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Paper discussion: Deep long asymmetric occultation in EPIC 204376071 (Rappaport et al. 2019)

- What are a few examples of dusty occulters
  - **Dippers:** Young M stars with irregular dips in brightness, attributed to dust near their inner circumstellar discs or even co-rotating with their magnetospheres.
  - **KIC 8462852, *Boyajian's Star*:**, with long-term dimming and irregular dips attributed to circumstellar material.
  - **Disintegrating Planets:** Such as KIC 1255b which results in circumstellar material.
  - **WD 1145+017:** a white dwarf where periodic dips are caused by dust clouds associated to orbiting asteroids.
  - **1SWASP J140747.93-394542.6 (J1407):** a young K star with very long and deep dip. Potentially attributed to a large (37) ring system.
  - **Young T Tauri stars:** Long dimming events potentially caused by occultations from tidally distrupted discs due to binary interactions.
  - **PDS 110:** Long deep dips seperated by ∼800 days due to unseen low mass planet or brown dwarf either with a very large (∼0.2au circumfrential disk) (this claim has since been retracted).
- What observations were used in the discovery? *The primary observations used in this study were from the Kepler space telescope's K2 mission. EPIC 204376071 was observed twice during this mission, and it was during the second campaign (C15) that the single, deep occultation event was detected.*
- What do we know about the age of the host star *We estimate the age of the host star by measuring its membership in the upper scorpius stellar association (this is done via distance, proper motion, and radial velocity). We know the upper Sco association is about 10 Myr old so we estimate the stellar age as approximatly 10 Myr.*
- How much of the stars light is blocked during the occultation *Approximatly 80 percent*
- How is the SED presented in this paper *Flux vs wavelength for a range of wavelengths from 0.5µm to about 20µm. The optical portion is built with contributions from Gaia, infrared from 2MASS and WISE.*
- What data were combined to produce the SED
  1. **Gaia:** G_{BP} and G_{RP} for optical.

2. **2MASS:** J, H, and Ks bands for near-infrared.
3. **WISE:** W1, W2, and W3 bands for mid-infrared.

- Approximate the peak wavelength of the SED. What's the temperature of the star from this calculation? How does it compare to the temperature reported in the paper for the star? *From the SED the effective temperature is approximatly 2900K. This is lower than the temperature reported in Table 1 (3861K).*

- How were the stellar parameters (radius, luminosity, and temperature) determined from the SED? *The authors compared the observed SED to a set of template spectra from young stars with known properties. They also used theoretical models (PHOENIX BT-SETTL) to fill in gaps in the template coverage. By finding the best match between the observed SED and the templates, considering factors like reddening (the effect of dust on the star's colors), they derived the stellar parameters.*

- The stellar parameter fitting mentions reddening, which is given by E(B-V). This tells you the differential amount of extinction in the B versus V filters, which is generally due to dust along the line of the sight to the object. At optical wavelengths, dust always makes a source look redder. What does this say about τ_ν? *Reddening implies that there's more extinction at shorter wavelengths (like the B filter) compared to longer wavelengths (like the V filter). Since optical depth (τ) is related to extinction, this suggests that τ is higher at shorter optical wavelengths. In other words, the dust is more opaque in the B band than in the V band.*

- Why do starspots and flares produce variations in the stellar lightcurve? What equation(s) in R&L are useful for assessing the amount of contribution?

  - **Starspots:** These are darker areas on the surface of a star. As the rotate in and out of view the integrated light over the surface of the star will change.
  - **Flares:** Sudden increases in brightness due to magnetic activity on the star.

  Equations relating to the blackbody flux are of most use.

- What are the two general models that are fit to the occultations?

  - **Inclined Disc Model:** This assumes the occulter is a circular disc of dust orbiting the star. The disc is tilted and inclined, so it appears elliptical in projection.
  - **Dust Sheet Model:** his envisions a more diffuse cloud or sheet of dust passing in front of the star. The optical depth (how much light the dust blocks) varies across the sheet.

- Three separate possible equations for the dust sheet model are given in Eq 1. What equation(s) in R&L are the basis for these equations? How were Eq 1 derived? What's the typo in Equation 1? *Equation 1.31 (Actually the expression just above it which is unlabeled)*

- How is the total mass of the dust estimated *The optical depth is a parameter which the paper can get a handel on. The optical depth is related to the column density of the media. Given that we also know the composition of the media from speactral measuements. Then the optical depth is is approximatly* $M_d \sim 4\rho a \tau A_d/3\xi$. *Where* ρ *is the bulk density of small particles, a is the charectaristic size of particles,* A_d *is the projected area of the inclined disk, and* ξ *is the cross section normalized to the geometric area of the particles. Then you assume that the disk of of uniform density.*

- The overall minimum mass of teh dust is estimated to be fairly small (1000 times less than Saturn's rings). The paper then goes on to discuss how optical depth depents on dist grain sizee. What would be required to get a dust mass closer to that of Saturn's rings. Does the data constrain this? *To achieve a dust mass closer to Saturn's rings, the paper suggests that the dust particles would need to be much larger. This is because the optical depth, or how effectively the dust blocks light, depends on both the number of particles and their size. Larger particles have a larger cross-sectional area, meaning they block more light per unit mass. However, the data does not strongly constrain the particle size. The observations are consistent with a range of particle sizes, including larger ones that could potentially lead to a higher total dust mass. More detailed observations or modeling might be needed to better determine the particle size distribution and the true mass of the dust.*

- The paper doesn't really discuss the importance of this type of research. Besides it being a cool phenomenon (which, having met the lead author, is definitely one of the reasons why they looked into it), why do you think it might be more broadly interesting to look into objects like this?