Computational Astrophysics 2025/2026

Physics of Data

Part 1: Transit Light Curves

Submission deadline: 07/11/2025

Assignment 1: Better Together!

"But we are strong, each in our purpose, and we are all more strong together."
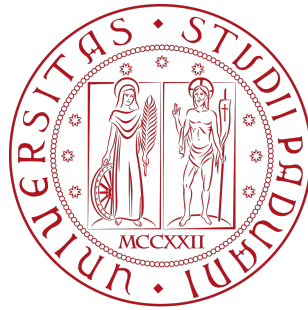*— Bram Stoker*

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Abstract

This report presents the work completed for Assignment 1: *Better Together!*. For each task, the actions carried out are described together with the relevant Git commit hashes and dates.

Task A : Let's start

The name of the repository for this assignment is `comp_astro_25`.
It is available at:https://github.com/bponnekanti/comp_astro_25.git.

Task B: Don't forget your parents

The original repository was added as remote `ca25repo`.
The latest information on the last remote commit was saved in `assignment1_taskB.txt` to document the remote state.

Document remote repository state

Commit: 606c80c6a9aaeded400ba565d642e6d406cfacd9

Date: Sun Oct 26 10:38:51 2025

Task C : Branch creation

Each group member created a file with their name under the new branch `assignment1_taskC` to document individual contributions. These files were committed and pushed separately.

Record of individual contributions

Username: mahdisrenia-coder

Commit (Mahdis): 8c173a6b1eba6e3f1913be0f9e6dfdc52b0531cb

Date: Sun Oct 26 11:43:49 2025

Username: lcballard

Commit (Lewis): 6161122a86f65114ae7a1f31e1c5abd2b36ce948

Date: Sun Oct 26 13:30:31 2025

Username: adityaswamy-Astro

Commit (Aditya): 1ac53c82f632e183278219549f4a093fce8b0381

Date: Tue Oct 28 12:11:59 2025

Username: bponnekanti

Commit (Bianca): c7720796a081293b7429ee11169998899944d2b1

Date: Fri Nov 7 11:56:00 2025

Task D : Let's merge

The main and assignment1_taskC branches were merged to integrate all individual contributions. The merge was performed using the command `git merge assignment1_taskC`.

    Commit: dd7d8e1006e4ac6186bc7e5337e560b5c348c2f9

    Date: Fri Nov 7 13:10:25 2025

Task E : Ready to go!

A Conda environment `assignment1_taskE` was created, including `batman-package`, `NumPy`, and `Python`. The installed packages were saved in `assignment1_taskE.txt`.

    Commit: 56e4c9a136a78177b92298d108e6d75f0c219bdc

    Date: Sun Nov 2 18:02:09 2025

Task F: Planet sweet Planet!

In the Python script, the `batman` package is used with the planetary parameters of HATS-12 b and its limb-darkening coefficients (from a CSV file) to model the transit and generate the corresponding light curve. The PNG file illustrates the change in the star's relative brightness (relative flux) during the planet's transit.

    Commit: 215a01276da016c8ca2d14c50daabbc2b5558436

    Date: Mon Nov 3 13:25:54 2025

The planetary parameters used in the transit model are summarized in Table 1:

Parameter	Value
Mid-transit time (t_0)	0.0 d
Orbital period (P)	3.142702 d
Planet radius $(R_p/R_\star)$	0.06951
Semi-major axis $(a/R_\star)$	9.48
Inclination (i)	$85.27°$
Eccentricity (e)	0.085
Longitude of periastron (ω)	$0.0°$
Limb-darkening model	quadratic
Coefficients (u_1, u_2)	0.227, 0.248

Table 1: Planetary parameters for HATS-12 b

The limb-darkening coefficients sample, extracted from stellar atmosphere data, are given in Table 2:

Eff	Logg	u_1	u_2
6250	4.5	0.569	0.199
6250	4.5	0.561	0.213
6250	4.5	0.520	0.237
6250	4.5	0.481	0.259
6250	4.5	0.454	0.262
...	...	...	...
6250	4.5	0.216	0.245

Table 2: sample of u1 and u2 extracted from limb darkening coefficinets

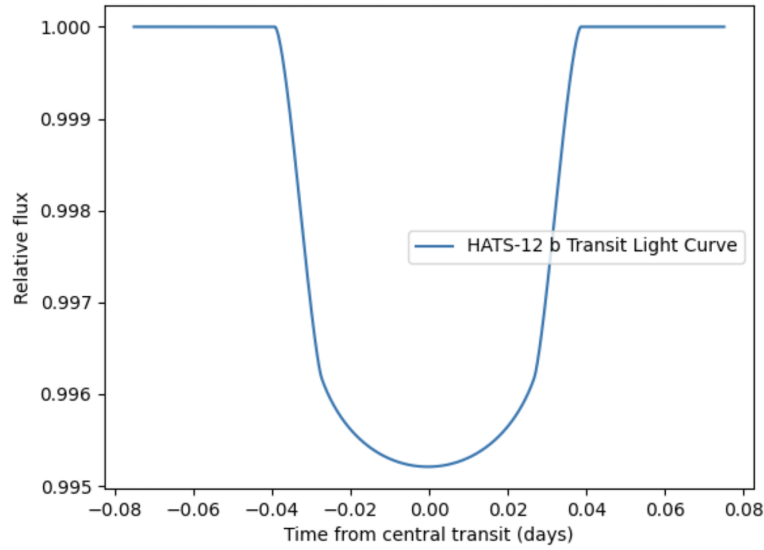The resulting light curve is shown in Figure 1:

Figure 1: Simulated transit light curve of HATS-12 b

Task G: Where is my transit?

In `transit.py`, the `daneel.transit` method was defined to generate a transit light curve from a YAML input file containing planetary parameters. The main script (`__main__.py`) was updated to allow command-line execution, so the transit function could be called with the flag `-t` and a path to the parameter file.

For this task, the transit of the planet WASP-121 b was simulated. The planetary parameters stored in the YAML file are summarized in Table 3:

Parameter	Value
Mid-transit time (t_0)	0.0 d
Orbital period (P)	1.580404 d
Planet radius ($R_p/R_\star$)	0.187
Semi-major axis ($a/R_\star$)	5.47
Inclination (i)	87.5°
Eccentricity (e)	0.0
Longitude of periastron (ω)	90°
Limb-darkening model	quadratic
Coefficients (u_1, u_2)	0.27, 0.02

Table 3: Planetary parameters for WASP-121 b

The transit light curve generated using the command:

```
daneel -i path_to_parameters.yaml -t
```
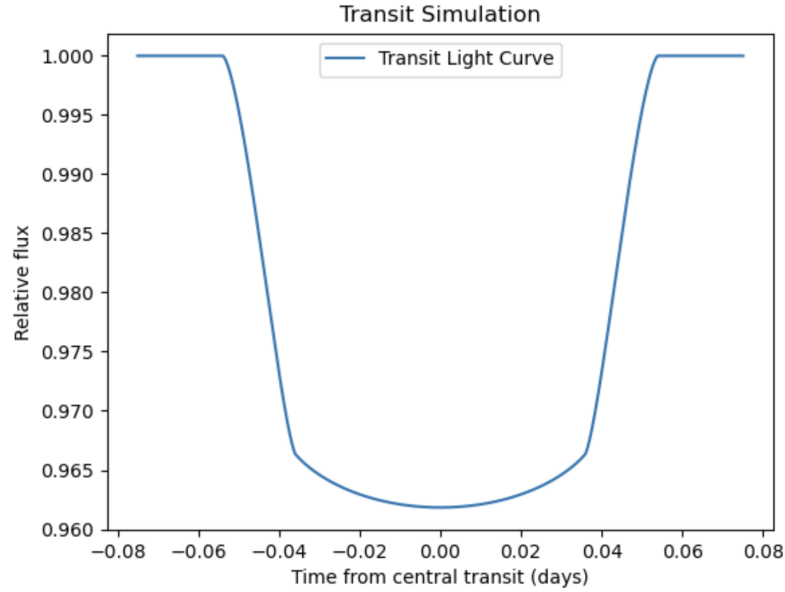
is shown in Figure 2:

Figure 2: Transit light curve of WASP-121 b generated via the command-line method

Commit (added transit.py file): 7b6365c5a88e81af4bdb31f607fce665089ee413

Commit (updated READ.ME): 72f695cf7f13a9b34dba3ccb829a478feda4105d

Commit (created YAML file): 1e4deb846160f71ad82070fe5fca7310840c9053

Date: Thu Nov 6 – Fri Nov 7, 2025

Task H: The Untouchable

The run_daneel folder was created outside the repository and contained the YAML parameter file for planet WASP-121 b(same planet as task G). The command ran successfully, generating the transit light curve, and the folder was then pushed to the repository.

Commit: c0cca1cc0fc1b265bf7361adc321a6a705a38e15

Date: Fri Nov 7 10:09:54 2025

Task I: Universe is a weird place

We proposed an acronym for our forked repository comp_astro_25. We chose **PEPPAPIG** as our acronym. This stands for **P**ondering **ExoP**lanetary **P**arameters **A**nd **P**lotting **I**ma**G**es of their transits. In creating this acronym, we paid tribute to many astronomical acronyms which both use multiple letters from the same word to aid the acronym, and leave words out entirely (i.e. **PLA**netary **T**ransits and **O**scillations of stars) for the upcoming PLATO mission. It was important to us that the average user is completely unable to guess what the acronym stands for, and that the long title is much less important than the acronym itself. When likened to the age-old philosophical question of the chicken and the egg, we wanted to make sure there would be no similarly elusive answer about whether our title or our acronym came first.

Peppa Pig is a reference to the eponymous animated children's TV show, which began airing in 2004 and is still running today. As Figure 3 shows, Peppa is a young piglet whose adventures and learning met with vast global success over the course of the show's nine seasons. The show is produced by Hasbro Entertainment. We acknowledge that we do not own the rights to this character, and if the code on this repository were ever to be published, we would change the name to avoid litigation. Currently, our usage of her name and likeness falls under fair-use rights for non-profit educational purposes.

Figure 3: Peppa pig