Impact Degeneracy

There are cases of reported discrepancies in the literature concerning the atmospheric characterization of exoplanets. One effect that can contribute to the inconsistencies is the degeneracy of the impact parameter, \( b \), with the optical slope.

Method & Results

- Synthetic light curves fitted with transit models of deviating impact parameters
- Fixed parameters with combinations of the inclination, \( i \), and the semi major axis in units of stellar radii, \( a_{\text{semi}} / R_* \)
- Fixed all other parameters except \( R_p / R_* \), and the period

\[
 b = \frac{a_{\text{semi}}}{R_*} \cos i
\]

<table>
<thead>
<tr>
<th>( \Delta b = 0.1 )</th>
<th>( \Delta b = 0.2 )</th>
<th>( \Delta b = 0.3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( R_p / R_* )</td>
<td>0.141</td>
<td>0.144</td>
</tr>
<tr>
<td>400</td>
<td>0.145</td>
<td>0.144</td>
</tr>
<tr>
<td>600</td>
<td>0.143</td>
<td>0.144</td>
</tr>
<tr>
<td>800</td>
<td>0.142</td>
<td>0.144</td>
</tr>
<tr>
<td>1000</td>
<td>0.141</td>
<td>0.144</td>
</tr>
<tr>
<td>1200</td>
<td>0.140</td>
<td>0.143</td>
</tr>
<tr>
<td>1400</td>
<td>0.139</td>
<td>0.142</td>
</tr>
<tr>
<td>1600</td>
<td>0.138</td>
<td>0.141</td>
</tr>
</tbody>
</table>

Fig. 2: Synthetic transmission spectra for transiting exoplanets with fixed orbital parameters in combinations that yield the same impact parameter. The symbols indicate different values of \( b \) and the colors represent the different wavelengths of observation.

Deciphering the atmosphere of HAT-P-12b

A specific example is the sub-Saturn HAT-P-12b:

- Mallonn et al. 2015 (M15)
  - ground-based photometric observations
  - derived a flat transmission spectrum
  - opaque layer of clouds
- Sing et al. 2016 (S16)
  - HST spectroscopic observations
  - strong Rayleigh-scattering signature
  - a haze layer

Fig. 3: The influence of \( b \) on the transmission spectra of three different groups of exoplanets, showing an introduced slope and an offset for different \( b \) values. The black dots indicate the synthetic spectra of each subgroup and the different symbols represent the derived spectra with the variation in \( b \). Black dashed line is the linear regression fit of each spectrum and the green dotted lines indicate two atmospheric scale heights from the average \( R_p / R_* \), for each group respectively.

Main motivation is:

- to solve this discrepancy
- and prevent repetition in future investigations.

Conclusions

- Joint fit and determination of new inclination value \( i = 88.83 \pm 0.19^\circ \)
- Linear regression line of all data points shows a slope of: \( \Delta b = (-2.96 \pm 1.26 \times 10^{-4}) \times \text{nm}^{-1} \)
- Signature of the planetary atmosphere as the host star has low activity

References