PROJECT FOR POST-DOCTORAL ON STELLAR ACTIVITY FROM SPOT MODELING

Project Title

Stellar activity from planetary transits spot modeling

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Summary

This postdoctoral project aims to better understand stellar activity through characterization of features on the surface of the star such as spots and faculae. One way of doing this is through the modeling of signatures in the light curve as a transiting planet eclipses such features. From this modeling, properties such as size, intensity, and position on the stellar surface can be estimated. Moreover, the rotation and differential rotation of the stars will also be determined.

Description of goals

The NASA Kepler satellite has detected over 1600 stellar systems with 2303 transiting planets. The idea is to apply the spot model to stars with diverse spectral types and study possible differences in the distribution of spots and faculae. A selection of stars based on their activity and spectral type will be made. The main goal will be to study how differential rotation, a key ingredient to stellar dynamos, depends on spectral type and age.

Work plan

Dark spots and bright faculae are manifestations of stellar magnetic activity. These features cause modulations of a few percent in the light curve of the star as it rotates, for most active stars. In the case of the Sun, the peak-to-peak variation is about 0.1%. If a star has a transiting planet in orbit, during one of these transits, it might cross in front of one of these spots, creating a “bump” in the transit light curve. By modeling these spot signatures, it is possible to determine the physical properties of the spots such as size, temperature, and location. On the other hand, if the occulted feature is a bright faculae, then a “dip” in the light curve will be detected. Likewise, the same properties may be

estimated.

A spot model was developed by Silva (2003) to apply on these variations in the light curve of stars with transiting planets. Some stars have already been analyzed this way, such as CoRoT-2 (Silva-Valio et al. 2010), Kepler-17 (Valio et al. 2017) and Kepler-63 (Netto & Valio, 2017). If the same spot is detected in a later transit, the stellar rotation and even differential rotation can be determined.

The first step is to identify in the Kepler database, those stars that are active and thus most prone to have spots on its surface. This is done by identifying periodic photometric variations in the out-of-transit light curve. Once the best targets are selected, a classification according to stellar spectral type will be done.

Next, the Silva (2003) spot model will be applied to at least one star of each spectral type. The spot physical parameters distribution for different stars will be compared. If faculae are also detected, also their characteristic will be analyzed.

For those stars that have enough data, the stellar rotation at the latitude of the transit and differential rotation will be calculated (Silva-Valio 2008, Silva-Valio & Lanza 2011). It is known that there is a strong correlation between age, activity and rotation period of stars (Skumanich 1972).

Differential rotation is a key ingredient in stellar dynamos. An important question is the dependence of differential rotation on age and stellar spectral type. We plan to shed light on this question with the spot modeling using the planetary transits on stars of varying spectral types and ages.

Schedule

Month 1: Familiarize with the spot model (Silva 2003)
Month 2 - 3: Download the light curves of active Kepler stars
Month 4 - 6: Fit the transit light curves for spots and faculae
Month 7 – 9: Analysis of the distribution of physical parameters of spots and faculae
Month 10: Write paper about the spots characteristics for stars with different spectral types
Month 11 - 13: Determine the rotation period at the transit latitude

Month 14 – 18: Estimate the differential rotation and age for all stars
Month 19 - 22: Interpret the differential rotation in the light of stellar dynamo models
Month 23: Write article about differential rotation with stellar spectral type and age
Month 24: Write FAPESP report.

How the postdoc fellowship fulfill the goals of the FAPESP postdoctoral fellowships

We intend to attract a promising young scientist, who has obtained its doctorate degree no earlier than seven years ago, thus fulfilling the goals and rules of FAPESP. We will conduct an internationally selection process, by advertising on international journals and job newsletters, as well as in the national newsletters and job databases.

Our request fits perfectly within our proposed FAPESP *Temático* project because the research plan deals with the study of stellar activity, hence it is important to have the postdoctoral grant approved along with the *Temático* project.

Following the recommendations of FAPESP, we will select preferably a scientist who has not done its PhD at the host Institution (either IAG/USP or Mackenzie), unless no suitable candidates from other institutions are found. Nevertheless, the proposed FAPESP *Temático* certainly has the potential to attract young talents from different institutions.

Bibliography

- Netto, Y. and Valio, A. 2017, IAUS, 328, 107
- Skumanich, A. 1972, ApJ, 171, 565
- Silva, A. V. R. 2003, ApJ, 585, L147
- Silva-Valio, A. 2008, ApJ, 683, L179
- Silva-Valio, A. et al. 2010, A&A, 510, A25
- Silva-Valio, A. and Lanza, A. F., 2011, A&A, 529, A36
- Valio, A. et al. 2017, ApJ, 835, 294