**A Curious Light Curve**

**KIC 8462852 ("Tabby’s Star")** was among the ~100k stars observed by NASA’s Kepler Satellite in its search for exoplanets. Unlike a typical exoplanet harboring star, its light curve exhibits an abnormal shape and multiple depths of unexpectedly large magnitude.

There are several explanations for KIC 8462852’s unexpected large magnitude. In the transit method, the width and depth of the light curve correspond to the transit duration ($t$) and the change in flux ($\Delta f$) respectively.

One observed dip of KIC 8462852 and the dip Jupiter would create if orbiting it.

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**Extreme Exoplanets**

Assuming a circular orbit with zero inclination, we used Newton’s 2nd law, Newton’s law of universal gravitation, and geometry to derive the equations for the period ($T$), transit duration ($t$), and radius ($R_p$) of the exoplanets:

$$T = 2\pi \sqrt{\frac{a^3}{GM}}$$

$$t = 2 \sqrt{\frac{a^5}{GM}} \sin^{-1} \left( \frac{R_p + R_*}{a} \right)$$

$$R_p = R_* \frac{\Delta f}{T}$$

Unlike a traditional light curve, KIC 8462852’s dips have no clearly defined start or end times so we chose several transit durations (3, 5, 8, 10, and 15 days) for each characteristic depth.

Applying these equations to our transit durations and the depths found by Boyajian et. al1, we determined planet radii $R_p = 0.7$ to $7.21 R_J$ (Jupiter Radii) and Semi-Major Axes (SMA) $a = 8.27$ to $402.65$ AU.

Assuming a density equal to that of Jupiter, we used the radii to calculate planet masses $M_p = 0.36$ to $375.04 M_J$ (Jupiter Masses).

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**Fitting the Planet Hypothesis**

With mass and SMA data from 5344 planets taken from the Exoplanet Orbit Database3, we implemented the gradient descent algorithm in Python to create a maximum likelihood fit for each property with the probability density function (PDF) $f$ given by:

$$f(x) = a \lambda e^{-\lambda x} + (1 - a)k e^{-kx}$$

After finding parameters $\alpha$, $\lambda$, and $\kappa$ for the mass and SMA distributions, we calculated the tail-probabilities ($P_{\text{mass}}$ and $P_{\text{SMA}}$) of each for KIC 8462852’s potential exoplanets by integration of the PDF:

$$P(x) = \int_x^\infty f(x')dx' = a \lambda e^{-\lambda x} + (1 - a)k e^{-kx}$$

It is important to note that although intrinsic distributions of exoplanet masses and SMAs as assumed in our work would be ideal to use, this is not possible due to selection effects and incomplete understanding of planet formation.

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**References**

2. MAST Database (archive.stsci.edu)
3. Exoplanet Orbit Database (exoplanets.org)