Observing planet-starspot crossings with the James Webb Space Telescope

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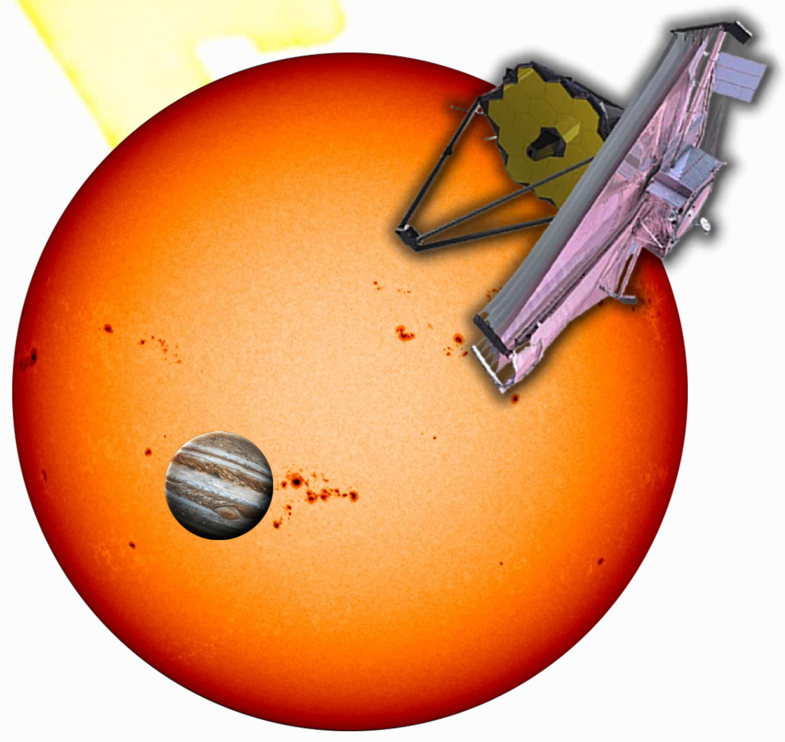
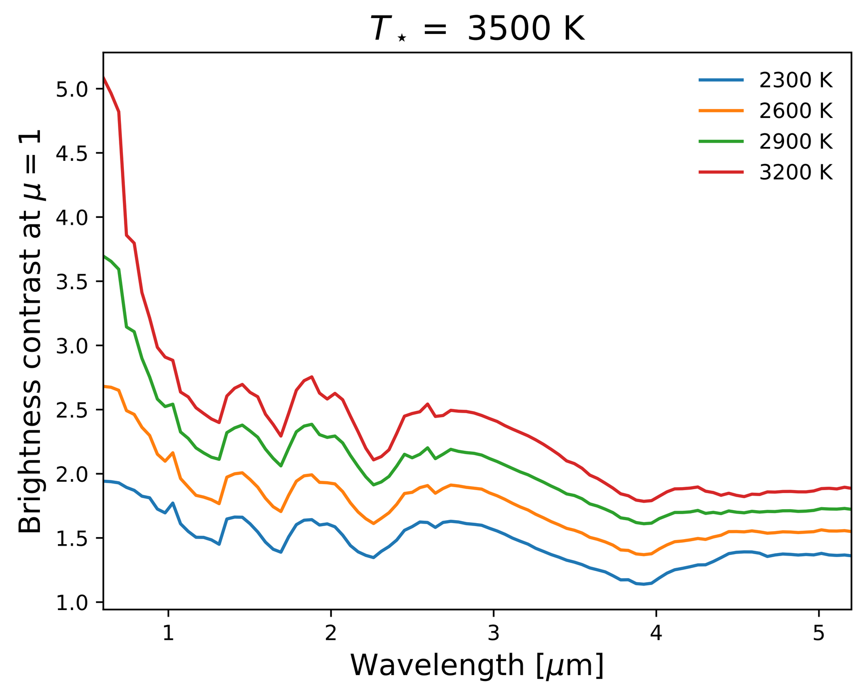
Transiting exoplanets orbiting active stars frequently occult starspots on the visible stellar disk. We must correct transit observations from these contaminations, but **can we also get some information out of them?**

We here test the capabilities of **JWST's NIRSpec/Prism** and the proposed **NIRCam/F150W2+F322W2** modes to determine occulted starspot temperatures.



Starspot contrast spectra

The specific intensity contrast between an occulted starspot and the stellar photosphere is a function of their effective temperature ratio, wavelength and angle between the stellar surface normal at the spot location and line of sight (here we use its cosine, μ).



This is a model example for starspots with different effective temperatures, placed at the center of the stellar disk of a 3500 K, M-type star.

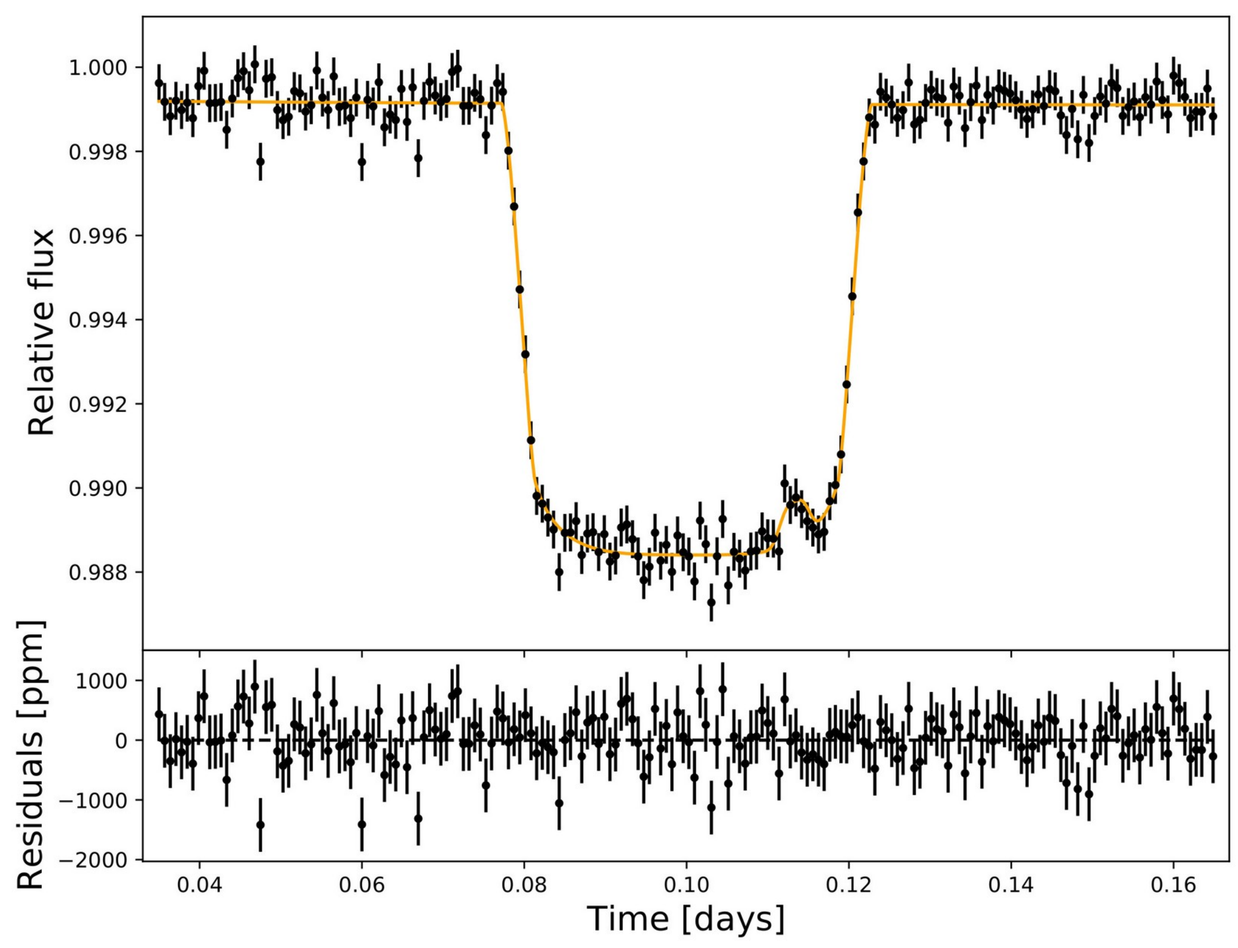
For each simulated scenario, fit the obtained contrast spectrum as in Sing et al. (2011):

$$\frac{\Delta f_{\lambda}}{\Delta f_{\lambda_0}} = \frac{1 - I_{T_{\text{spot}}}(\lambda, \mu)/I_{T_{\text{star}}}(\lambda, \mu)}{1 - I_{T_{\text{spot}}}(\lambda_0, \mu)/I_{T_{\text{star}}}(\lambda_0, \mu)}$$

Where Δ*f* is the flux bump peak, *I* is the specific intensity spectrum at different temperatures, wavelengths and stellar limb angles, and λ_0 is a reference wavelength.
The model is a scaled version of the figure pointed by the hand above.

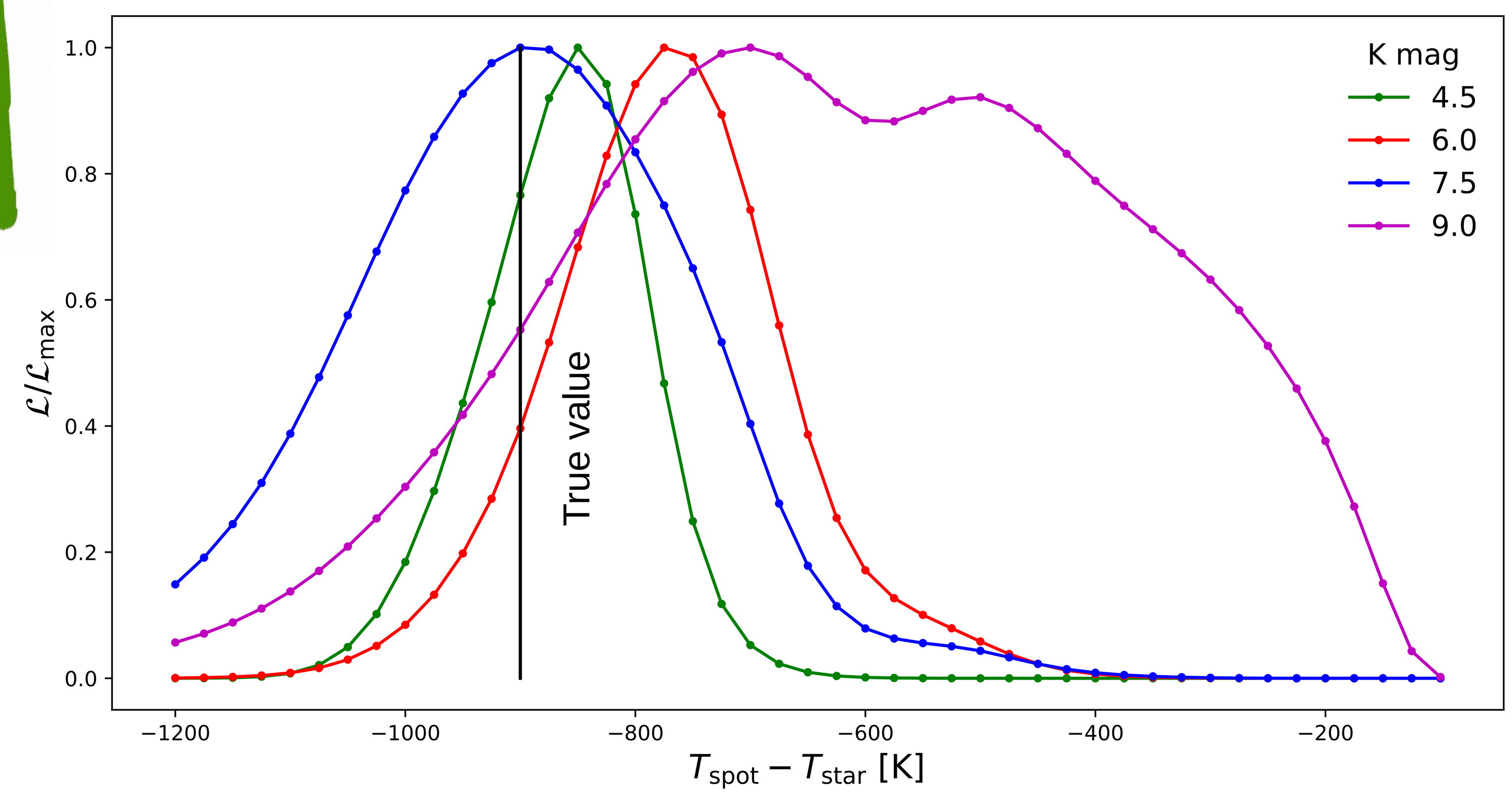
Predicting spectrophotometric transit shapes: the recipe

1. Simulate a transmission spectrum with PandExo (Batalha et al. 2017) for NIRSec/Prism, or with a custom SNR estimator for NIRCam/F150W2+F322W2 (as in Schlawin et al. 2016).
2. For every spectroscopic bin, simulate a transit and add a starspot occultation for a given starspot T_{eff} and size using the KSint code (Montalto et al. 2014).
3. Add instrumental noise following Sarkar et al. (2020).
4. Repeat for varying stellar, planetary, and starspot parameters (including μ angle), as well as stellar K magnitudes.



On each simulated transit, fit a combined transit and occulted starspot model (different from KSint) and measure the starspot "bump" peaks.

The most likely result is within a few hundred kelvins from the true value, but the likelihood distribution (y-axis in the figure, representing the case of a 5000 K star) sometimes follows a complex behavior. Work is in progress to interpret this.



This study has been submitted and work is in progress to address the comments by the referee. Stay tuned!

References Batalha N. E., et al., 2017, Publications of the Astronomical Society of thePacific, 129, 064501; Schlawin E., et al., 2016, Publications of the Astronomical Society of thePacific, 129, 015001; Montalto M., Boué G., Oshagh M., Boisse I., Bruno G., Santos N. C., 2014,MNRAS, 444, 1721; Sarkar S., Madhusudhan N., Papageorgiou A., 2020, MNRAS, 491, 378; Sing D. K., et al., 2011, MNRAS, 416, 1443

Acknowledgments GB acknowledges support from CHEOPS ASI-INAF agreement n. 2019-29-HH.0. GM and GC acknowledge the support of the ARIEL ASI-INAF agreement n.2018-22-HH.0. This research has made use of the SVO Filter Profile Service (http://svo2.cab.inta-csic.es/theory/fps/) supported from the Spanish MINECO through grant AYA2017-84089. The background of this poster was designed by Freepik.

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