Chapter 1: So, you want to be a photometrist?

If you own or have access to a telescope with a CCD camera, you can use them to obtain scientifically useful variable star data. The AAVSO supports several different observing modes, with CCD observing and visual observing (with the aided or unaided eye) being the two most popular. Both kinds of observing have strengths and weaknesses, and each has its place in variable star astronomy. This guide is intended to help a novice observer become a better CCD photometrist. This is critical for our mission, because the quality of data we receive from the observers impacts the quality of science that researchers will do with it. A CCD camera is capable of obtaining very good variable star data, and like most scientific instruments, it is also capable of obtaining very **bad** data. We want to help you aim for and produce **good** data.

Our CCD observer community is drawn from a number of different populations. Some former (and current) visual observers made the leap to CCD observing. Some people who used CCDs for astro–imaging wanted to do more than astrophotography. Some people may use remote or shared facilities to obtain astronomical observations and want to maximize their value. Some people may have come across an article on variable star observing and thought *I want to try that!* They may have taken the leap directly into CCD observing.

For the sake of simplicity, this guide will assume you have a passing knowledge of astronomy – you should know for example how stars move across the sky during a night and what astronomical coordinates are (like Right Ascension and Declination), and what the magnitude of a star means. We will also assume that you have already learned enough about how to set up and operate your telescope, how to connect your CCD camera to a computer, and how to use the software that came with the camera and telescope to operate them. At this stage, you should at least be able to turn on your telescope, point it to a field in the sky or have the telescope point itself, and take an image with the camera. If you've taken a picture of a star field, cluster, nebula, or galaxy with your telescope that you're reasonably satisfied with, you're all set with what you need to know. If you're just starting out with a new instrument, learn the basics of how to operate it and have some fun first. Get a good feel for how the telescope works, and — especially — how to use it to take images that track properly.

Along with this you should be comfortable with the software that came with your telescope, or at least have a copy of the software manuals. Most commercial CCD software will have everything you need to at least process your images to scientific usability. Later in the *Guide* we'll talk about how to extract data from those images, and that can be done with most commercial CCD software packages, or with the AAVSO's own *VPhot* software. More on that later.

In general, you do not need to be a mathematician, an engineer, or an astrophysicist to obtain good data. Some knowledge of mathematics including algebra and trigonometry *will* be assumed — many of the calculations required for CCD photometry can be automated with spreadsheet software, but a basic understanding of math is required so that you understand what goes into that spreadsheet and what comes out. You will need to develop the habit of examining your results carefully, and assessing whether they make sense every time you submit an observation.

Finally, we'll assume that you have an interest in both variable stars and taking good quality scientific data. Familiarity with variable stars before you start doing CCD observing would be great, at least at the level of knowing what a variable star is in comparison to a non–variable star, but you can learn as you go along, and we'll cover the basics of what "variable star photometry" is and why we do it in the next chapter. Many of our best CCD observers got their start as visual observers, and we encourage everyone to pick up this guide's sister publication, the *AAVSO Manual for Visual Observing of Variable Stars.*

Note that obtaining "good data" may involve making some mistakes and (crucially) learning from them. Taking **very** good data is complicated, and it requires some effort. It's easy to get bad data from a CCD; it's fairly easy (or at least straightforward) to get good data. It's harder to get ***great*** data whether you're an amateur or a professional, but we're confident that you ***can*** do it if the circumstances allow; otherwise we wouldn't be writing this. It's ok to make mistakes, but if you learn from them, you'll be on your way to collecting good data.

Photometry

When we "observe" a variable star, we mean that we're measuring the amount of light that the star appears to give off at a given moment. We repeat that measurement over and over, making the measurement as often as we need to completely track all of the variations. If our measurements are consistent and accurate, we can then make physical models that try to explain why the brightness changed in that manner. Your task as a variable star observer is to make good measurements so that researchers can make good models. The better your data, the better their models. The process of measuring the light from a star is called **photometry**, and a person who does this is a *photometrist*. We're hoping you'll become one, and a good one at that, once you work through this guide.

There are a number of details about how you make that measurement that can improve researchers' chances of making realistic models, and not all of those details will be relevant to you. You can take excellent data for some stars just by pointing your telescope at the target, taking one or more images, and processing the images with simple methods. That's *not* how the majority of stars are observed effectively, but it is possible sometimes. Most of the time you'll be using your camera to take one or more images of a star on a single night, and then revisiting that star again and again

over time. You might even spend many hours a night on just one star, taking images over and over again, as quickly as you can. You may use one or more *filters* to measure light with well–defined wavelengths. You will even spend time measuring specially selected *non–variable stars* to better *calibrate* your observations. All of these and more are involved in turning your observations into useful data.

Photometry is the measurement of starlight intensity by any means. While this guide will teach you how to do photometry with a CCD, a CCD isn't the only instrument capable of doing this, and your ultimate goal isn't to be a "good CCD observer", it's to be a good *photometrist who is using a CCD camera*. There's a difference. Nearly everyone can saw a piece of wood in half, but that doesn't make them a carpenter. A CCD camera will produce numbers that get turned into another set of numbers inside your computer, and perhaps another set of numbers in your analysis software, spreadsheet, and so on. Those numbers aren't photometry unless the process of doing this is correct. Don't focus on the technology, focus on the purpose. Your goal isn't to produce *numbers*; it's to produce *knowledge* that may lead to *understanding*. We'll show you why and how, starting now.