Photometry for Amateurs Using iTelescopes

By Gord Tulloch (AAVSO:TGR)

Most amateur astronomers who get into astrophotography are focused on pretty pictures – imaging the majesty of the universe and bagging those faint objects that truly test your skills and equipment. But more and more the images that used to be incredibly onerous to take are becoming a matter of goto target, expose some form of CCD, process on a computer and viola an image that would have made someone on the 200" at Palomar faint in 1950. So where is the challenge now?

Amateurs have a role to play in the advancement of the science of astronomy. More and more data being used by professional astronomers are generated by amateurs on small telescopes. More and more Pro-Am collaborations are resulting in ground breaking papers on a variety of subjects.

The American Association of Variable Star Observers (AAVSO aavso.org) has been in this space for a long time. The AAVSO membership has been monitoring variable stars since 1911 and has data dating back to the 1800's. Right now, the AAVSO has about 1,400 members and observers from 52 countries contributing over a million observations per year. But whats a variable star and why do we care?

Variable stars are stars that change measurably in brightness over time. Even though stars appear to remain static they are often in fact varying in brightness quite substantially. In fact it's thought that most stars vary in brightness in some way, even our own Sun. And, as is often the case, astronomers have discovered ways to explore the innermost workings of these stars by analyzing their light (spectroscopy) and how it varies in intensity over time (photometry).

Photometry can be done with the naked eye, or with photometers that measure the intensity of light through a slit, but a lot of photometry these days are done using CCD cameras. Rather than measuring the light of the star directly, the stars are compared to other stars of known brightness to arrive at an estimate of the brightness of a star. This is known as differential photometry.

Photometry with roboscopes works really well for me since I 1. Don't like the cold 2. Don't like mosquitos 3. Don't like staying up late and 4. Don't see very well in the dark any more. So taking pictures with a roboscope that someone else maintains and has paid big bucks for at a low monthly cost makes staying involved in the science of astronomy ridiculously easy. I can usually process images while I eat my lunch at work! Since iTelescopes are also available in Spain and Australia, daytime observing is also possible.

AG Draconis Artist Impression – M. Garlick/University of Earwick/ESO

I've thus been happily engaged in a program of observing variable stars, with my current target being AG Draconis. This is a symbiotic binary star consisting of an orange-red star, along with a white dwarf, both of which revolve around a centre of gravity every 550 days. The transfer of material from the larger companion to the smaller causes periodic novae outbursts once every 15 years which last about 3-6 years. A reason to watch AG Dra right now is it's in an active stage and doing interesting things[1]!

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[1] "Recent outburst activity of the super-soft X-ray binary AG Draconis" - https://arxiv.org/pdf/1710.04831.pdf

So AAVSO put out a request for observations [2]of AG Dra in Apr 2017 requesting daily observations in a variety of wavelengths. Since I'm still perfecting my process and it's an easy target, it seemed a good candidate for an observing program.

iT-005
Takahashi Epsilon 250mm
SBIG ST10XME
Science/Imaging

Using an iTelescope in New Mexico (see left) I set up observing runs to take pictures of AG Dra using a monochrome CCD camera and several photometric filters. The reason for using a monochrome camera and filters is that you image the star in known wavelengths. Unlike the normal Red Green Blue and Luminance filters used to take astrophotos, photometric filters are UBVRI or Ultraviolet, Blue, Visual, Red, and Infrared wavelengths. Measuring the brightness of a variable in these wavelengths and how that brightness varies provides astronomers with a lot of information about the characteristics of the star or system. As well keeping these stars under observation allows amateurs to alert professional astronomers with high precision instruments that something is going on with the object so they can have a closer look.

So how does one make a photometric measurement?

The first phase is much the same as taking pretty pictures – a telescope on a very stable mount is pointed at the star and an exposure is made. The iTelescope system incorporates equipment and a software environment (see below) that would be a massive investment for an amateur but essentially rents it to me on an hourly basis for a low monthly purchase of usage points.
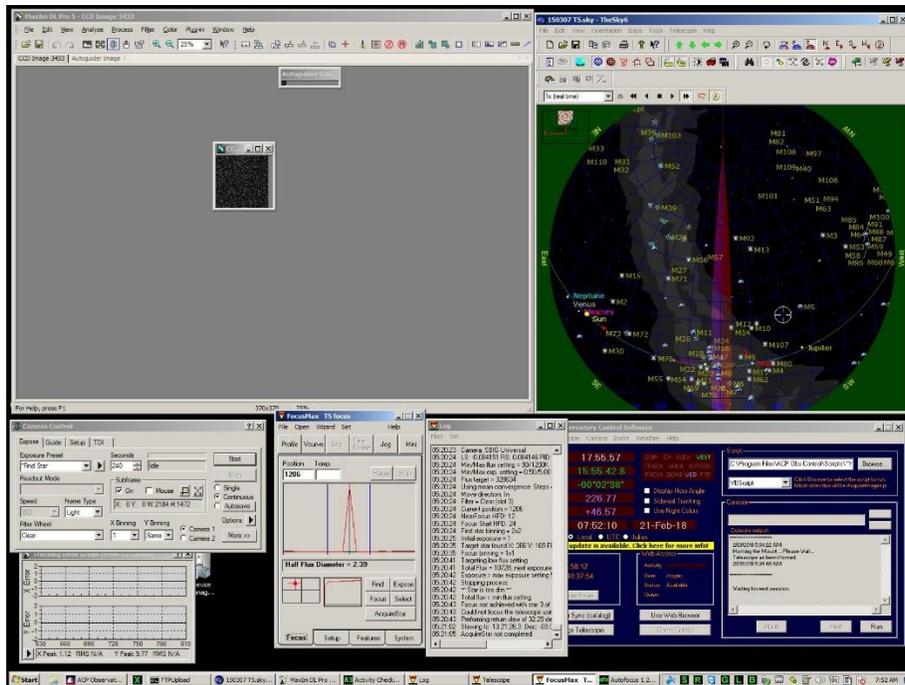

iTelescope 005 Desktop image

[2] "Alert Notice 572: AG Dra monitoring requested" - https://www.aavso.org/aavso-alert-notice-572

A simple to use web interface allows users to simply and easily execute the mechanics of pointing the scope and making the shot, and also automates calibration functions to remove bias, flats, and darks from the image, resulting in a perfectly calibrated image to do science with. In addition the image is plate solved so the actual RA and Dec for the image is embedded in the FITS format file (a dedicated format for astronomy that includes both image and meta data) to facilitate analysis.

Using the ACP software that runs the iTelescope can be done manually, but I generally simply make an appointment that executes a specific script for the imaging I want to do. My script for AG Dra is as follows:

```
#vphot
#defocus
#count 4,4,4
#interval 30,30,30
#binning 1,1,1
#filter V,B,I
AGDra     16.028055555555557 66.80277777777778
```

This script tells ACP to take 4 images of 30s each at 1 binning using a V filter, a B filter, and an I filter. The image is slightly defocused which is helpful in analyzing photometric data. Once imaging is complete the images are copied directly to my account on the AAVSO VPHOT photometry web application, normally by 9am the next morning. I can schedule multiple observing sessions throughout the week through a spiffy reservation system (see below). Each session takes 15 minutes to run and is about 5 minutes of actual imaging time, so the cost (at my current lowest discount level) is $5/session[3].

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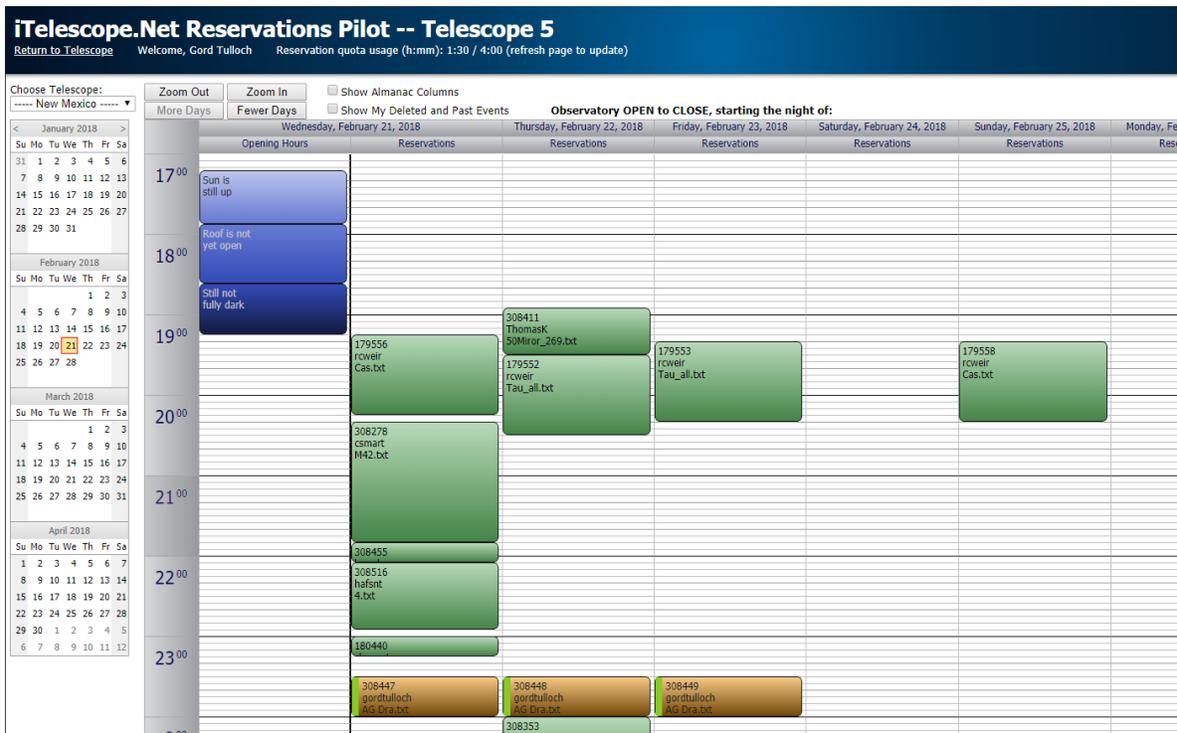
[3] Costs for iTelescopes are in points that at the lowest discount levels (not counting membership level and moon phase discounts) is essentially $1US per imaging minute at my Starter-Trial level. Plans that buy 40,60, 90, 160 etc. points for $1USD/point offer steeper discounts on imaging minutes. Education plans are available.

The next day I log into VPHOT via the AAVSO site and can see my images loaded. From VPHOT I can stack the images to increase signal to noise ratio - hence the multiple exposures. I'm experimenting to see what SN ratio is most cost effective – 10 images gave me extremely low SN ratios but cost a lot! I can then load the images into an analysis page to see what I ended up with. VPHOT is really nice in that it has functions to identify the variable star in the field and also comparison stars with a mouse click.
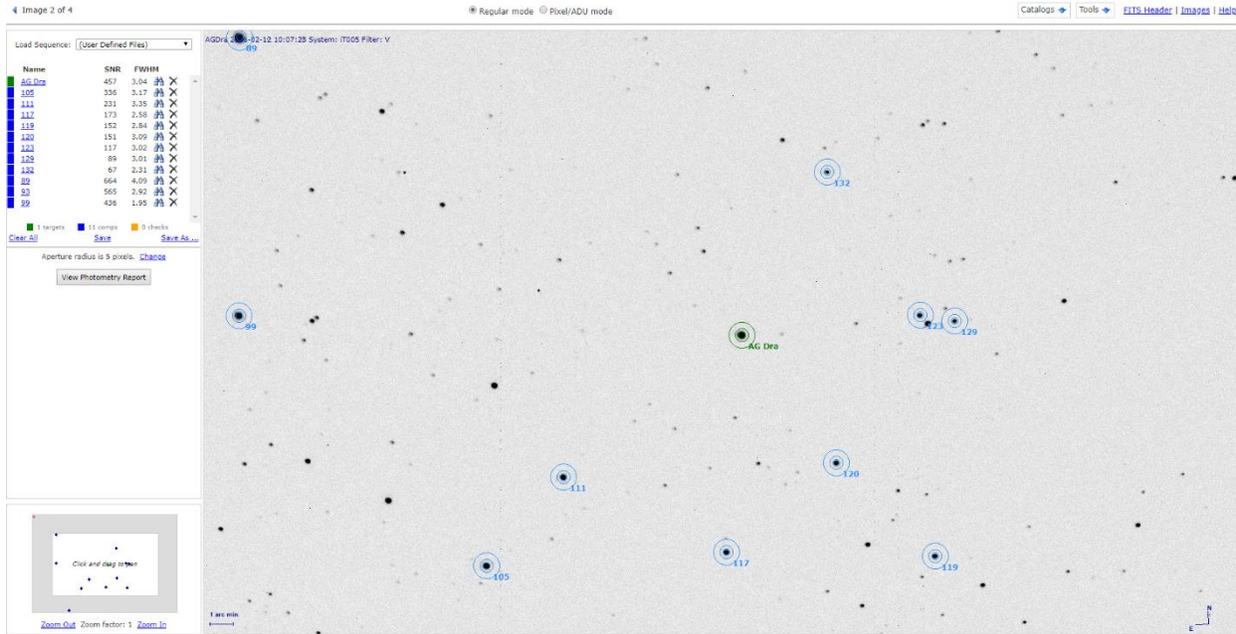
This screen gives you the image taken with comparison stars. Each star is surrounded by an aperture which contains the star in question as well as a comparison of the background sky in an annulus circle. Comparing the apparent flux of the variable star against comparison stars carefully selected for best seeing (measured by the FWHM measure) and Signal to Noise ratio allows me to get a pretty accurate magnitude estimate for the star. Once I have the magnitude estimate I can dump the information out into a text file like the following:

```
#TYPE=EXTENDED
#OBSCODE=TGR
#SOFTWARE=VPhot 3.1
#DELIM=,
#DATE=JD
#OBSTYPE=CCD
#NAME,DATE,MAG,MERR,FILT,TRANS,MTYPE,CNAME,CMAG,KNAME,KMAG,AMASS,GROUP,CHART,NOTES
AG Dra,2458161.92834,11.036,0.005,B,NO,STD,ENSEMBLE,na,117,12.302,1.3969,na,X22691LM,na
```

You can see from this file my AAVSO observer code TGR (rawr!) is submitting VPHOT 3.1 produced data for AG Dra for Julien date 2458161 etc. with a B filter of mag 11.036 +- 0.005 magnitude.
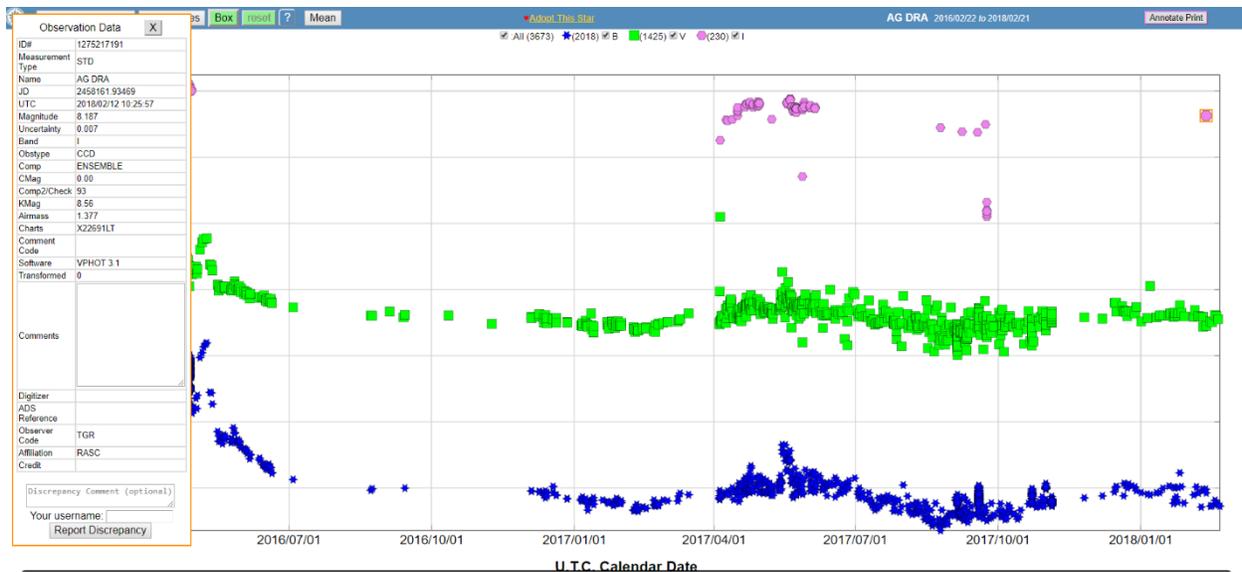
The end result is an addition to the light curve for the star which is distinctive and can be analyzed to determine what is happening with the star.

In this plot for AG Dra you can see that few data points are available in Infrared so more observations have value (including my observation at top right) whereas lots of observers are contributing Visual and Blue wavelength observations.

Photometry is an interesting and rewarding activity that allows you to make a positive contribution to the science of astronomy while having fun learning about new objects in the sky, and actually taking measurements of them. While you can use just about any telescope and camera to take photometric images, the iTelescope system makes it easy for anyone to engage in the science without a huge outlay in time and cost of equipment. The cost is not inconsiderable however – running my script every night would cost $150 per month! But running an occasional campaign and letting points accumulate even on on a $19.95/mo plan makes it quite affordable, especially if like me you tend to have long breaks between spurts of activity.

On other fronts I've been experimenting with iTelescope T17 in Australia, which has a Staranalyzer 200 in it's custom filter slot. T17 is a 0.43m Planewave CDK on a Paramount with a a FLI ProLine E2V CCD47-10-1-109 CCD camera that has 'extended red sensitivity' when compared to standard CCD's. This gives the scope almost a near infrared mission profile. T17 holds multiple world record achievements for the most distant objects imaged by amateur astronomers.

This large aperture scope combined with the Staranalyzer 200 spectroscopic diffraction grating filter should enable reasonable resolution spectra to be obtained from my target variables. I've used a Staranalyzer 100 on my scope years ago so this is an exciting option on really high end equipment with flawless pointing accuracy that will do a good job. The cost is a bit steep at 136 points per imaging hour (versus T5 at 34) but for occasional spectra that's not a huge drawback.

Another interesting science activity that is not well suited to iTelescopes is observing exoplanet transits. Since the transit is often 4-6 hours in duration it would get pretty expensive to observe! The AAVSO actually also has roboscopes available for members to use for observing programs like transits, but you need to apply for the time and provide a complete project outline so it's not nearly as convenient as iTelescopes. However since transits are relatively compact events that are well suited to this kind of activity, and I just finished taking an AAVSO course on observing exoplanet transits, I'm anxious to tick this activity off on my astronomy bucket list. No doubt I'll write about it!

However I'd encourage you to get your feet wet with photometry either using an iTelescope or start out with your own telescope and a photometric V filter (about $50US).   If you need some help happy to chat at a meeting or email me at gord.tulloch@gmail.com. Clear skies!