Chapter 15

Pro-Am Research

Historical Perspective

There has been a long and proud tradition of amateurs contributing to the field of astronomy almost back to the invention of the telescope itself. (And here, let's remember that the distinction between amateur and professional astronomer is a relatively recent one. Many famous astronomers of the past were technically amateurs including Sir William Herschel, discoverer of the planet Uranus in 1781.) And this work has been done almost exclusively by eye visually at the telescope rather than by photography or imaging of any kind.

One particularly outstanding example of such contributions is that made by members of the American Association of Variable Stars Observers (A.A.V.S.O: www.aavso@aavso.org). Since its founding in 1911 by William Tyler Olcott, mentor to generations of stargazers, they have amassed *several million* visual magnitude estimates of variable stars of all different types. This vast database has been widely used by professional astronomers over the years in their research.

And while today most of the observations are being undertaken using electronic imaging, for much of its history these were made by eye at the telescope. A striking example of the latter is that of the legendary American observer Leslie Peltier, who contributed over *130,000 visual magnitude estimates* of variables during his lifetime—strictly as an amateur astronomer working from his backyard observatories! (He also discovered or co-discovered 12 comets and six novae!) (Fig. 15.1).

J. Mullaney, *A Buyer's and User's Guide to Astronomical Telescopes and Binoculars*,
The Patrick Moore Practical Astronomy Series, DOI 10.1007/978-1-4614-8733-3_15,

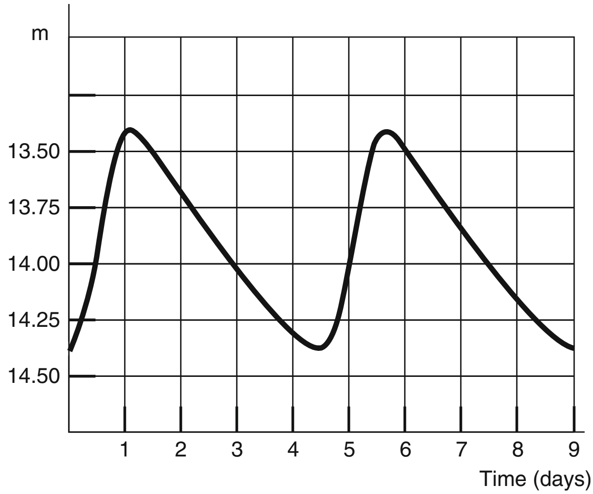

Fig. 15.1 Typical light curve of a variable star composed of visual magnitude estimates made by amateur astronomers—who have contributed *millions* of such observations! These plots are then used by professional astronomers for studying the complex inner workings of these restless suns. Courtesy of Astronomical Society of the Pacific

There's also the British Astronomical Association (B.A.A: www.britastro.org) and the U.S.-based Association of Lunar & Planetary Observers (A.L.P.O: www.lpl.arizona.edu/alpo), both devoted primarily to monitoring the Moon and planets. Until recently, the human eye reigned supreme for catching glimpses of fine detail on these bodies in fleeting moments of steady atmospheric seeing. But video and CCD imaging have made it possible today to equal and even surpass what was once only visible with the human eye in fleeting moments. And while visual observers have traditionally been the first to spot changes on the planets and report them to professional planetary astronomers, such discoveries today are being more frequently made using some form of astroimaging.

Since professional astronomers use observations provided by the above organizations, these might well be viewed as examples of pro-am research. Another organization that deserves special mention in this regard is the International Amateur-Professional Photoelectric Photometry (IAPPP). Founded in 1980 specifically to foster collaboration between amateur and professional astronomers doing photometry of stars, along with a wide range of other celestial objects from solar system bodies to galaxies, using photoelectric photometers. (More information can be had by contacting its director at: douglas.s.hall@iappp.vanderbilt.edu.) CCD imagers (which technically *are* "photoelectric" devices—photons in, electrons out) have all but replaced the photocells of traditional photoelectric photometers and the IAPPP has been quick to embrace their use in its work.

Extra-Solar Planets

An amazing change has occurred in the field of amateur astronomy over the past few years that has now largely replaced the human eye as a receptor—one making it possible for serious observers to actually work right alongside of professional astronomers on cutting-edge astronomical research. This is largely a result of the new imaging technology discussed in the previous chapter, and also the explosive growth of large-aperture "backyard instruments" due to the "Dobsonian Revolution" as it's being called. (We're talking here about scopes as big as 24- to 50-in. in size!) And the most exciting aspect of such research certainly has to be that of confirming, and even in some cases actually discovering, exoplanets—other solar systems beyond ours!

There are three indirect techniques used to detect planets around other stars (as opposed to actually seeing them directly, which has only recently become feasible using the very largest of telescopes and the most sophisticated electronic imagers). One is the *astrometric method* which detects the minute wobbling of a star in its path across the sky (its proper motion) as its planets pull it to-and-fro while orbiting it. Another is the *spectroscopic method* that uses changes in a star's line-of-sight motion (its radial velocity) caused by its planets tugging it towards and away from us as they orbit. Both of these techniques require huge optical telescopes and sophisticated accessory equipment. The third technique—and the one being successfully used by amateur as well as professional astronomers today—is the powerful *photometric method*. More specifically, it's better known as the *transit technique*. It measures slight drops in a star's brightness resulting from planets transiting across it (ones whose orbits lie in our line-of-sight). This is the amazingly successful technique employed by the orbiting Kepler space telescope which has discovered *thousands* of other solar systems monitoring just a small section of the summer sky! Interestingly, many of these planets lie in the so-called "goldilocks' zone" where the temperature is not too hot nor too cold—just right for liquid water to exist and with it perhaps life of some kind! (For more about the Kepler mission, see: http://kepler.arc.nasa.gov/.) (Fig. 15.2).

As this is written, an international pro-am collaboration called the "Microlensing Follow-Up Network" (or MicroFUN) has reported the discovery of two planets orbiting a remote red dwarf star using an advanced version of the transit technique itself. One of these worlds is described as a super-Neptune and the other a sub-Jupiter in size. This particular collaboration currently consists of 23 observatories scattered around the world—16 of them belonging to and operated by amateur astronomers! And this is just one such example of cutting-edge research being conducted by pro-ams. It's the phenomenal sensitivity of CCD (and to a lesser extent video) imaging detectors to minute changing levels of light that has made the transit technique so powerful a tool in the hands of the well-equipped backyard observer. Their initial contributions were, and continue to be, confirming reported planets discovered by professional astronomers using both ground- and space-based instruments. But a number of stars surrounded by planets have actually been detected by amateurs *first* and then later confirmed by professionals!

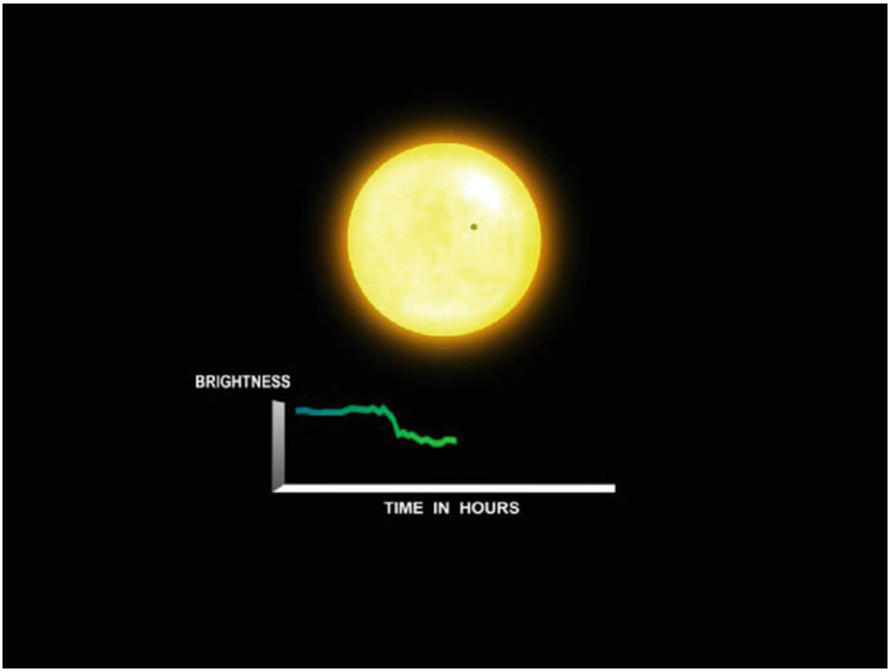

Fig. 15.2 Stylized example of a light curve from combined CCD observations by amateur and professional astronomers of an extrasolar planet transiting its host star, revealing its presence by slightly reducing the star's normal brightness. The actual drop in the star's magnitude would be significantly less than shown in this graph. Courtesy of NASA

Planetary Monitoring

As they have done for centuries, amateur astronomers continue to monitor the planets (and to a lesser extent the Moon) for signs of changes, activity, or outbursts of one kind or another. But As mentioned above, most of this is being done today using electronic imaging rather than with the eye—especially video with its ability to "shoot" large numbers of frames and catch fleeting moments of good seeing. This ranges from detecting changes in appearance of the atmospheres of Venus, Uranus and Neptune to ongoing major activity in the dynamic cloud covers of Jupiter and to a lesser extent Saturn. As examples of the latter, Anthony Wesley discovered impacts (by asteroids or comet nuclei) on Jupiter in both 2009 and 2010, and announced the disappearance of one of the planet's major bands! And S. Ghomizadeh and T. Kumamori first reported what became a major atmospheric storm on Saturn in 2010 (Fig. 15.3).

In the case of bodies with solid surfaces like Mercury or the Galilean satellites of Jupiter, very subtle surface features can be imaged which slowly change with their

Fig. 15.3 Discovery of a storm in Saturn's cloud cover by amateur astronomers. This resulted in worldwide study by planetary astronomers using the Hubble Space Telescope and large ground-based observatory instruments. There's been a long tradition of amateurs monitoring the planets for professional astronomers. CCD image courtesy of Sean Walker

rotation. The outstanding target in this regard is Mars, especially when around opposition and closest to us. Here we're talking about "seasonal" changes in appearance of the dark markings, melting of the polar caps, cloud and haze formations, and occasional planet-wide dust storms raging across the deserts. There have also been a number of flashes seen over the years, attributed to reflection off icy surfaces or perhaps volcanic activity. On at least one occasion, a "mushroom-shaped cloud" was observed moving off the limb of the planet into space! It was seen visually (and eventually reported in *Sky & Telescope* and other journals) simultaneously by experienced amateur astronomers in both the United States and Japan, leaving no doubt as to its reality. One of these individuals is personally-known to the author—Clark McClelland, who was using a superb classic 13-in. refracting telescope built in 1861.

Comets and Asteroids

Amateur astronomers continue to contribute to professional research involving these bodies ranging from actual discovery to monitoring changes. And today this is being done primarily through astroimaging of one type or another rather than by traditional visual observations. But famed amateur David Levy has discovered or codiscovered 23 of them to date—using *both* astroimaging and visual observations! (It should be pointed out here that automated professional surveys are now picking up most new comets and asteroids, but a few continue to be first detected by amateur astronomers employing backyard telescopes.) In addition to searching for potential "Earth grazing" objects in the case of asteroids and monitored changes in brightness resulting from their rotation, for comets it's changes generated by evaporation of nucleus ices, and tail length and structure, caused by radiation pressure and heat from the Sun. An important organization here that gives amateurs an opportunity to contribute to research on minor planets is "Target Asteroids!" (http://osiris-rex.lpl.arizona.edu/?q=target_asteroids), which works in conjunction with a number of other organizations including the A.L.P.O. mentioned above.

Work in these areas is reported to the International Astronomical Union's Minor Planet Center headquartered at the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts, (www.minorplanetcenter.net)—in conjunction with the Central Bureau for Astronomical Telegrams. The latter is where actual discoveries and flare-ups (in the case of comets) are reported to the professional astronomical community. As an active observer of the night sky, its Internet site is one you should always have close at hand: www.cbat.eps.harvard.edu/index. You just never know when you might need to use it!

Variable Stars

While the magnitudes of millions of variable stars are now being recorded nightly by automated sky surveys, there are still certain types of these restless suns that need continuous monitoring. One is eruptive variables like flare stars and recurring novae, which can dramatically increase in brightness without advance warning. Perhaps the most famous of the former is UV Ceti ("Luyten's Flare Star"), which normally hovers below 12th magnitude but can suddenly (in one case, in just *20 seconds*!) brighten to around 7th magnitude. T Coronae Borealis (the "Blaze Star") is the best-known recurrent nova. Normally 10th magnitude, it has brightened to 2nd magnitude—easily visible to the unaided eye! And there's also the reverse case, where a star suddenly *drops* in brightness rather than increases. A noted example here is R Coronae Borealis (not far from T in the sky!). This "Reverse Nova" as it's called is normally just visible to the eye in a dark sky at just above 6th magnitude and is easily seen in binoculars. But it has on occasion dropped to below 14th magnitude, requiring a fairly large instrument to glimpse. CCD cameras in particular are able to reach magnitudes far below the visual limit for any given telescope and are ideal for monitoring such bizarre antics as these. The "Center for Backyard Astrophysics" (www.cbastro.org) is "A global network of small telescopes dedicated to photometry of cataclysmic variables" like the above stars. And while (as its name implies) it's open to amateur astronomers—its membership also includes many professionals as well. The A.A.V.S.O. itself has a cataclysmic variable division specifically dedicated to observing these fascinating objects.

While not strictly a "variable star" in the usual sense, mentioned should be made here of a recent amazing astrophysical observation by Berto Monard. He is the first amateur astronomer to ever discover the visible-light afterglow of a gamma-ray burst—in his case, using astroimaging on his 12-in. reflector! These rare events have previously been the province of only orbiting and large Earth-based telescopes! (He is also actively involved in exoplanet research.)

Eclipsing Binaries

Using electronic imaging devices, amateur astronomers today are routinely timing the orbital periods of eclipsing binaries to professional-level accuracies. These are stars belonging to the same class as Algol (Beta Persei), the famed "Demon Star." Among the many physical parameters of the stars involved that can be determined from studying these waltzing duos, observers are looking for minute changes in their periods. From these, professional binary star experts and astrophysicists can glean much about the individual suns themselves—including even something of their internal structure! As for variable stars in general, observations of eclipsing binaries along with those of all other types should be submitted directly to the A.A.V.S.O. or similar organizations.

Extragalactic Supernova Patrol

There's nothing quite so thrilling to the seasoned deep-sky observer—those who thrive on seeking out "faint fuzzies"—like detecting a supernova explosion in a remote spiral galaxy!

Here again, automated professional surveys are now picking up most new extragalactic supernovae outbursts, but a few continue to be first detected by amateur astronomers employing backyard telescopes—both visually at the eyepiece and, increasingly, using astroimaging devices. This basically involves routinely comparing the normal appearance of a galaxy to the one being taken on a given night. Storing and comparing previous images on a computer make this process easier than ever before. Two outstanding examples of amateur supernova hunters are Rev. Robert Evans and Tim Puckett. The former has discovered more than 42 of them to date visually using his 10- and 16-in. reflectors—while the latter's Puckett Observatory Worldwide Supernova Search team of dedicated amateurs have discovered 271 as of the time of writing using imaging techniques on "backyard" telescopes! (Fig. 15.4).

Should you detect a star not previously seen visually or not present in your images, first check an Internet source like *Sky & Telescope* (www.skyandtelescope.com) and its alert service for any supernova already discovered in that galaxy. If none, a message should be sent electronically to the Central Bureau for Astronomical Telegrams at the site given above. Include such information as the

Fig. 15.4 Another example of amateur contributions to professional research—in this case, a supernova outburst in a neighboring spiral galaxy as shown in these before and after images that was first spotted by backyard observers Courtesy of NASA

designation and position of the galaxy, estimated magnitude of the star, equipment used, sky conditions, your contact information, and—ideally, an attached astrophoto or electronic image of your discovery!

Before closing, the recent rage known as "Citizen Science" should be mentioned. This involves not only amateur astronomers, but also just average citizens who are interested in contributing to our knowledge of the universe. The difference here from traditional amateur astronomy is that there is no actual observing of the sky. Rather it involves pouring over the absolutely enormous astronomical databases being generated by professional observatories and posted on the Internet—so much of it, in fact, that the pros are totally unable to research it all for discoveries. The result is that there have been frequent requests by professional astronomers for help from amateurs and the general public to mine this mass of data using home computers. Discoveries have not only been made this way, but when reported carry the names of the person making them as coauthors on published professional papers. Talk about pro-am collaborative research!

This concept may sound familiar to some readers, for there was a well-publicized earlier instance of citizen science. It was known as "Home SETI" in which radio astronomers searching for extraterrestrial signals from other civilizations sought the help of the public sifting through the enormous flood of data coming in from radio telescopes around the world. This involved a process in which the "idle or down time" of personal computers was automatically used by the SETI Institute to help in processing this massive database, again using the Internet. At its peak, more than 2,000,000 people had signed up to participate in the program!