

# AST 51 Assignment #3 - Star Spots and Flares on an Eclipsing Binary

**Task:** Analyse the relationship between star spots and flares on the eclipsing binary CM Draconis, in the form of a Jupyter Notebook tutorial. Create an accompanying short public outreach audio/visual presentation.

**Professor:** David V Martin

**Grade amount:** 10% of final grade

**Given:** Thursday Feb 22nd, 2024

**Due date:** Thursday March 14th, 2024 @ 12pm

**Early reward:** 3% per day for max 3 days, applied multiplicatively (max 100%)

**Late penalty:** 3% per day with no maximum, applied multiplicatively

**Marking metric:** Out of 100% (plus potential bonus marks)

- Clear pedagogy including clearly written English **(30%)**
- Thorough, interesting and correct statistical tests **(45% total)**
  - Recreation of some Martin et al. 2024 results **(30%)**
  - Bonus points for new analysis **(15%)**
- Slick, entertaining and informative public outreach presentation at an appropriate level **(30%)**
- Code is well commented and explained **(10%)**

## What you are given

- A raw light curve of CM Draconis.
- A derived fit of the spot modulation flux as a function of time.
- A list of flares and their time (in days), amplitude (in normalized flux) and energy content (in erg)
- A Jupyter notebook which loads in and plays around with the data a little bit:  
"assignment\_3\_intro"
- The published version of Martin et al. 2024.

## FAQ

**Who is the target audience of this notebook?** Other astrophysics undergrads or grad students. You can assume they have some basic knowledge of Python and some basic astrophysics, but they have not done this task before. If unsure, err on the side of providing more explanation than less.

**What do we hand in?** Each group will hand in **ONE** tutorial notebook and **ONE** public outreach presentation. All tutorial text will be contained with the notebook.

**Am I in the same group as for assignment 1 and 2?** The groups have changed

**The end goal seems rather vague?** Yep, like in research, there is an element of you setting your own goal, rather than having something very clearly defined for you. Ultimately you should

produce something that has interesting (and correct results) and demonstrates interesting relationships between the star spots and flares. Your project should contain lots of pretty plots and interesting commentary. There is no set minimum or maximum length.

**I'm still confused about the end goal?** That's fine, ask a question in Slack or come to office hours!

**Should I read the Martin et al. 2024 paper?** Yes! This is essential for understanding the CM Draconis system and the purpose of this study. You also get marks for re-creating some results there!

**Do I have to understand all of the Martin et al. 2024 paper?** No! You are always encouraged to read up on various astrophysics things that are mentioned that are of interest, but ultimately you have a fairly self-contained task of analysing spots vs flares with data that has already been heavily processed for you.

**Where did the data come from?** The TESS spacecraft!

**Do I have to understand how the data were acquired?** No! Although later in the year we will study this a bit

**What is this assignment building up to?** Your final assignment will have you doing some thorough analysis on new data - i.e. brand new science! For now, you are doing real analysis on real data but I've done some of the steps for you so your task is a little more focused and introductory.

**Do I have to find the flares?** No! I already found them for you! You can read the paper to discover how, but it's not essential

**Do I have to model the spot rotation?** No! I already did that for you. You can read the paper to discover how, but it's not essential

**Do I have to care about the eclipses?** My main interest for you is spots vs flares, but you are also welcome to analyze them with respect to the eclipses if that interests you.

**How much should I discuss the underlying astrophysics in the tutorial?** You should discuss briefly what the basic concepts are (flares, spots, eclipses, binaries) but the main emphasis is on the statistical analysis.

**I don't know that much statistical analysis yet?** You actually know more than you might appreciate. Class #6 will cover some basic ideas which you might use (p-values, Z tests, t tests) and class #7 will cover some further ideas (bootstrapping, correlations).

**What format does the public outreach presentation have to be in?** Anything that contains audio and or visual information (i.e. not a blog or newspaper article). Examples include:

- Purely audio NPR-style mock interview
- Youtube video where you have a VoiceOver discussing various results and figures but no video
- Audio & video, e.g. a TikTok or Youtube short or Instagram reel, or mock television interview

**How long should the presentation be?** No set length but a reasonable time to get across some interesting points. If it's short, it should be very snappy and concise. If it's a bit longer, it needs to not drag. We're not looking for a 7 hour David Attenborough epic here...

**Does everyone in the group need to speak/be seen on the presentation?** No, you can delegate rolls there (e.g. 1 person makes the slides, 1 person writes the script, 1 person speaks it) but you must all contribute fairly evenly

**You mention Youtube, TikTok etc, do I need to actually publish this on the internet?** No, you will simply hand it in to me (although if you chose to publish it online with the consent of your whole group that's up to you).

**Can some people do only coding and some people only outreach?** No, everyone must contribute to both aspects of the assignment

**How is this graded?** Everyone in a group will receive the same mark, barring cases of insufficient contribution

**The total marks don't seem to add up?** The base marks add up to 100%, but if you do the extra challenge of some analysis that wasn't seen in Martin et al. 2024, then you can get a bonus 15%.

**What if I fall ill or other unforeseen circumstances?** Communicate with me! I am here to support you.

**How is plagiarism and insufficient contribution handled?** Every student must hand in a signed (e-signature is fine) document where in a couple of sentences they state their original contribution to the project and a rough assessment of the distribution of work amongst the group. This will be anonymous. This document is on Canvas. In addition, several times throughout the year students will be randomly interviewed to discuss their code (assignment or homework) with the professor or TA and to demonstrate their knowledge of the code's working.

**What is the punishment for plagiarism/insufficient contribution?** Cases will be handled on a case by case basis. Ultimately, we are all adults and will be treated as such. But we also want to have assessment that is fair and with integrity. Violations could result in reduced individual or group marks or other disciplinary action.

**How do we hand this in?** **ALL** students must hand in the aforementioned "integrity form" but only one student per group (could be any) needs to hand in the actual assignment. If multiple students in a group hand in the assignment I'll consider the first one, unless otherwise told. All of this will be on Canvas.

**How are late/early marks applied?** They are applied multiplicatively. If your base score is 70% but you handed it in 3 days early, then you'd receive  $70 * 1.09 = 76.3\%$ . If you handed it in 3 days late then you'd receive  $70 * 0.91 = 63.7\%$ . In terms of timing, if you hand in within 24 hours of the due date, that is considered "on time", i.e. no early or late marks. Between 24 and 48 hours before the due date = 1 day early, so a 3% early award, and so on... Within 24 hours after the due date = 1 day late, 24-48 hours = 2 days, etc...

**Can I ask the teacher/TA/rest of the class for help?** Absolutely. Whilst your first port of call should be to discuss/ask your teammates, you are always encouraged to come to office hours and post on Slack. We won't do the assignment for you but we'll happily assist you

**Can I program using a different language?** No, using python 3 is required as it is an astronomy "industry standard" that we'd all do well to learn, even if you already know another language.

**Can we include downloaded packages?** The fundamentals of the assignment have to be done "from scratch". I.e. you can use some basic numpy packages but you have to write the code to do the random sampling. For many of the aspects of this assignment there exist packages out there (e.g. randomly sampling from an IMF). You are welcome to use these in order to check the validity of your work, and that can be included in your tutorial for that purpose, but ultimately you have to do the work yourself.

**Can we use code from the assignment 1 pretty plots knowledge base?** Yes, indeed the purpose of that assignment was to provide pretty plot codes that you can use! However, you still have to comment and clearly document everything that you use.

**Should the Jupyter notebook run?** Yes, it should run on Python 3.8. If you require any packages, it should be clear what needs to be downloaded.

**Can I turn in a .py script instead of a Jupyter notebook?** No, whilst the use of .py scripts is common, for consistency of grading and the fact that Jupyter notebooks are worth learning, we require them. Jupyter notebooks are also very popular for tutorials, like the one you are writing

**Can I incorporate code that I found online?** Realistically, astronomers use StackExchange, Github and in general Google a lot. This is fine in moderation, as long as it is documented. Ultimately, to obtain full marks the code submitted should illustrate that you a) know how to write sophisticated code and b) know what each line of the code is doing.

**Can I use ChatGPT?** As a tool that helps you learn, e.g. finding bugs in your code, sure. However, you cannot use ChatGPT to write the whole assignment (it'll be pretty obvious and a pretty poor result). Remember that the coding part of this assignment is only one aspect; many marks are awarded for the pedagogy.

**Can we be inspired by tutorials we see online?** Inspired, for sure! Copied, no.