Exoplanet Aeronomy: A Case Study of WASP-69

W. Garrett Levine (Yale University), Shreyas Vissapragaada (Harvard/CfA), Adina Feinstein (Univ. of Colorado), George King (Univ. of Michigan), Aleck Hernandez (Wayne State Univ.), Lia Corrales (Univ. of Michigan), Mike Greklek-McKeon (Caltech), Heather Knutson (Caltech)

Aeronomy, the study of upper planetary atmospheres, is a long-researched foundation of geoscience.

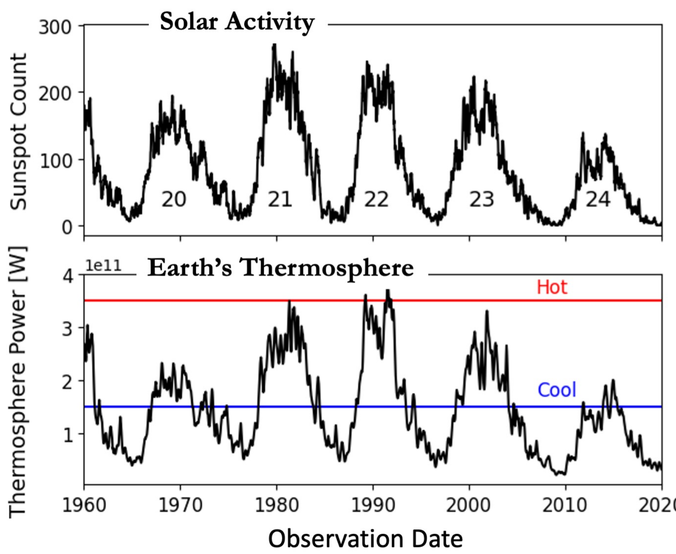
Studying aeronomy in exoplanet systems can…

(1) Constrain the dynamics of exoplanet atmospheres.

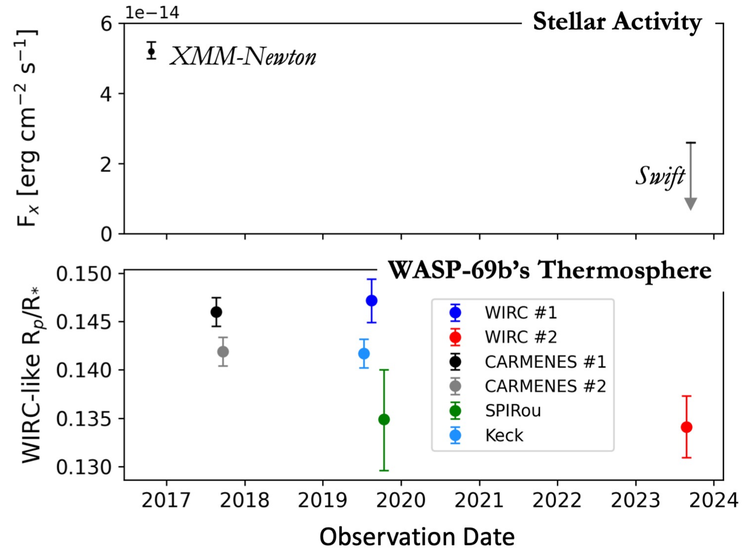
(2) Test models of photoevaporation that may sculpt exoplanet radii on billion-year timescales.

(3) Connect extrasolar planets with solar system analogs to contextualize our Sun's planets among their peers.

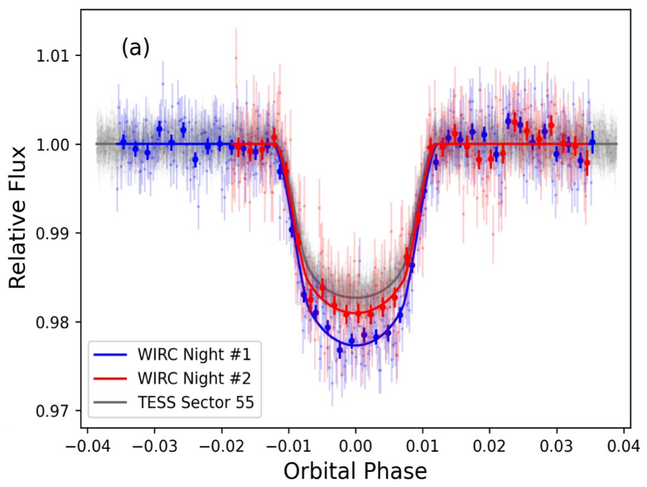
A well-known process in aeronomy is the response of planetary thermospheres to changes in the XUV irradiation from their host stars across the stellar activity cycle.



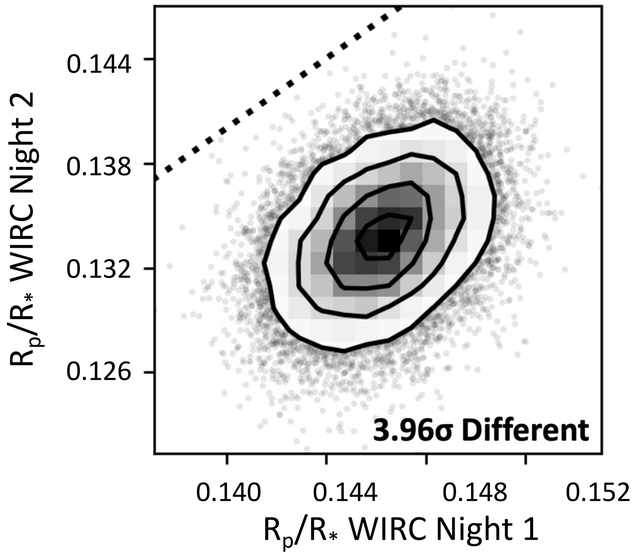
With multi-wavelength, multi-epoch data, we have documented the same interplay happening in the WASP-69 system with a K-type main sequence star and hot Jupiter.



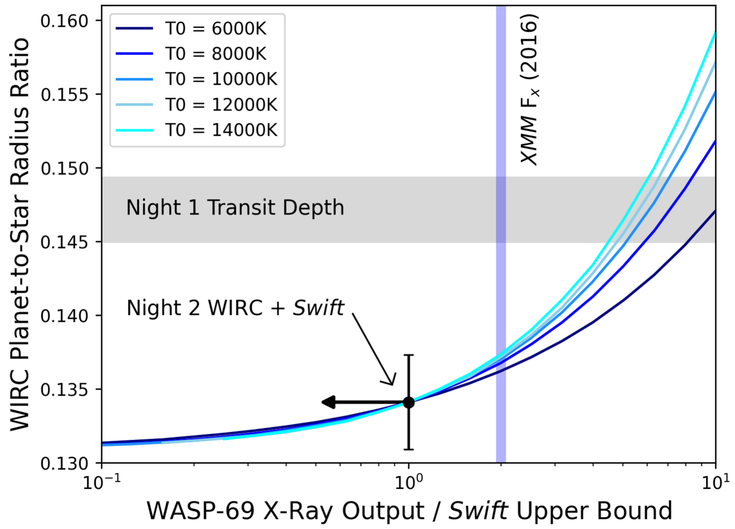
(1) We observed WASP-69b's metastable He absorption with Palomar/WIRC in Aug. 2023 and compared our measurements to archival data from multiple instruments.



(2) We found significant variability in the metastable He transit depth, indicating that WASP-69b's thermosphere had changed on years-long timescales.



(3) We observed WASP-69 with *Swift* in X-Ray, then found that the change in stellar XUV was similar to what theoretical models predict to explain the change in WASP-69b's atmosphere.



References

(1) Allart et al. (2018). *Science*. 362, 1384.
(2) dos Santos et al. (2022). *A&A*. 640, A29.
(3) Levine et al. (*in review)* and references therein.
(4) Nortmann et al. (2018). *Science*. 362, 1388.
(5) Tyler et al. (2024). *ApJ*. 960.2, 123.
(6) Vissapragada et al. (2020). *AJ*. 159, 78.
(7) Vissapragada et al. (2022). *AJ*. 164, 234.

Acknowledgements

WGL acknowledges support from the DoD NDSEG fellowship, the John F. Enders Fund at Yale Univ. for dissertation research travel, and the LSST-DA Data Science Fellowship Program which is funded by the LSST-DA, the Brinson Foundation, and the Moore Foundation; his participation in the program has benefitted this work. ADF acknowledges funding from NASA through the NASA Hubble Fellowship grant HST-HF2-51530.001-A awarded by STScI.

We thank Greg Laughlin, Sarbani Basu, Christopher Lindsay, Earl Bellinger, Emma Louden, Sam Cabot, Darryl Seligman, Quang Tran, Leonardo dos Santos, Fei Dai, and Elena Gallo for useful conversations.

We are grateful to Palomar Observatory, especially Tom Barlow, Carolyn Heffner, Diana Roderick, Isaac Wilson, Kathleen Koviak, Jennifer Milburn, and Andy Boden for supporting these observations. We are also grateful to the *Swift* team for an expedient approval and execution of our ToO request.

We appreciate that Romain Allart, Lisa Nortmann, and Dakotah Tyler shared their reduced spectra from WASP-69b for the analysis of all archival data.