## A Bayesian approach to assessing the sensitivity of detecting planets in photometric data

# EXOPLANET DETECTION LIMITS

WOW! OCCURRENCE RATES!

NEW METHOD!

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WE WANT TO MEASURE THE OCCURRENCE RATES OF EXOPLANETS AROUND LATE-TYPE M DWARFS

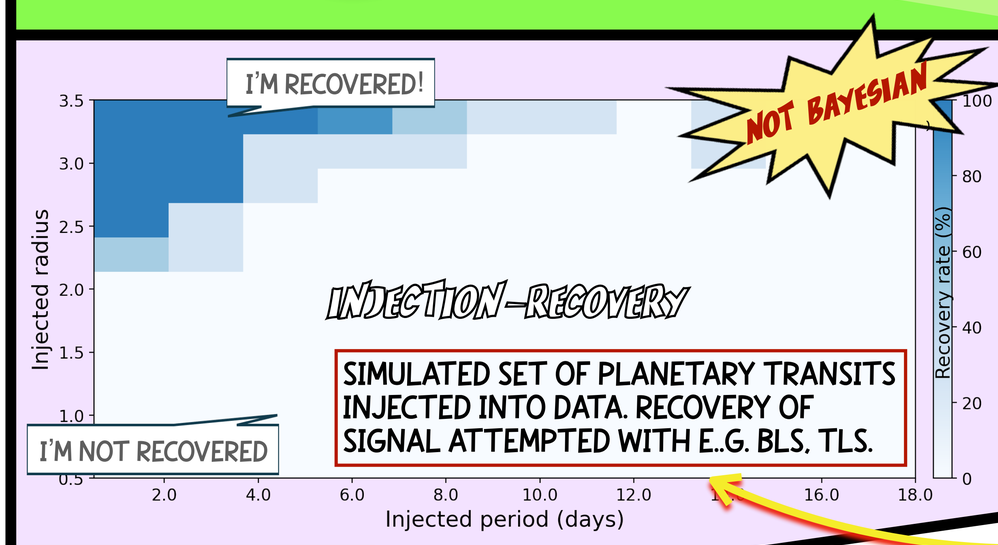
WE WANT TO FIND WHERE OUR DETECTION LIMIT LIES FOR A GIVEN PHOTOMETRIC DATASET

THIS WILL HELP INFORM OCCURRENCE RATES BY ASSESSING OUR COMPLETENESS USING DETECTION LIMITS

WE ARE ASKING THE QUESTION
"WHAT IS COMPATIBLE WITH THE DATA?"

WHAT REMAINS FORMALLY UNDETECTED?

THIS IS NOT INJECTION RECOVERY




NOT BAYESIAN

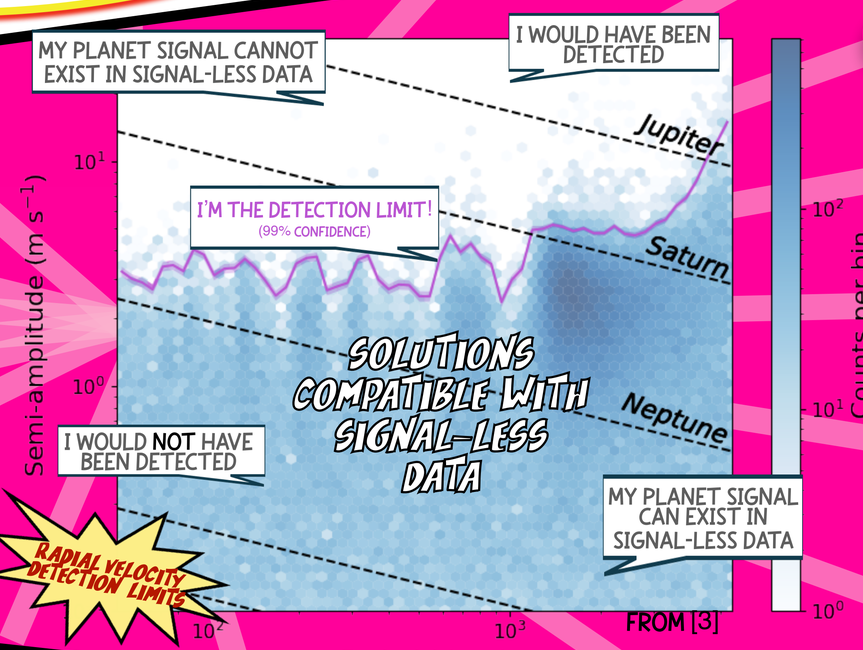
**PROBLEM 1** ONLY TESTS FOR A VERY SPECIFIC SET OF PLANET PARAMETERS.

**PROBLEM 2** EACH RECOVERY IS COMPUTATIONALLY INTENSE: COARSE GRIDS USED

COMPUTATION TIME ~ 5 DAYS

THIS HAS BEEN DONE FOR RADIAL VELOCITY DATA USING KIMA [2]

KIMA IS A PYTHON PACKAGE FOR THE DETECTION AND CHARACTERISATION OF EXOPLANET SIGNALS IN IN RADIAL VELOCITY DATA




FOR A GIVEN PERIOD + SEMI-AMPLITUDE UNDER THE PURPLE LINE, THE RV SIGNAL PRODUCED COULD EXIST IN THE DATA.

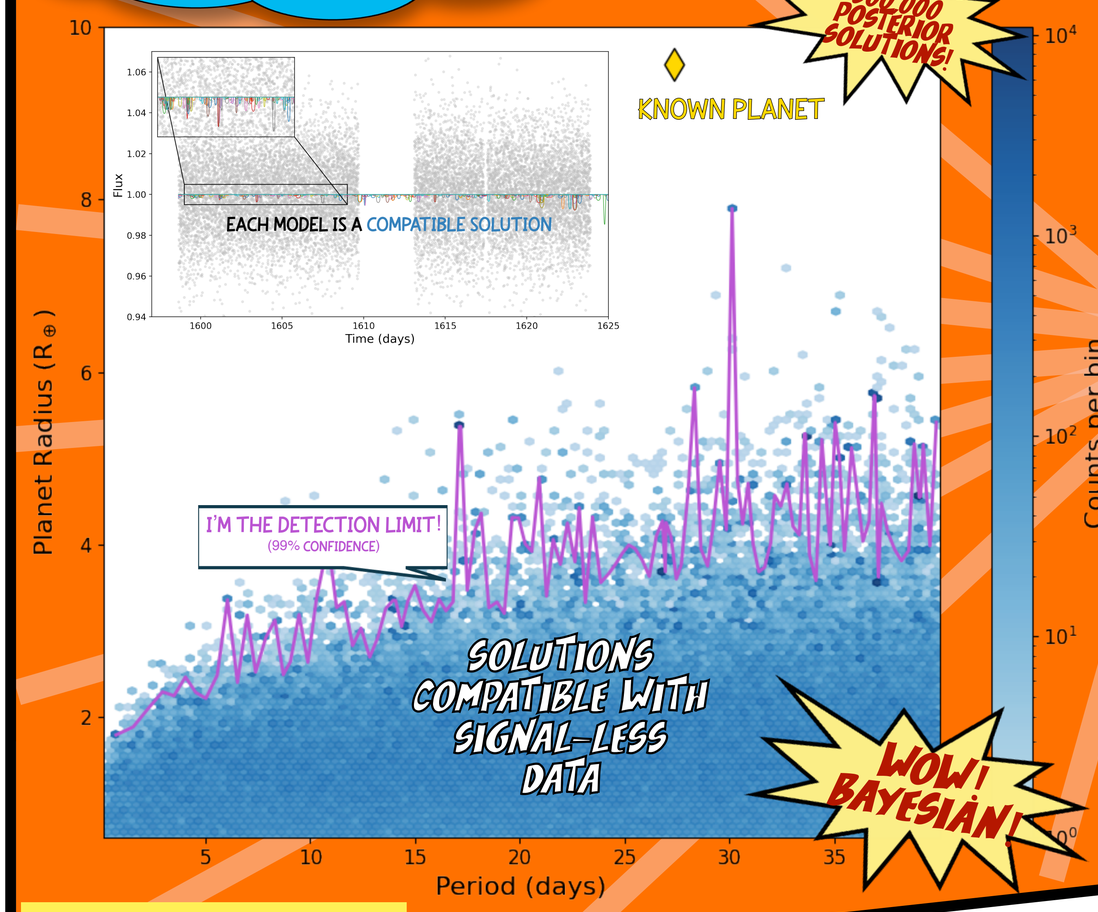
ITS "HIDDEN" IN THE NOISE AND REMAINS FORMALLY UNDETECTED. EVERYTHING ABOVE THE PURPLE LINE WOULD HAVE BEEN DETECTED.

THE APPROACH IS MORE COMPLEX FOR APPLICATIONS TO TRANSITS.

**PROBLEM 3** UNLIKE RV DATA, THERE IS NOT A SIGNAL ACROSS THE ENTIRE ORBIT OF THE PLANET.

**PROBLEM 4** HOLES IN THE DATASET HAVE BIG IMPACTS ON EXOPLANET DETECTIONS.

HOW ARE WE DOING IT FOR PHOTOMETRY?




COMPUTATION TIME ~ < 5 HOURS

### METHOD

BATMAN [4] + DYNESTY [5] PYTHON PACKAGES.

PRIORS ON MODEL PARAMETERS ARE EITHER LARGE + UNIFORM $(t_0, P, R_p/R_\star, \omega)$ OR INFORMED FROM THE CURRENT TRANSITING EXOPLANET POPULATION $(e, i)$

TENS OF THOUSANDS OF MODELS ARE PROPOSED. MODELS ARE EITHER REJECTED IF NOT COMPATIBLE WITH SIGNAL-LESS DATA, OR ACCEPTED AS A COMPATIBLE SOLUTION.

### ADVANTAGES COMPARED TO INJECTION RECOVERY

1. BAYESIAN
2. NON-DISCRETE SOLUTION GRID
3. 4 MORE PARAMETERS DRAWN FROM DISTRIBUTIONS
4. $100s - 1000s$ MORE SOLUTIONS
5. ~20 × FASTER

SCOTT, TRIAUD & DAVIES, IN PREP

COMING 2025/26!

REFERENCES

[1]DÉVORA-PAJARES, M. AND POZUELOS, F. J., "MATRIX: MULTI-PHASE TRANSITS RECOVERY FROM INJECTED EXOPLANETS"

[2]FARIA, J. P., SANTOS, N. C., FIGUEIRA, P., AND BREWER, B. J., "KIMA: EXOPLANET DETECTION IN RADIAL

[3]BAYCROFT, T. ET AL., "BEBOP VII. SOPHIE DISCOVERY OF BEBOP-3B, A CIRCUMBINARY GIANT PLANET ON AN ECCENTRIC ORBIT"

[4]KREIDBERG, L., "BATMAN: BASIC TRANSIT MODEL CALCULATION IN PYTHON"

[5]SPEAGLE, J. S., "DYNESTY: A DYNAMIC NESTED SAMPLING PACKAGE FOR ESTIMATING

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