Starspots on eclipsing giant stars

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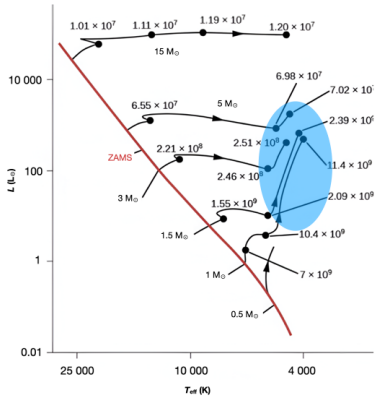
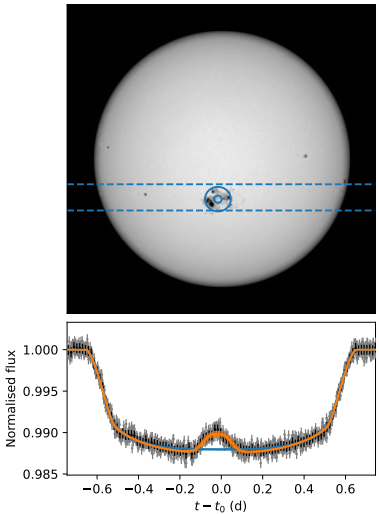
Motivation

- Magnetic activity after main sequence
- RS CVn stars
- $P_{\mathrm{rot}} \lesssim 10$ d
- Binarity + tidal locking: strong dynamo
- Until recently: activity from rotational modulation and long-term variations, ground-based telescopes
- Space photometry (Kepler, TESS)
- Eclipsing binaries: high spatial resolution



Eclipse mapping

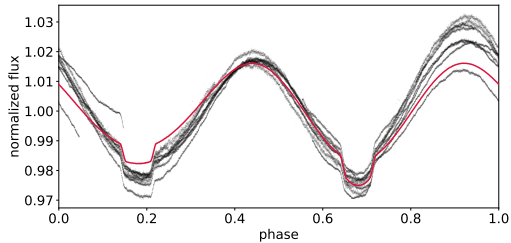
- Companion occults starspots during eclipse
- Spot crossings create bumps in light curve
- Information obtained:
  - latitude, longitude
  - size
  - contrast
  - (temporal evolution)
- High spatial resolution in a narrow latitude/longitude range



Haris et al. (2025)

Sample

- Visual Survey Group (Kristiansen et al. 2022)



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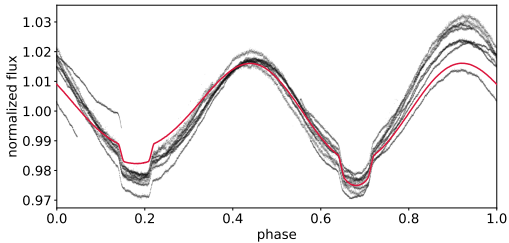
Sample

- Visual Survey Group (Kristiansen et al. 2022)
- Criteria:
  - large modulations due to spots
  - rotational modulations much larger than any ellipsoidal light variations
  - orbital periods longer than roughly five days
  - both eclipses being relatively shallow



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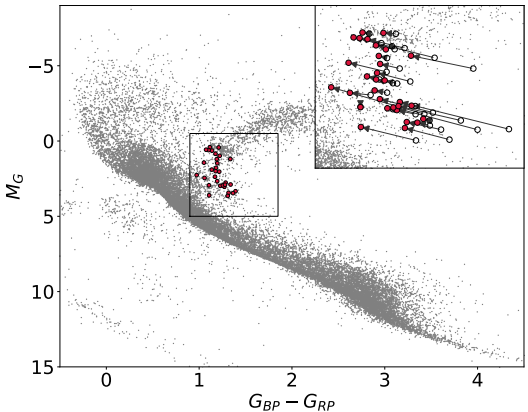
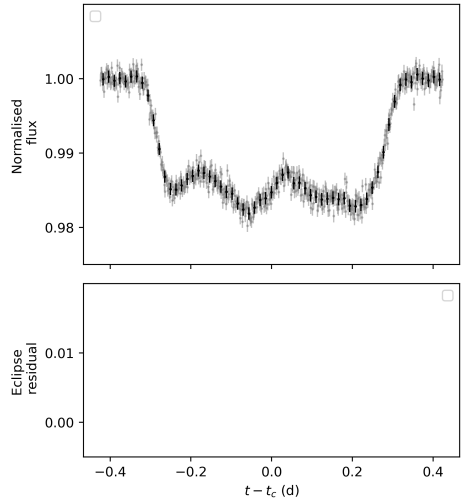
- 29 systems



Oláh et al. (2025)

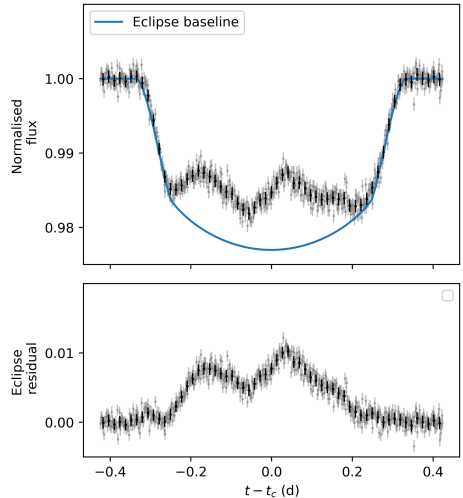
Model



Haris et al. (2026, under review)

Model

- Baseline: modified Mandel & Agol exoplanet transit model with primary + secondary eclipses, scaled by flux ratio of binary
- Flux ratio, radius ratio, inclination, separation, limb darkening, eclipse timings



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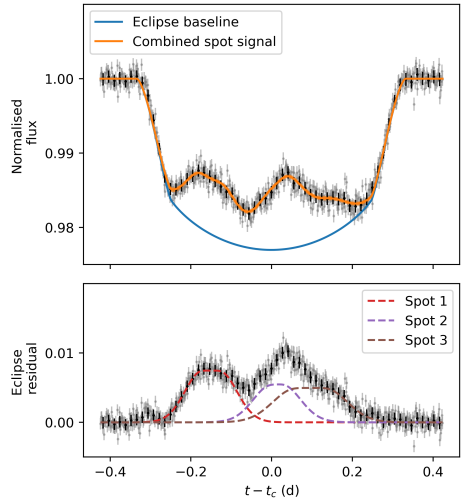
- Spot eclipses modelled as additive "plateau" signals (exponential ingress/egress + flat top)



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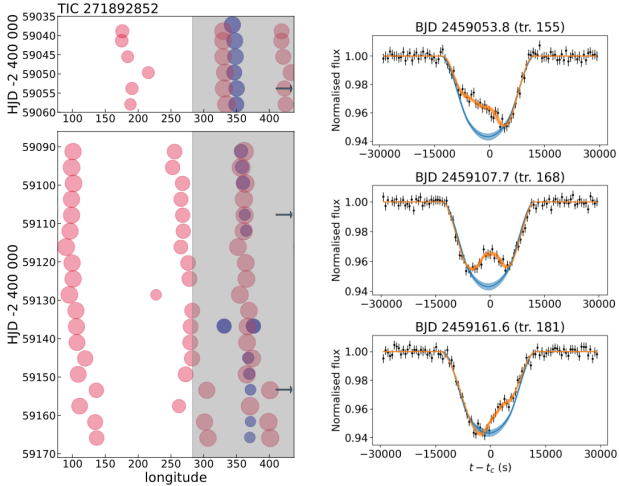
Pilot study

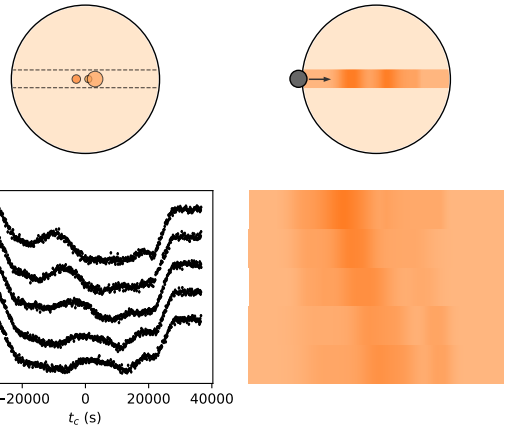
- Three binaries with $1 - 2$ yr TESS coverage
- Eclipse mapping, full light curve modelling (TESS), multi-band photometry (ground)
- High latitude (40°) spots
- Signs of spot drifts



Oláh et al. (2025)

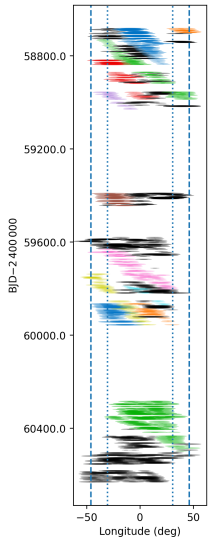
Case study: V521 Dra

- Best-observed system in sample
- $P_{\rm orb} = 4.27$ d,
  $M_A = 1.7 \pm 0.1\ M_\odot$,
  $M_B = 0.74 \pm 0.04\ M_\odot$
- 5.3 years of TESS coverage
- $>$ 200 eclipses



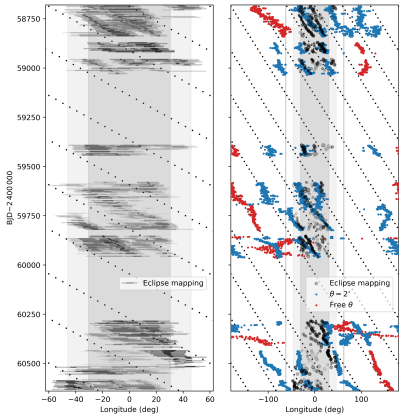
Differential rotation and spot evolution

- Evolution of spot parameters, spot lifetimes > 250 d
- Orbital–rotational period discrepancy
- Difference in spot Ωs in eclipse mapping data: shear in convective layer



Eclipse mapping + full light curve modelling

- Eclipse mapping:
  high spatial precision
  only eclipse chord
- Rotational modelling:
  global spot coverage
  lower spatial precision
- Together:
  more complete magnetic topology



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Conclusions and outlook

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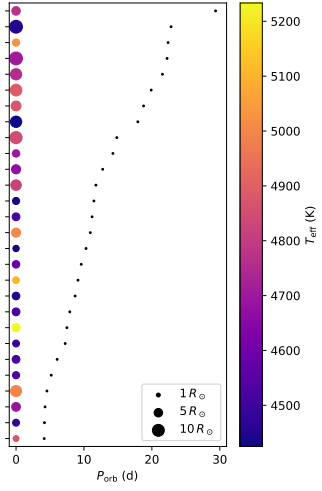
  - TESS enables eclipse mapping of giant stars
  - 29 active eclipsing giant binaries identified
  - Spot properties measured from eclipses
  - V521 Dra shows evolving active regions and differential rotation



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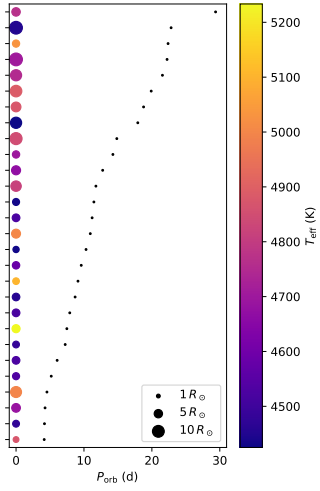
  - V521 Dra shows evolving active regions and differential rotation
- Outlook
  - Extend sample
  - Spectroscopic follow-up
  - Differential rotation statistics



Thank you!