Appendix A: What is starlight?

There's much more information in starlight than how much of it there is and when you measure it. We ask CCD and other instrumental observers to use standard filters when doing photometry because filters allow you to measure both the amount of light, and its spectral distribution. The key physical property of light relevant here is the wavelength. Light is composed of *photons*, which are small bundles of electric and magnetic fields that travel through space at the same speed — the speed of light, **c**. These small bundles behave both like particles and waves, and since they are waves, they have a characteristic wavelength.

In optical light, the different *colors* you see correspond to light with different wavelengths. Red light has longer wavelengths than yellow light, which has longer wavelengths than green light, which has longer wavelengths than blue and violet light. All of the different colors of light observed together are called a *spectrum*. The visual spectrum is roughly composed of all light having wavelengths between 300 and 700 nanometers, from the violet to the red. There's more light beyond that range, too. Beyond the violet toward shorter wavelengths lie the ultraviolet, X–ray, and gamma–ray regions of the electromagnetic spectrum. Beyond the red toward longer wavelengths lie the infrared, microwave, and radio regions. We only define the visual spectrum this way because that's what the human eye is capable of seeing — our eyes aren't sensitive to light outside that range. Most normal stars emit the bulk of their light in the optical and infrared, and our own Sun emits the greatest amount of light around 500 nanometers, which appears green to our eyes.

A related quantity for each photon is its energy, which is also a function of wavelength. Specifically, the energy carried by a photon is inversely proportional to wavelength:

$$E = hc/\lambda$$

where h is Planck's constant, c is the speed of light, and λ is the wavelength. Note the inverse relationship with wavelength: shorter wavelength, blue photons have more energy than longer wavelength yellow photons, which have more energy than even longer wavelength red photons. The wavelengths of light that astrophysical sources emit are related to the total energy density of the system that's doing the emitting. A relatively cool star is unlikely to emit high–energy radiation *unless there are special sources of energy within the system*. Conversely, a hot star may be capable of emitting higher energy radiation, *but it also emit photons with lower energy*. (More on that in Appendix B.)

There is another property of light that we won't go into detail in this guide, and that is its *polarization.* Photons are bundles of electromagnetic radiation, where each particle consists of an oscillating electric and magnetic field. All photons received from a single source may be assumed traveling in parallel when they get to your detector, but the oscillation axes of each photon will be different. The fields may oscillate in a single direction perpendicular to the direction of motion but with random orientation, or they may have a circular component to the oscillation (i.e., the photon is elliptically or circularly polarized). If the emitting source is polarized or if the light passes through a polarizing medium (like a dust cloud), there will be a preferential orientation for most photons you see. Circularly polarized light can also be created in environments or physical processes having strong magnetic fields.

Polarization can be measured with special filters, but it is a time–consuming process. We won't discuss it further, but be aware that it is another fundamental property of light that you observe.

Appendix B contains a brief discussion of radiative processes common in stellar astronomy, and how these can be described or explored using photometry.