Stellar Rotation Between 45 Myr and 2.7 Gyr from NGTS IC 4665, NGC 2516 and Ruprecht 147 Clusters

Douglas R. Alves[1], James Jenkins[2,3], Edward Gillen[4], NGTS consortium

1. Departamento de Astronomía, Universidad de Chile
2. Instituto de Estudios Astrofísicos, Universidad Diego Portales
3. Centro de astrofísica y tecnologías afines (CATA)
4. Queen Mary University of London

douglasalvesastro12@gmail.com
dalves@das.uchile.cl

SCAN ME FOR MORE RELATED WORKS!

SUMMARY

We determine rotation periods for IC 4665 (45 Myr), NGC 2516 (150 Myr) and Ruprecht 147 (2.7 Gyr) from an ~200 day photometric monitoring campaign with the Next Generation Transit Survey (NGTS). The rotations were derived homogeneously using Autocorrelation Functions and Lomb-Scargle periodograms. Visual inspections as well as Gaia binary filters helped to enforce a high purity in our samples. The time-series will be made available for about 2,000 stars, with an overall period detection rate of ~30% for F0-M3 stars, which is likely connected to the mass dependence in spot properties. In addition, we found that the median of each cluster rotation periods rises with cluster ages, thus in agreement with gyrochronology predictions. Finally, as part of this ongoing work, we aim at probing gyrochronology models by combining our rotation periods with others from NGTS cluster data across the time domain.

The Next Generation Transit Survey[I]

The NGTS facility at ESO's Paranal observatory.

- Planned to search and characterise transiting exoplanets
- Photometric time-series for ~30 million stars
- Wide-field photometry with 12 robotic 20 cm telescopes
- Wavelength coverage 520-890 nm
- 150 ppm precision on bright stars (V < 10 mag)
- Follow-up transit candidates from space-based missions
- 25 exoplanets[II, III] works + 5 stellar rotation articles[IV,V]

Membership Selection

1. Initial membership list from the literature[VI,VII]
2. Convert their astrometric parameters from GAIA DR2 to DR3
3. **Rejected** stars from membership list with Gaia DR3 parameter*
   a. $\sigma_{\varpi} / \varpi > 0.1$
   b. $\sigma_{\mu\alpha} > 0.2$ & $\sigma_{\mu\delta} > 0.2$
   c. No G band magnitude
   d. No ϖ
4. Construct astrometric bounds based on their astrometric distribution
5. Select stars in the NGTS fields with astrometric parameters within the established bounds from 4.
6. Derive the rotation periods

* ϖ, μ_{α}, μ_{δ}, G, σ represent the parallax, proper motion in right ascension and declination, Gaia G band magnitude and the uncertainty of a given parameter, respectively.

Computing Rotation Periods

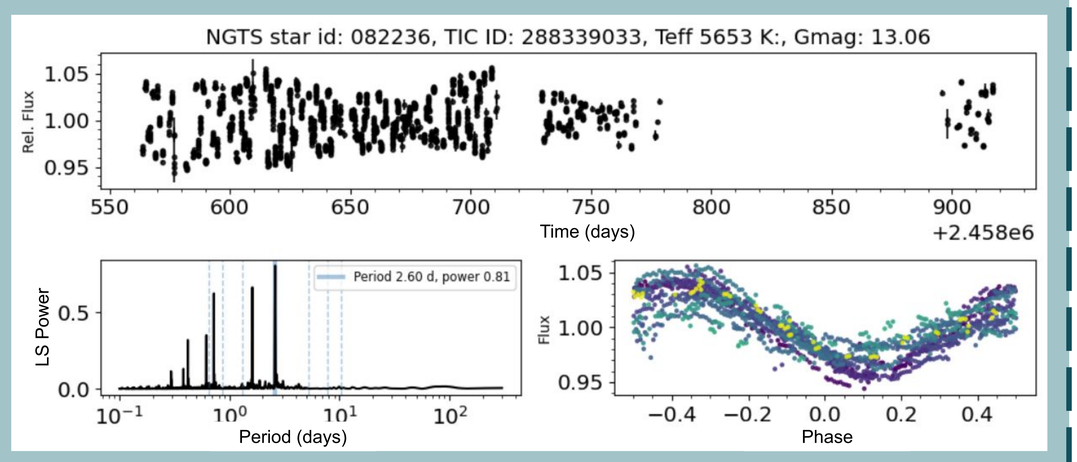
13 sec cadence lightcurve

↓

NGTS quality flags and 3-σ clipping to remove poor measurements

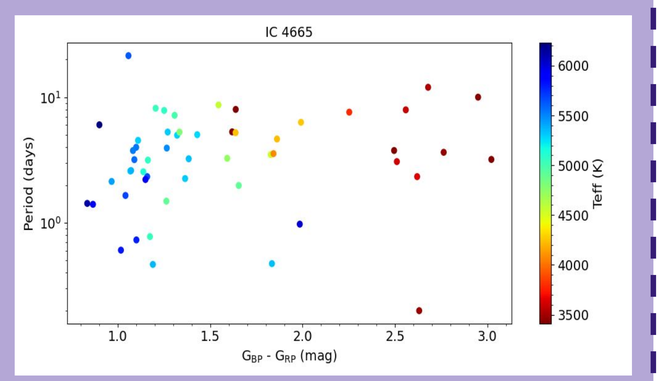
↓

Time-series binning to 30 min prior to computing the GLS periodogram & ACF

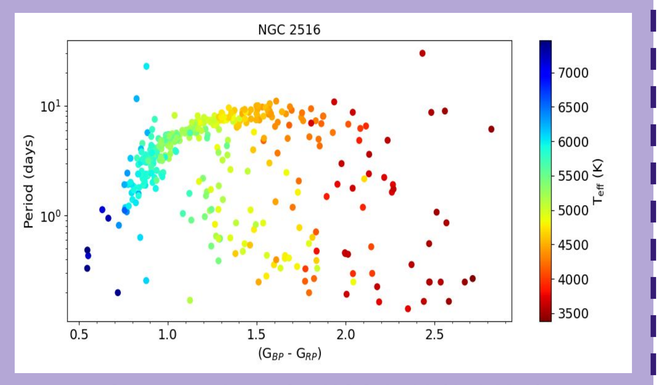


NGTS lightcurve for one of the IC 4665 members binned to 30 min (top). Its generalized Lomb-Scargle (GLS) periodogram (bottom left) and folded lightcurve to the GLS period at highest peak color-coded (dark to light) in time.

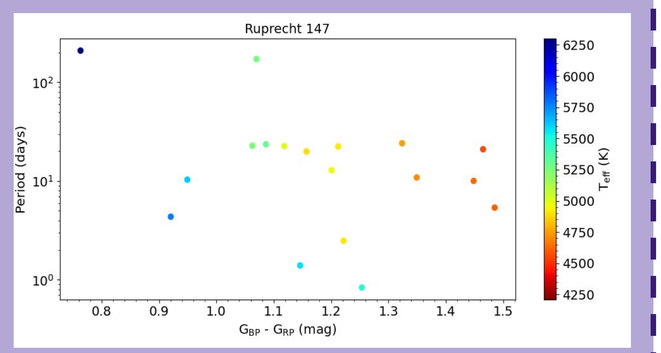
Rotation Periods



Rotation periods from NGTS photometry for IC 4665 (45 Myr) color-coded by their effective temperatures.

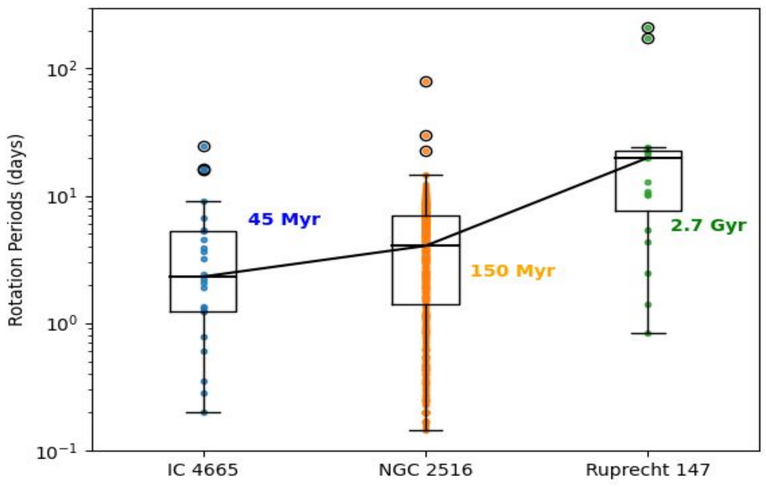


Same as above for NGC 2516 (150 Myr)



Same as top figure for Ruprecht 147 (2.7 Gyr)

Preliminary Results & Future Steps



Box plot showing the three NGTS clusters with the median rotation distribution increasing with age, the foundation of Gyrochronology.

- The analysis of membership revealed that within the NGTS images, 209 stars were identified for IC 4665, 1634 for NGC 2516, and 196 for Ruprecht 147
- IC 4665, NGC 2516 and Ruprecht 147 rotation period detections are of ~29%, 28%, and 10%, respectively.
  - The low detection rates are likely connected to:
    - Distinct spot properties as a function of mass
    - Spot density dependence with stellar activity and age
- NGC 2516 rotation periods from TESS[VIII] were mostly in agreement with NGTS, though a ~13 day systematic was apparent for a ~16 stars, which might be related to ½ the sectors' baseline
- Literature search revealed limited data for IC 4665 and Ruprecht 147, thus this work will increase the number of rotation periods for these clusters
- We aim at investigating Gyrochronology models with a homogeneously derived rotation sample from NGTS, thus helping our understanding of the stellar spin vs mass-age effect[IX]

REFERENCES

I. Wheatley et al. (2018)
II. West et al. (2019)
III. Alves et al. (2022)
IV. Gillen et al (2020)
V. Smith et al (2023)
VI. Gaia Collab. et al (2018)
VII. Cantat-Gaudin et al (2018, 2020)
VIII. Bouma et al. (2021)
IX. Bouvier, et al (2014)