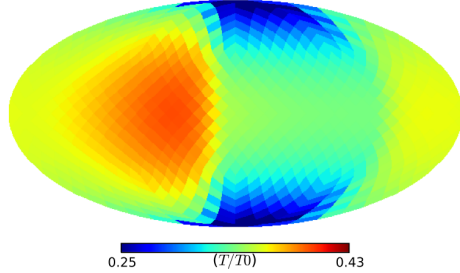
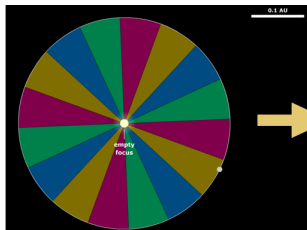


## THERMAL PHASE VARIATIONS OF ECCENTRIC HOT JUPITERS : AN ENERGY BALANCE MODEL

Planet Temperature at a Moment in Time



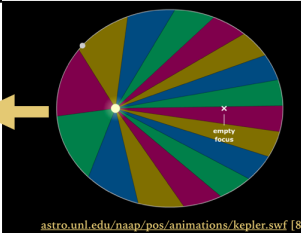
SURA summer research project by: Diana Jovmir  
Supervisor: Prof. Nick Cowan, MSI



### EVERYTHING'S SPINNING!

- Tidally Locked : The sun is stationary in the sky and planet receives uniform flux throughout the orbit.
- Heat recirculation in the atmosphere will cause light curves to shift and lose amplitude.

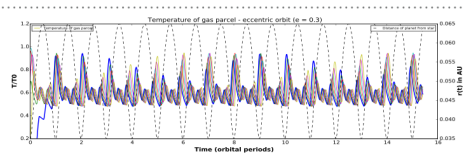
- Planet is only 'tidally locked' at periastron.
- Radiative timescales, prevailing winds and variations in incident flux due to orbital position will interact to generate more complicated light curves.



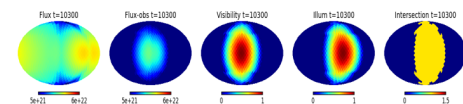
[astro.unl.edu/naap/pos/animations/kepler.swf](http://astro.unl.edu/naap/pos/animations/kepler.swf) [8]

## THE MODEL IN PICTURES

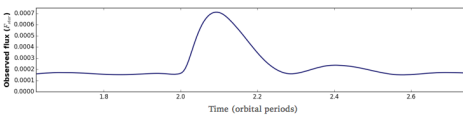
Step 1: Solve differential equation for temperature as a function of time and position



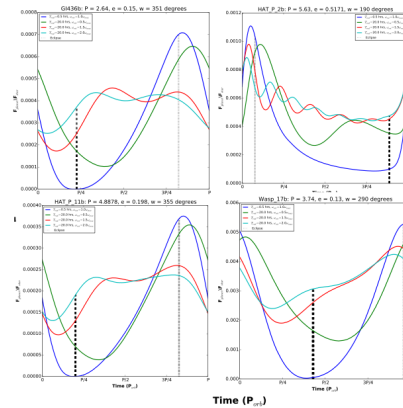
Step 2: Flux maps and viewing geometry



Step 3: Calculate the light curve!

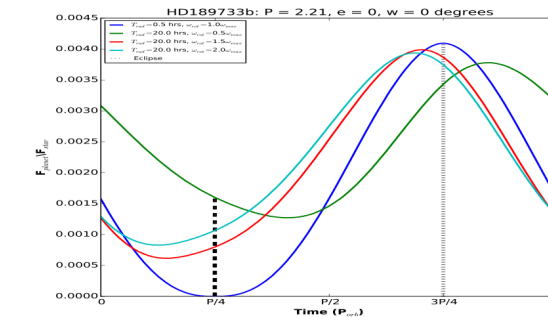


## EXAMPLE LIGHT CURVES : ECCENTRIC ORBITS



- For eccentric planets, transits don't necessarily happen at a minimum in flux.
- There can be ringing.
- Takes a little less than 0.1 seconds to generate a light curve.

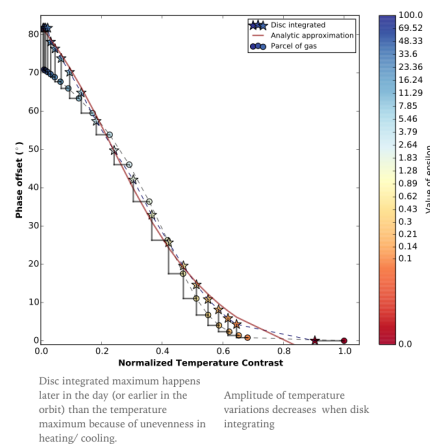
## SPECIAL CASE: CIRCULAR ORBITS



- Depends only on circulation efficiency parameter:  $\epsilon = \tau_{rad} * \omega_{adv}$
- The amplitude of temperature contrast and offset observed in the light curve can be related to each other (parametrically) through the circulation efficiency parameter  $\epsilon$ .

## APPLICATION : CIRCULAR ORBIT

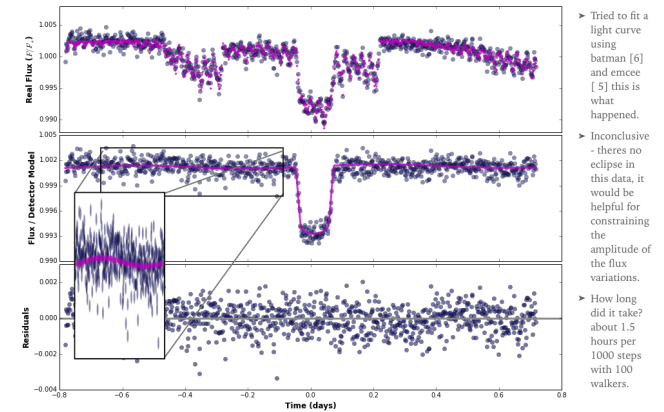
- Prediction for FINESSE mission
- FINESSE is a space telescope that will measure bolometric flux for many planets
- We'll get to see if this simple energy balance model would make a good approximation for phase curves once that data is available.



Disc integrated maximum happens later in the day (or earlier in the orbit) than the temperature maximum because of unevenness in heating/cooling.

Amplitude of temperature variations decreases when disk integrating

## APPLICATION: FITTING



- Tried to fit a light curve using batman [6] and emcee [5] this is what happened.
- Inconclusive - there's no eclipse in this data, it would be helpful for constraining the amplitude of the flux variations.
- How long did it take? about 1.5 hours per 1000 steps with 100 walkers.

## WHAT'S NEXT??

- Fitting phase curves worked so far but inconclusive. Would like to try it on data that contains an eclipse.
- More detailed explanations about how the model works in Nick's paper [1].
- Code and examples on Github, you can use it or improve it if you'd like. <https://github.com/dianaj/heatmap/tree/master>
- Code isn't perfect, some of it is even very rushed. Testing takes a long time. Bugs and problems I noticed are mentioned in the docstrings to the files.
- Contact me if you want to use this and you have questions: [djovmir@gmail.com](mailto:djovmir@gmail.com)



## REFERENCES

- [1] N. Cowan, E. Agol, A Model for Thermal Phase Variations of Circular and Eccentric Exoplanets, The Astrophysical Journal 726 (2011) 12.
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