AST1002 Spring 2018 Project 1
Characterizing an Unknown Star

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Overview of project

In the textbook, Chapter 9, "Measuring the Stars," has been about how to determine various characteristics of stars in the sky. The major characteristics of a star are:

1. The **stellar parallax**, p
2. The apparent brightness (the **flux** F or **apparent magnitude** m)
3. The **color**
4. The **emission/absorption spectrum**
5. The **distance**, d
6. The inherent brightness (the **luminosity** L or **absolute magnitude** M)
7. The **temperature** T
8. The **spectral class**
9. The **radius** R
10. The **mass** M
11. The **transverse velocity**, v_t, the **radial velocity**, v_r, and the **total velocity**, v

(Note that both absolute magnitude and mass use the variable M; whenever you use M, you need to make it clear which you are talking about.) Something important to know about the above characteristics is whether a characteristic is **directly observable** – meaning you can measure it directly with a telescope – or is **indirectly observable** – meaning you can calculate it based on directly observable characteristics. For instance, apparent brightness is directly observable. When taking an image with a telescope, a modern camera uses a CCD chip which automatically determines the brightness of the star based on the amount of light *that reaches Earth*, i.e. the apparent brightness. On the other hand, the inherent brightness of a star is **not** directly observable, but it can be calculated if you know the apparent brightness and the distance to the star.

In the list above, **characteristics 1 through 4 are directly observable, while the rest are indirectly observable**. As I mentioned in the previous paragraph, the CCD chip on a modern camera can directly measure the apparent brightness of a star. It can also, of course, tell the color of the star. The emission/absorption spectrum of a star can be determined by **spectroscopy** – if you

put a prism or filter in front of the camera, you can break the light from the star up into individual colors, and measure the relative brightness of each color individually; that's the spectrum of the star. Finally, stellar parallax is directly measurable because when you take a picture of the night's sky, you're capturing an image of the relative **angular separation** of stars, **not their physical separation in space**. We don't know how far away from us each star is, so we have no idea how far apart each star actually is from one another, but we can absolutely tell how far apart in angles each star is from one another, so we can directly measure the parallax angle of a star as the Earth moves around the Sun.

Based on the first 4, directly observable characteristics of a star, **you can calculate the other 7, indirectly observable characteristics**. This is what we spent a lot of time on in Chapter 9. For example, finding the distance d to a star, in parsecs (pc), is very simple: if you know the parallax p of the star in arcseconds (”), then the distance to the star in parsecs is:

$$d = \frac{1}{p}$$

All of the other equations that you need to determine the rest of the indirectly observable characteristics are in the lecture slides for Chapter 9 on the class website.

So, what you'll be doing is quite straightforward: **based on direct observable characteristics of a star, which you will be provided, you must calculate the remaining indirectly observable characteristics of the star and type up your findings in a research paper.**

What you will be given

I will give you a **set of data that you will use to find the 5 directly observable characteristics** of some unknown star. Note that the star may be real, but I may also have to simply make up data, so the star might be fake. The apparent brightness and the spectrum of the star will simply be given to you – the apparent brightness will be a number, while the spectrum will be a graph – but the others won't be simply given to you. To measure the parallax and the transverse velocity, images from telescopes will be given to you, from which you'll be able to measure the parallax and transverse velocity using the methods outlined in the lecture slides for Chapter 9. You'll also be able to figure out the color of the star from the data given (this will be fairly easy to do).

What you will turn in

As I said in the overview, you're going to use the directly observable characteristics – the parallax, apparent brightness, color, and spectrum – to calculate the indirectly observable characteristics – the distance, inherent brightness, temperature, spectral class, radius, mass, and the velocities – of the unknown star that you're assigned. Once you've completed these calculations, **you will turn in a research paper outlining the calculations and the results**.

The research paper needs to be broken down as follows:

- **Introduction**: Here you outline the project. You need to focus on *what* you're doing, not *why* you're doing it. For instance, you need to calculate the distance that your unknown star lies from Earth. To calculate this, you need to know the stellar parallax. So in your introduction, you'd want to mention that you *will* be using stellar parallax to calculate the distance to the star. However, you won't be saying *why* you need to know parallax, and not some other characteristic of the star, to find the distance. That's left for the next section.

- **Overview of the Relevant Physics**: Here is where you explain the *why*. Why do you need to know parallax to measure distance? This is shown geometrically in the lecture slides, so you would need to replicate that explanation here. **Your explanations only need to be brief; they don't need to be paragraphs long. And (obviously), do not plagiarize your explanations**. I will literally be Googling what you write out for the explanation, to make sure you didn't copy any explanations word-for-word. It's not worth it to plagiarize something, especially Wikipedia, which everyone seems to do. his section should be the second-longest section in the report. You're essentially going to have to re-explain Chapter 9, so it should be several paragraphs in length, total, if not more.

- **Data**: Here you will simply replicate the data that I give you on your unknown star. Give the numerical value for the apparent brightness that I tell you, and copy/paste the spectrum for the star. Copy/paste the telescopic imagines that I give you as well, and give the corresponding value of parallax. Also list the color of the star, and your justification for that color.

- **Calculations of Indirectly Observable Characteristics**: This is going to be the longest section in the report, and it is the meat of the project; this is the whole point on doing what you're doing.

- **Results**: List all 7 indirectly observable characteristics of the star in a table, summarizing your results from the previous section. For example:

Distance	5.7pc
Absolute Magnitude	3.5
Temperature	8800K
Spectral Class	A
Radius	$4R_\odot$
Mass	$3M_\odot$
Transverse velocity	55 km/s
Radial velocity	100 km/s
Total velocity	114 km/s

  Notice the units that I've used for each characteristic: these are the units that you want to give you values in. Recall that the subscript $_\odot$ means "Sun," so $R_\odot$ is the radius of the Sun, and $4R_\odot$ means "4 times the radius of the Sun."

- **Conclusions**: Here you should discuss the results and what they mean about your unknown star. For instance, if I compare my spectral class and luminosity, as well as radius, on the Hertzsprung-Russel Diagram, I see that my star is a main sequence star, so it's living a healthy life right now. If, on the other hand, my star had an absolute magnitude of -3 (and a radius of $50R_\odot$), but was still an A class star, then it would be a supergiant star. You should also give a well-known star (i.e. one listed on the HR diagram) that is similar in characteristics to yours, if possible. For instance, both Vega and Sirius appear on the HR diagram and have nearly the same characteristics as those listed in the above table.

Format of report

Your report **doesn't need a cover sheet**, but if you prefer one due to your personal taste, feel free to include one. The report definitely needs a **title, author, and author information** (such as the class that you're in). The report should be typed in a reasonable font – something like Times New Roman or Calibri, not Comic Sans – at a reasonable size (10-12 pt). It should be double spaced. **Your grade has nothing to do with the length of the report**, so don't increase the size of the font or triple space or or really work to increase the number of words to the point where everything drags on. Your grade, as far as the formatting of the report is concerned, is going to be based on: **following the format guidelines** (Are you missing any of the sections listed above?), and **presentation, neatness, and readability for your report** (Can I understand your report? Is it organized well? Is it a complete mess to the point I have no idea what is what?). You won't lose points for things like grammar or spelling **as long as I can understand it**; this isn't an English class. Though you do have access to spell check, so I would use it.

Grading

As long as I can understand your report, formatting should only account for 10% of your grade; **the other 90% is going to be based on the actual science**. This is going to be split between your section on relevant physics (Were your explanations correct? Were you missing any explanations? Were there any serious flaws in your explanations?) and your calculations (Did you get the correct answers?), probably about 30% - 60%, respectively. As far as your grade in the class is concerned, this project is worth 20% of your total grade.

Final thoughts

You will get roughly a week and a half to complete this report. Please, don't wait until the last minute to do it! I'd like this report to essentially be for participation credit. If there are any calculations you're confused about, you can ask me in class, come to my office, or email me. If you need help formatting your lab report, ask. If you have any questions about the explanations, ask. You should have confidence in what you're turning in because you'll have plenty of time to discuss anything you need to with me! I'd like everyone will get A's on this project.