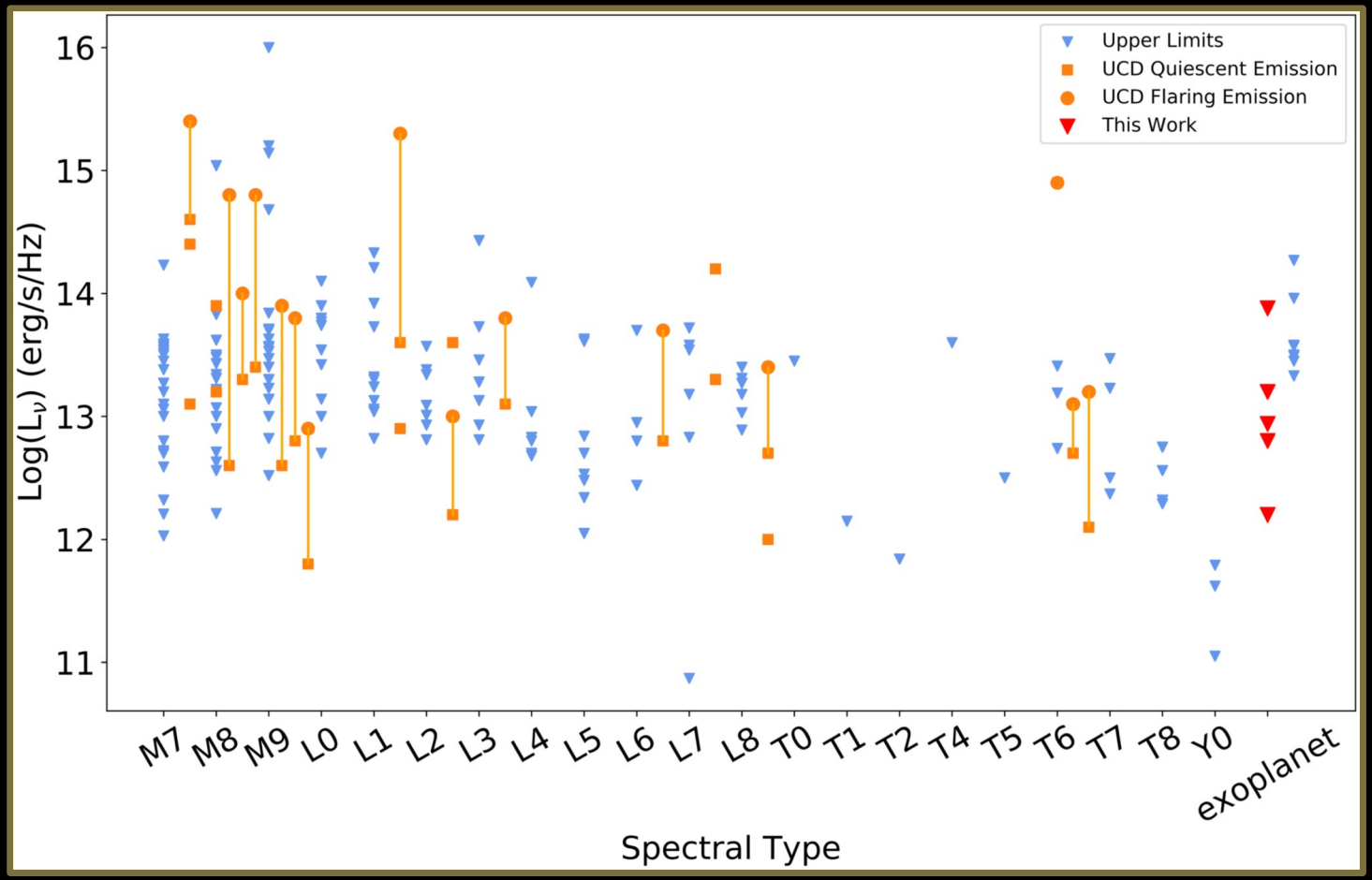
Parameters	Value
Spectral Type	L3.5
Mass	$66.07 \pm 12.98\, M_J$
Radius	$1.01 \pm 0.07\, R_J$
Age	0.5 - 10 Gyr
Distance	8.76 ± 0.06 pc
P_{rot} IR	$2.7 \pm 0.3\, h$
P_{rot} Radio	$3.08 \pm 0.05\, h$

Our Goals

- **Improve the radio period measurement**
- **Apply an auroral ring model.**
- **Improve the IR/optical period measurement**
- **Comparative analysis of both VIS and radio light curves.**

WORK IN PROGRESS!

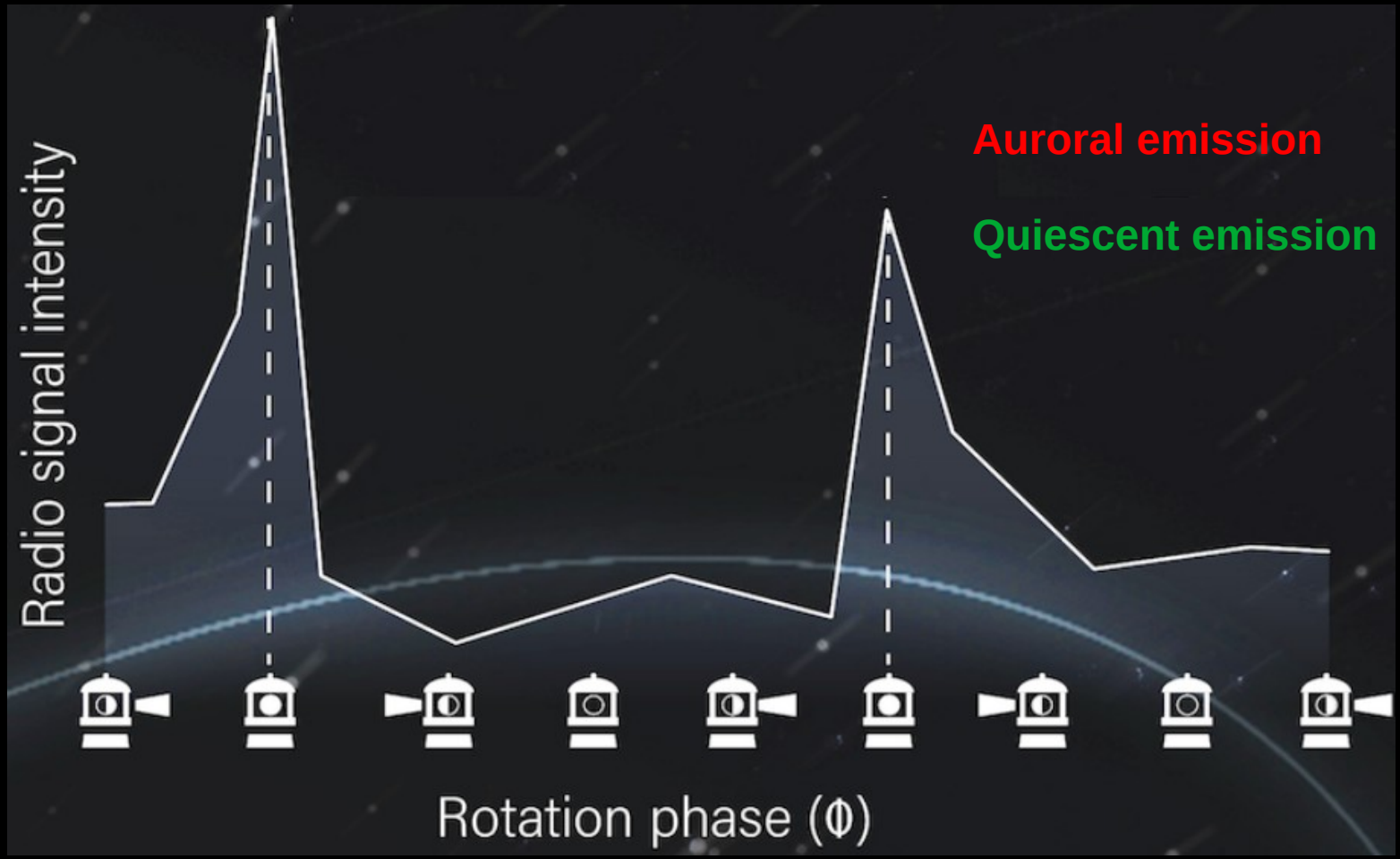
UCD at radio wavelengths



Cendes et al. 2022

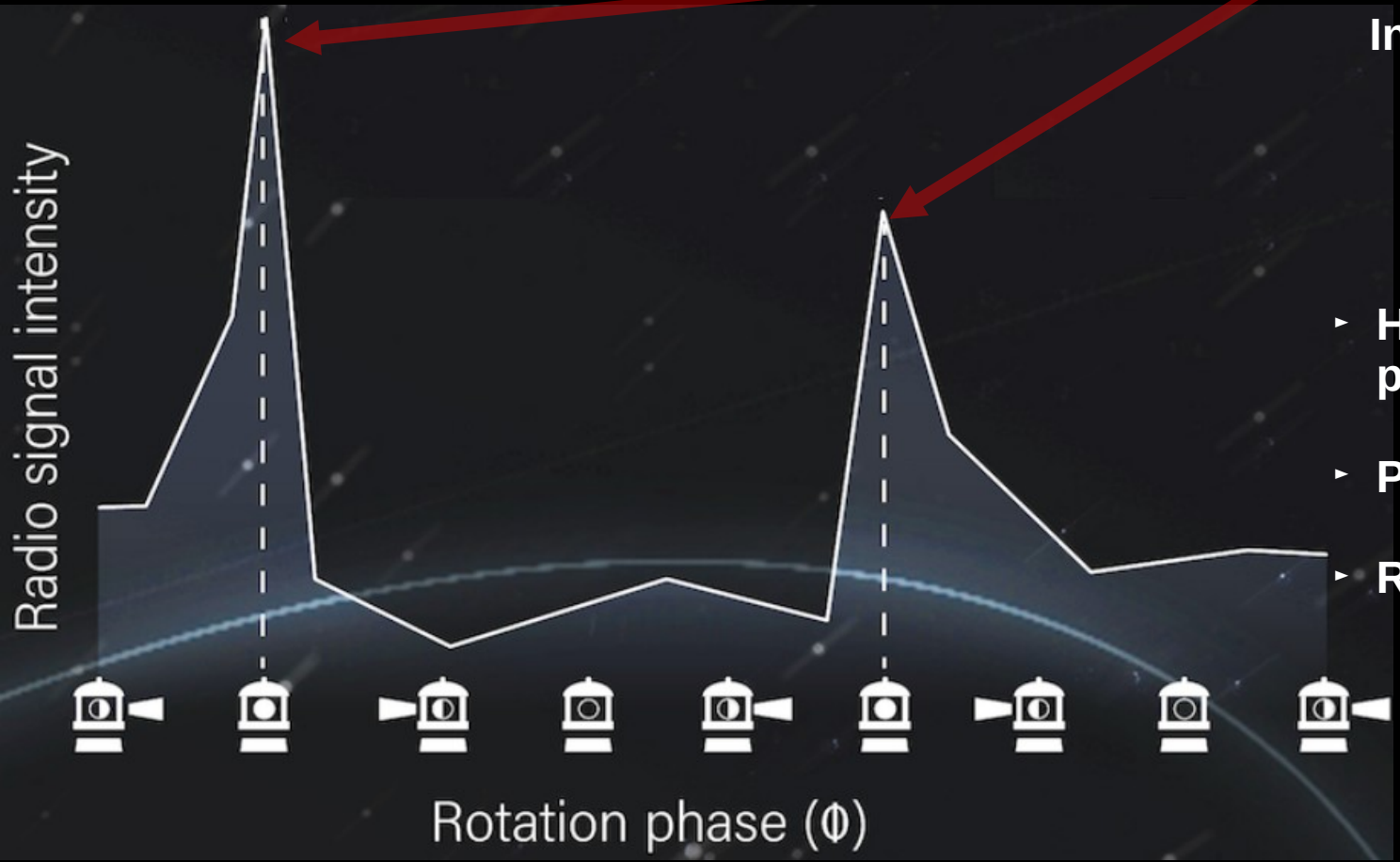
~ 10 % of all UCDs present radio emission! (Kao & Shkolnik 2024)

Typical UCD radio emission



Credits: Hugo Salais/ Metazoa Studio; Climent et al. (2023)

UCD’s auroral emission

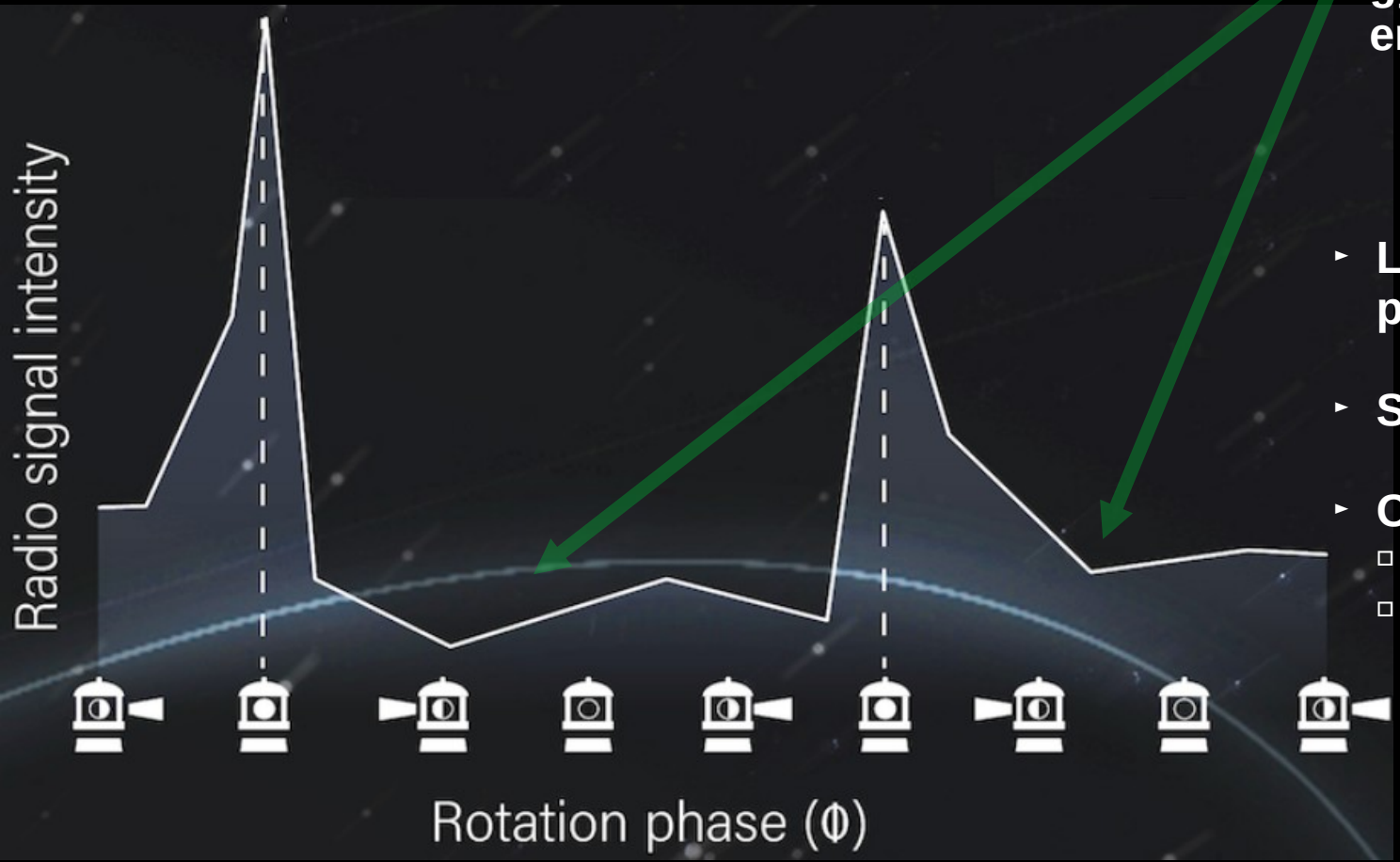


Auroral emission via Electron Cyclotron Maser Instability (ECMI)

- **Highly circularly polarised**
- **Pulsed**
- **Rotationally modulated**

Credits: Hugo Salais/ Metazoa Studio; Climent et al. (2023)

UCD’s quiescent emission



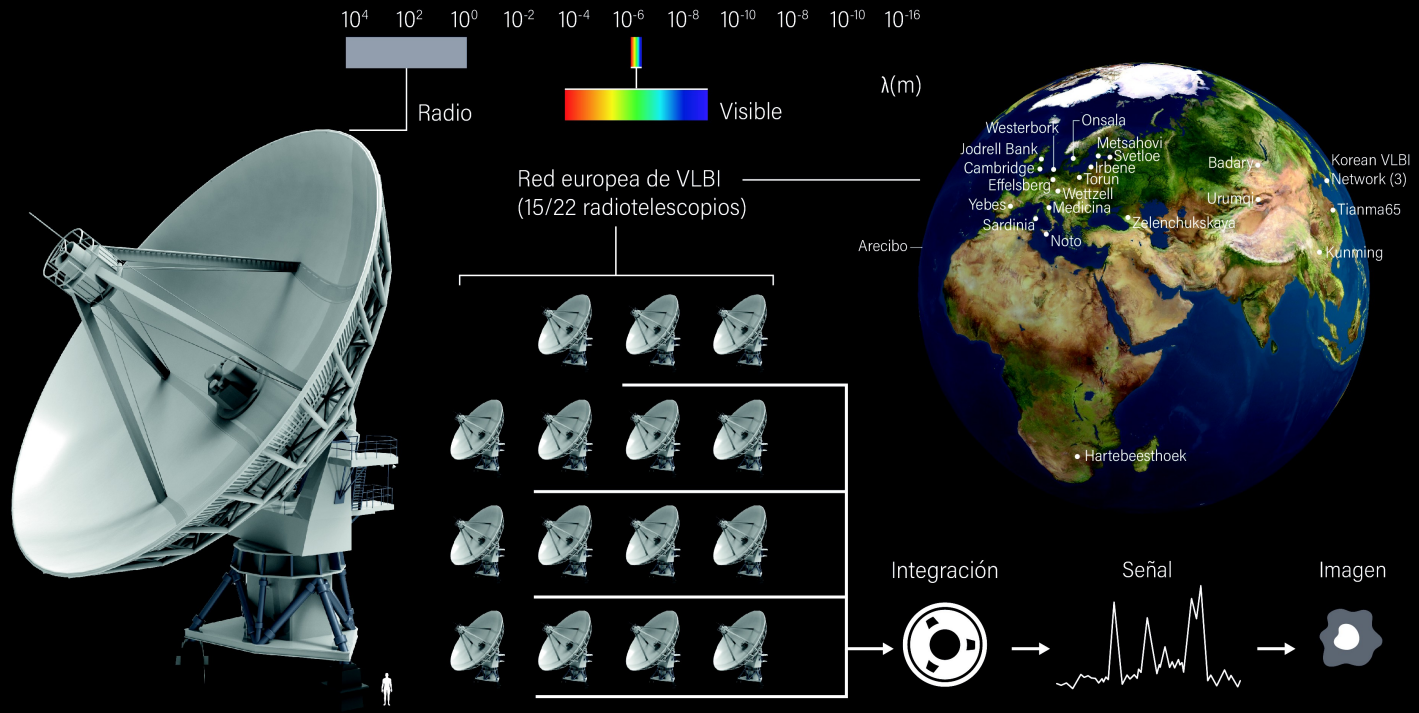
Quiescent emission via gyrosynchrotron emission

- **Low degree of circular polarization**
- **Slowly-varying**
- **Origin:**
  - **Coronal reconnections?**
  - **Radiation belt?**

Credits: Hugo Salais/ Metazoa Studio; Climent et al. (2023)

VLBI technique

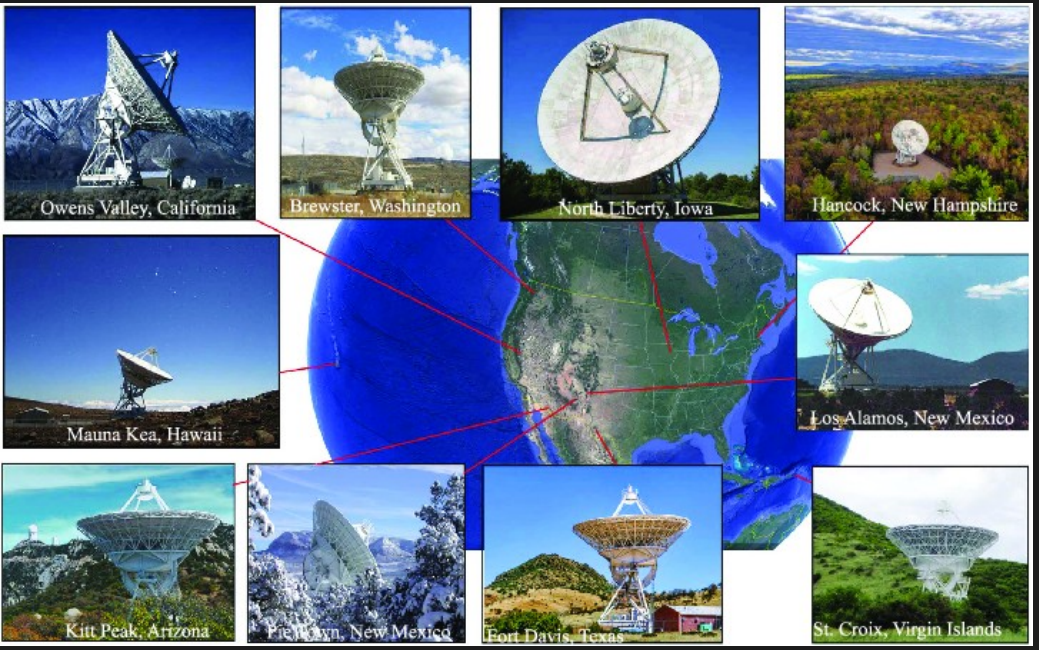
Very **L**arge **B**aseline **I**nterferometry



Credits: Hugo Salais/ Metazoa Studio; Climent et al. (2023)

VLBI *observatories*: VLBA & EVN

Very Large Baseline Array



Kooi et al. (2023)

Ten 25-meter antenna across the United States

European VLBI Network

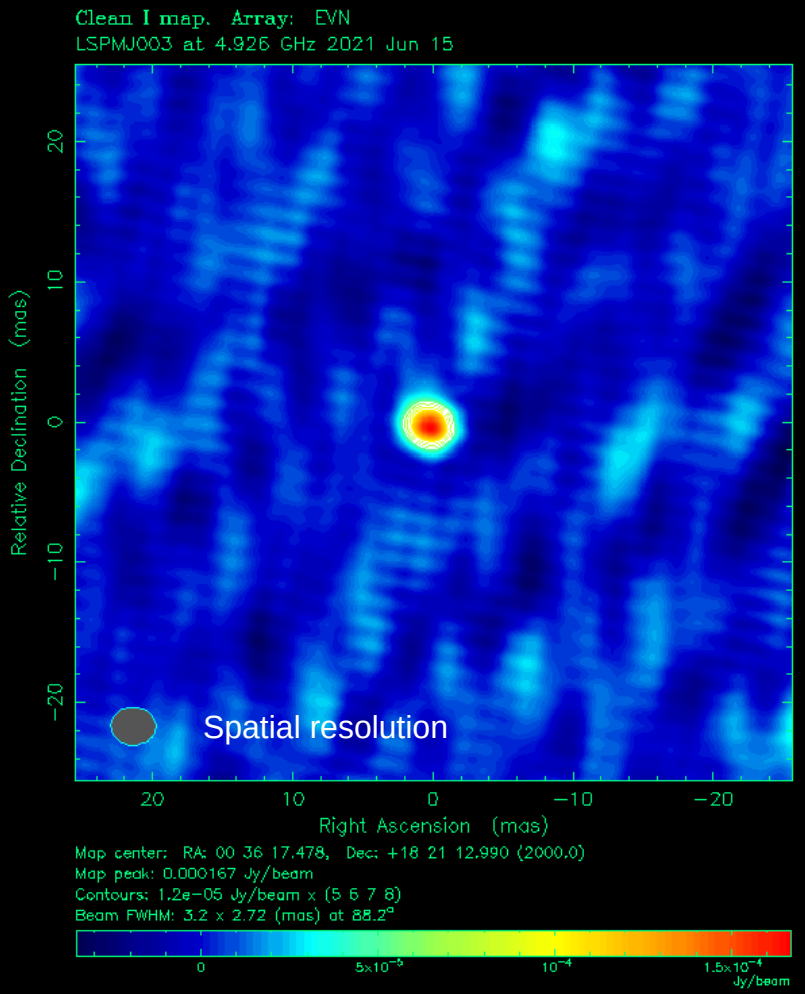
Credits: EVN

22 telescope facilities across Europe, Asia and South Africa

LSPMJ0036 +1821: Radio observations

- 13 VLBA epochs + 2 EVN epochs (2019-2021)
- C band: 3.9 – 7.9 GHz
- At least one complete rotation per epoch
- RCP, LCP, Stokes I, Stokes V

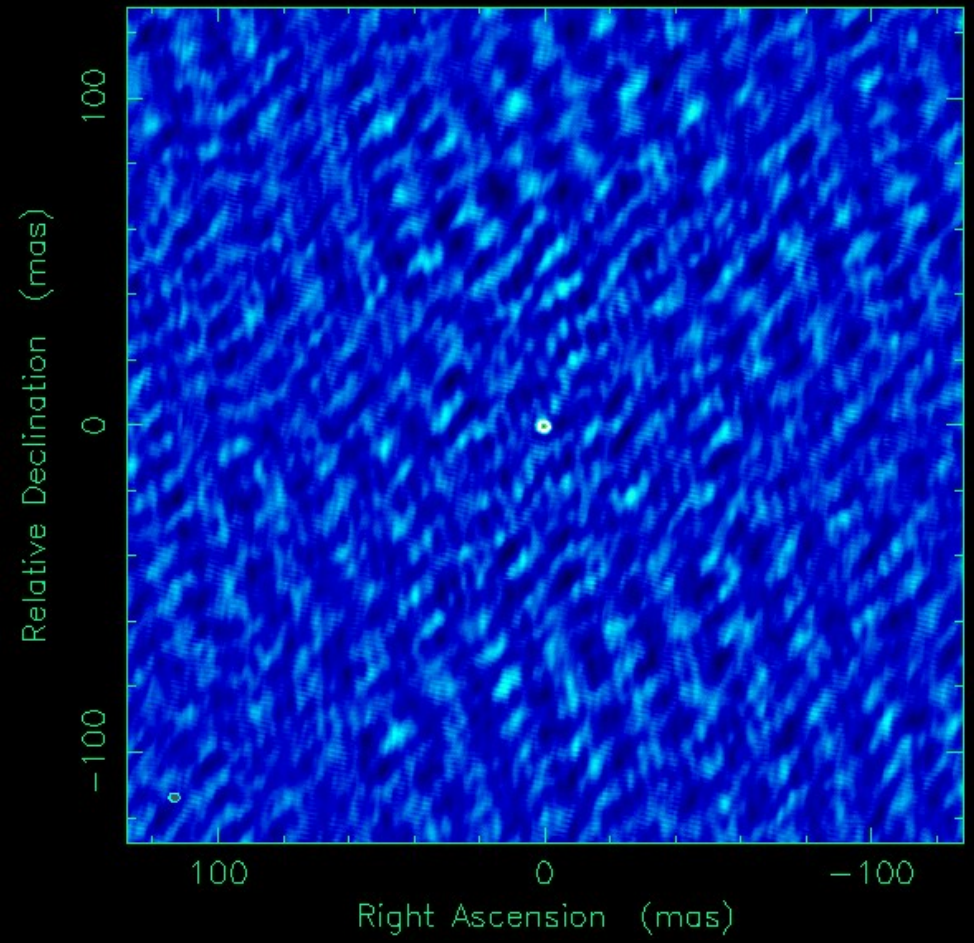
J0036 VLBI radio imaging



- **Point source, no structure observed in any epoch.**
- **We do not detect companion proposed in Bernat et al. (2010)**
- **If companion, radio flux < 27.6 μJy (3σ)**

Beam FWHM: 3.2x2.72 (mas)

J0036 VLBI radio imaging



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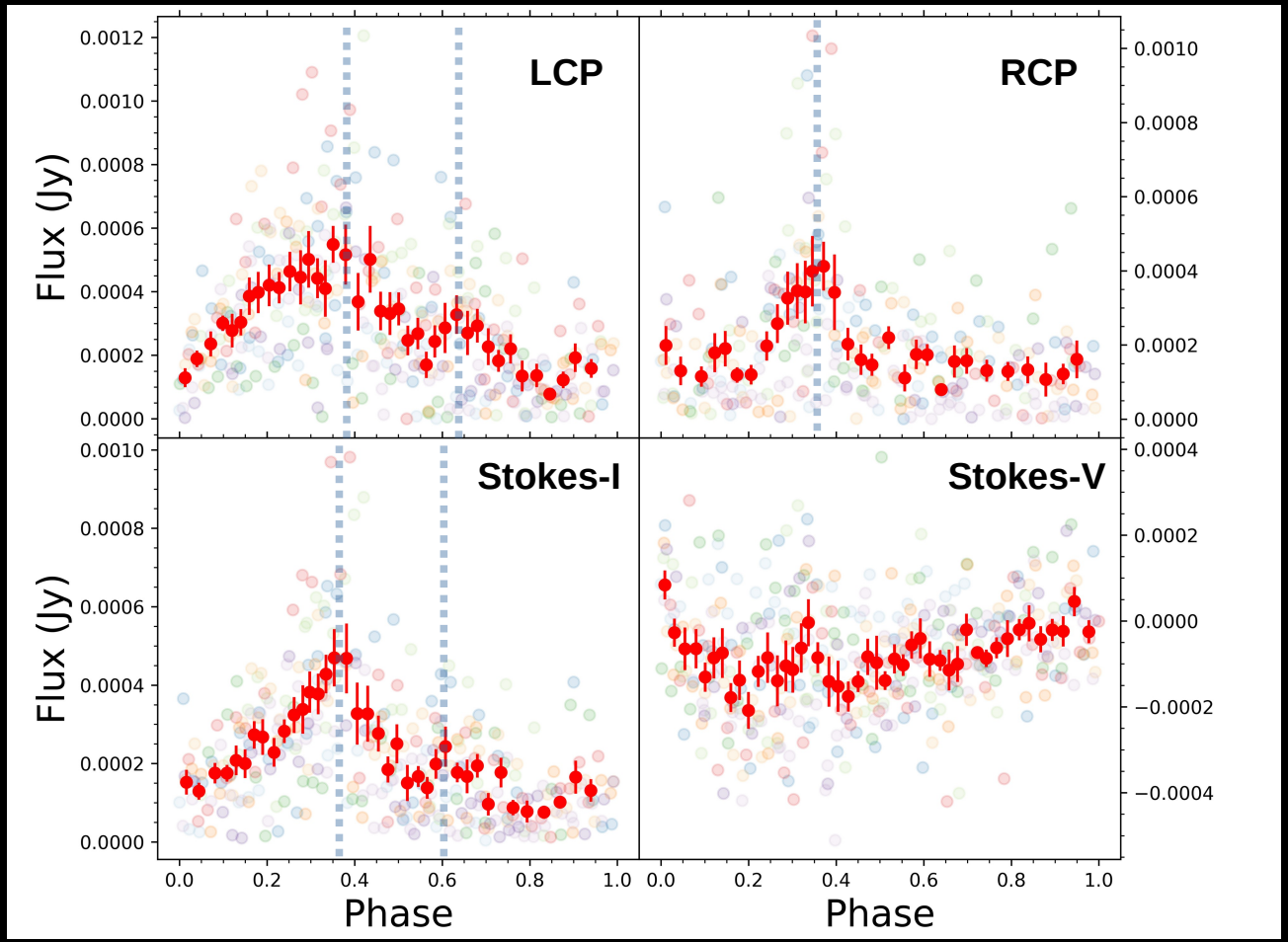
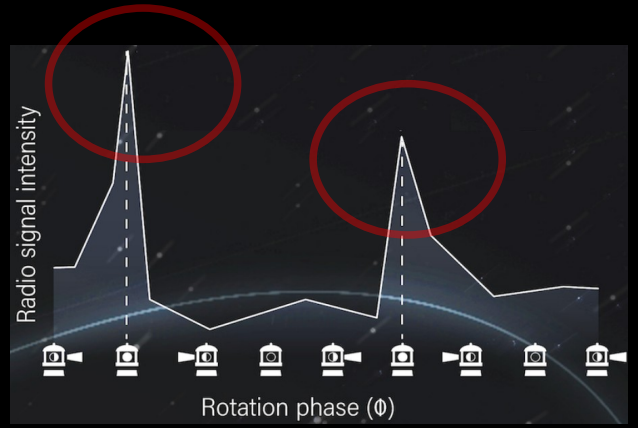
Phase-folded J0036 radio light curves



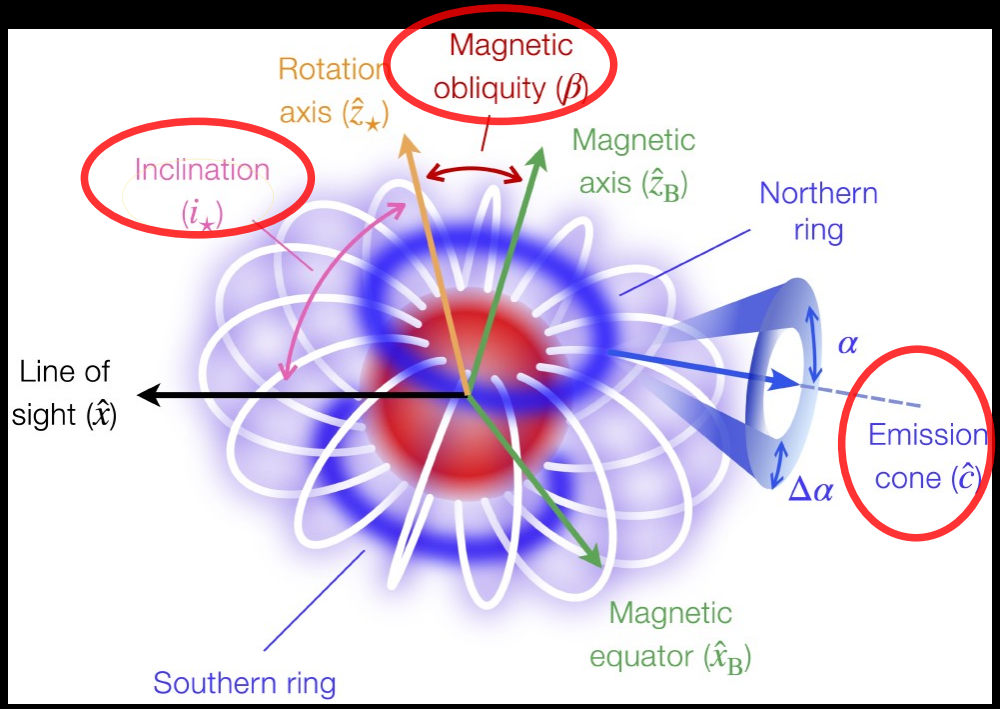


- **Auroral emission**
- **Probably not enough sensitivity to see quiescent emission… VLA!**

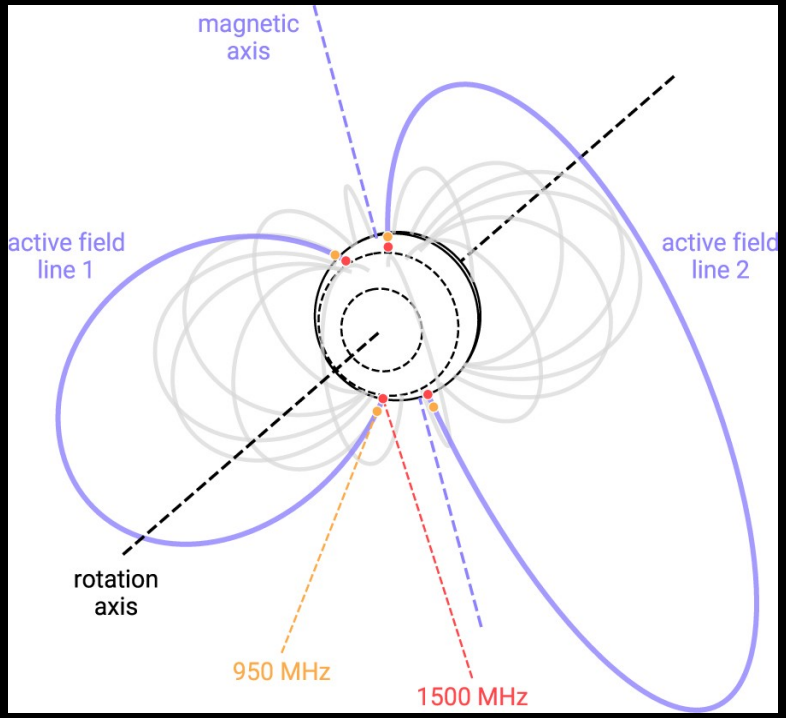
P_rot = 3.07943 ± 0.00005 h

Auroral ring model

- Model presented in Kavanagh et al. (2024) **(Next talk!)**.
- Geometric model, based on the auroral ring model
- Assumes there are just 2 active lines

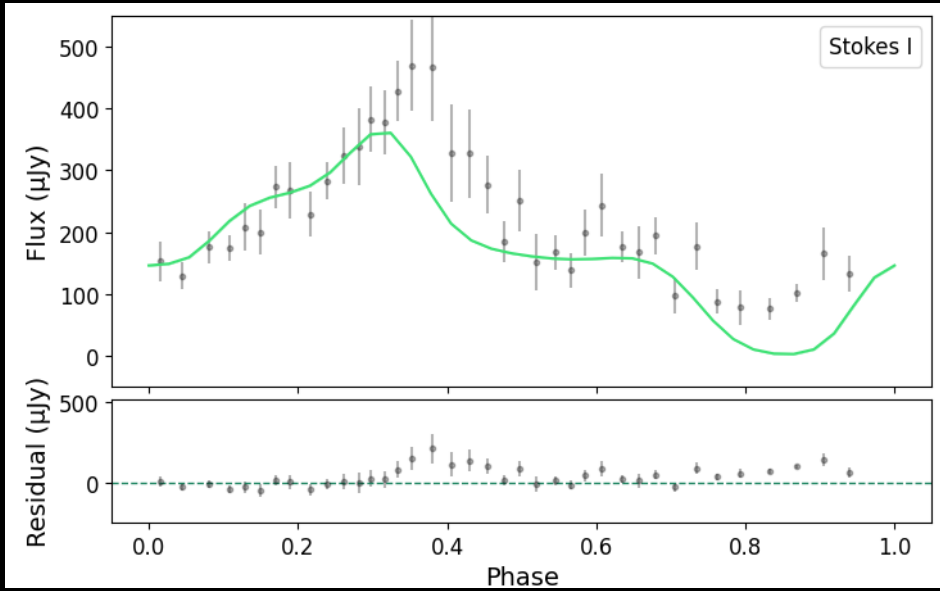


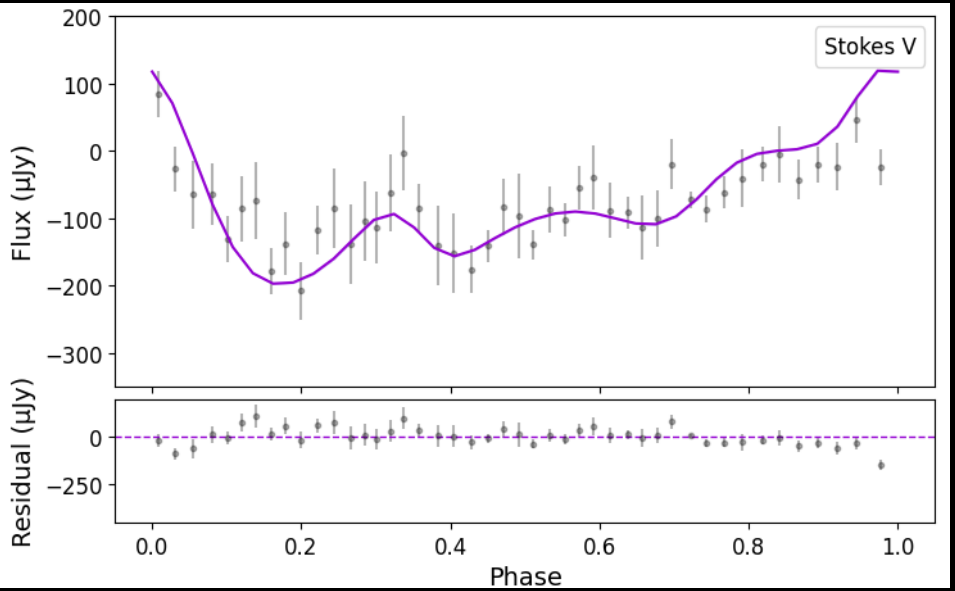
Bloot et al. (2024)



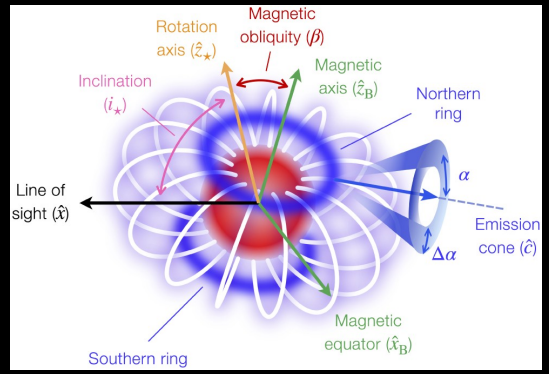
Kavanagh et al. (2024)

J0036: Auroral ring model fitting





Parameters	Value
Rotation axis inclination (i)	$59.3 \pm 1.7°$
Magnetic obliquity (β)	$14.5 \pm 1.4°$
Cone opening angle (α)	$89.6 \pm 0.4°$
Cone thickness ($\Delta\alpha$)	$9.9 \pm 0.1°$

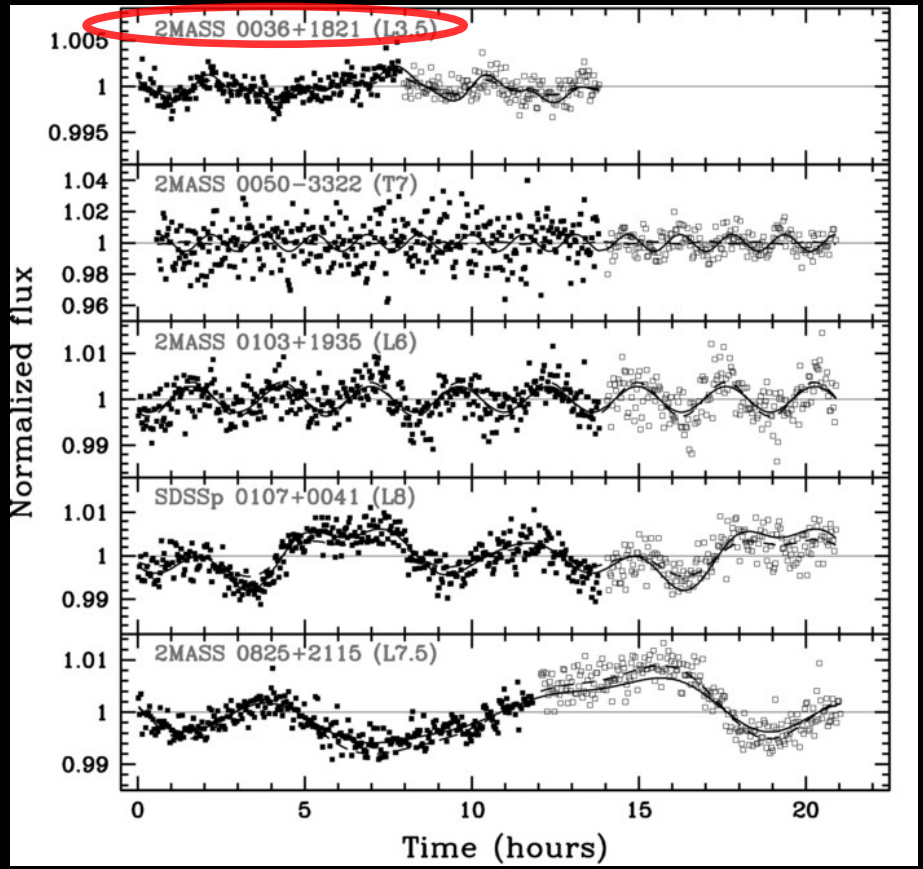


See Kavanagh et al. (2024) and Guirado et al. (2025)

UCD's Infrared/optical photometric variability

Jupiter IR

Credits: Gemini North Observatory

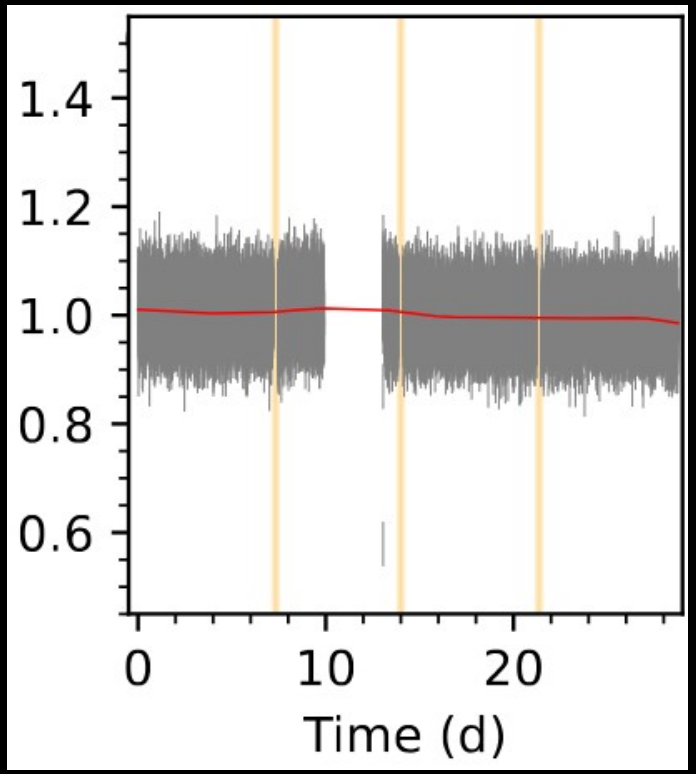


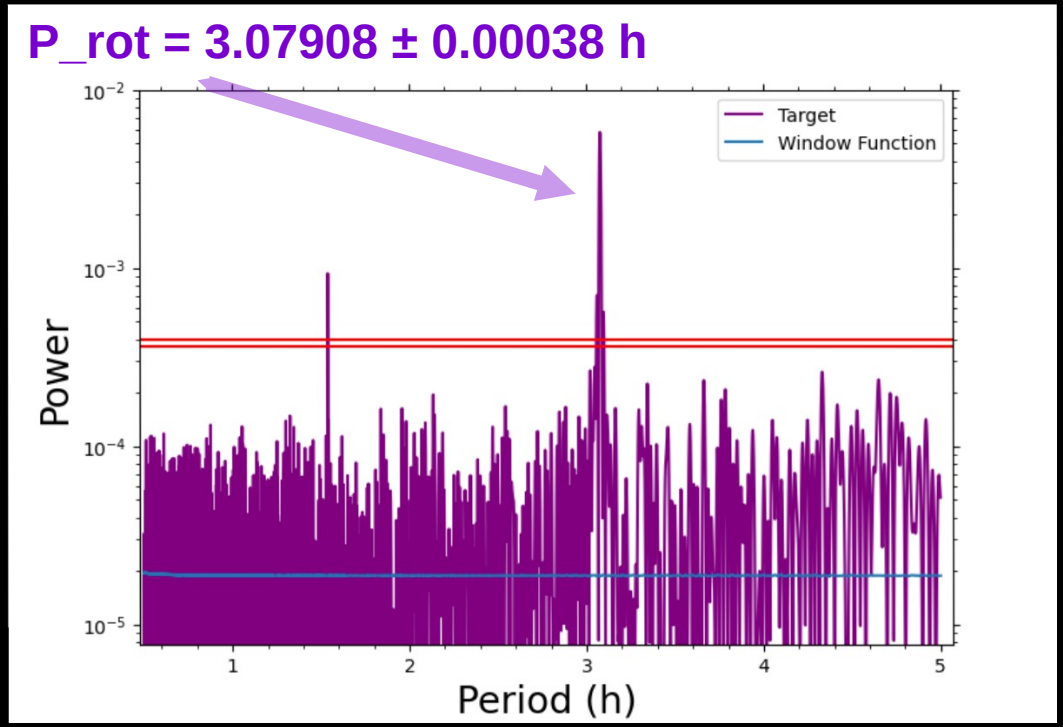
Metchev et al. (2015)

J0036 Optical observations (TESS)

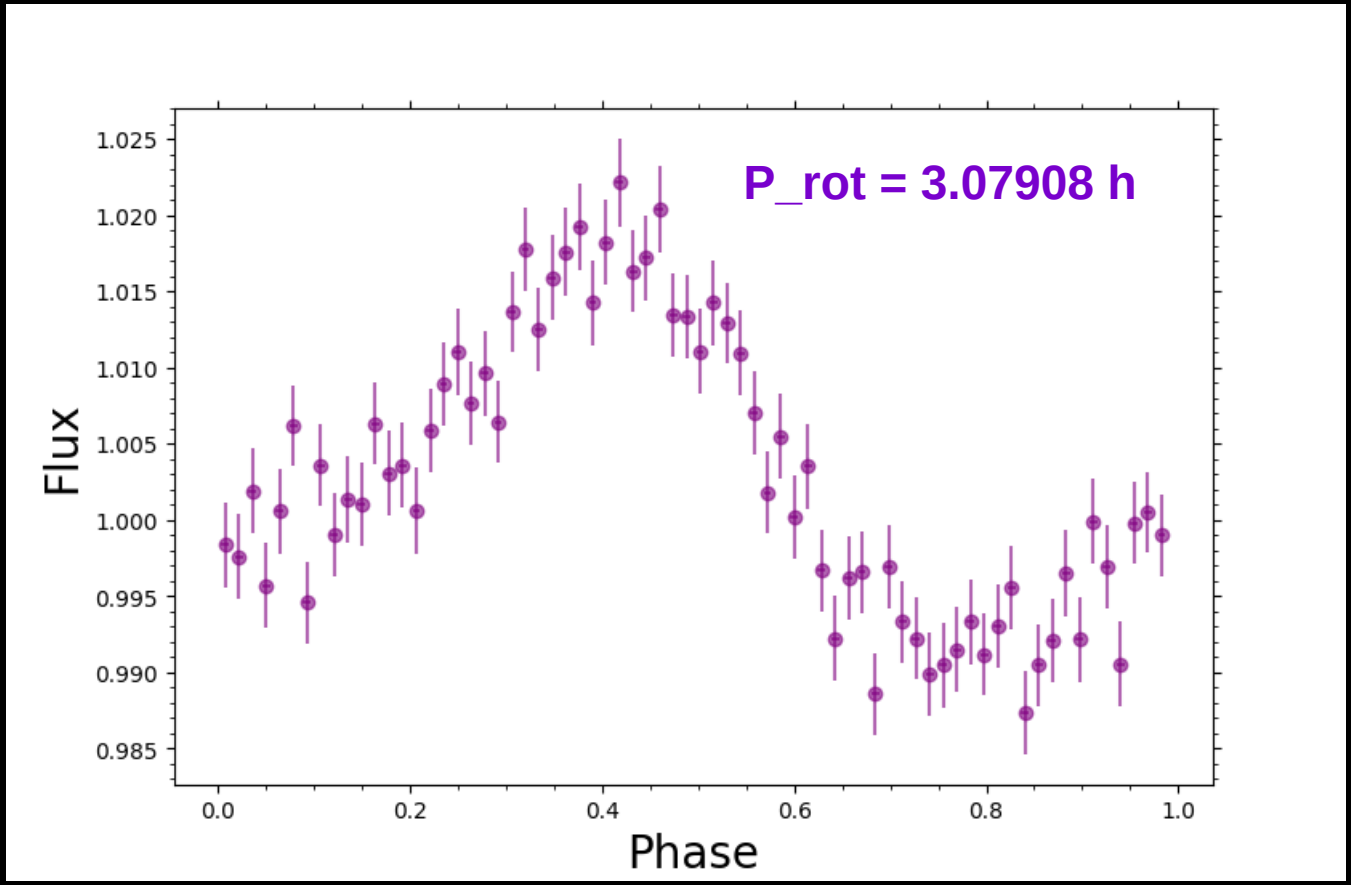
- 2 TESS sector (S17 & S57)
- Bandpass: 600 – 1000 nm
- There is a third sector (pending analysis).

TESS J0036 light curves

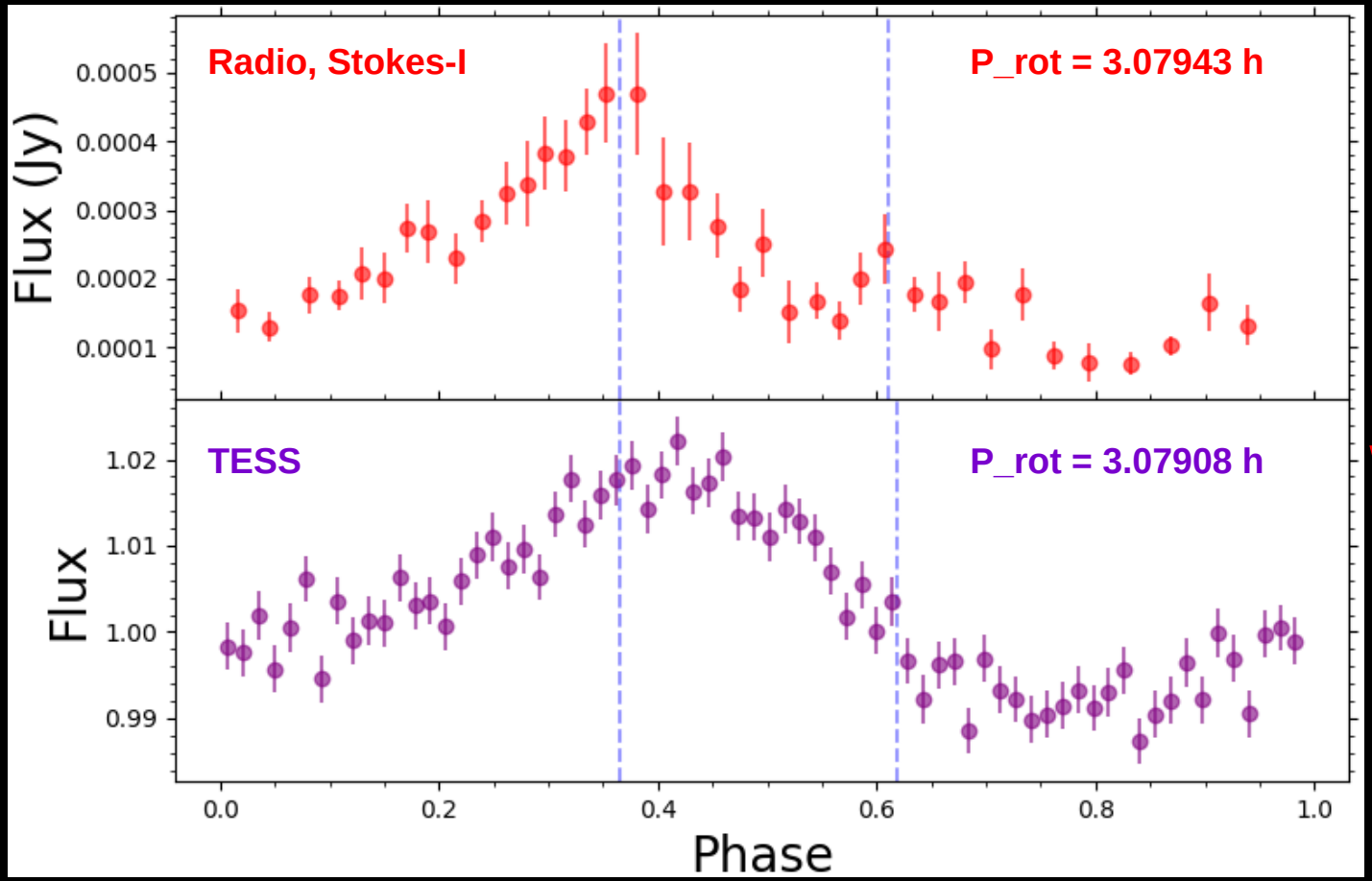




Phase-folded J0036 TESS light curves



J0036: A multi-wavelength approach



Hint of correlation

Work in progress!!

Future work: A lot!

- Refine LSPM J0036+1821 radio (VLBA, EVN & VLA) and optical (TESS) data reduction.
- Improve the fitting of the auroral ring model and obtain geometric paramenters
- Compare both, radio and infrared, light curves
- Zonal winds measurement? (See Allers et al. (2020))