Development of DSLR Photometry as an Example of a Citizen Sky Team

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Abstract

One of the primary goals of the Citizen Sky project is to foster the development of Teams of every-day people with an interest in astronomy. These groups are composed of people with different, yet complementary skill sets who work together towards a common goal. Each team has a team leader and a professional astronomer assigned to act as an advisor. Here we highlight the work of one particular team who has produced documentation and software to teach first-time observers how to use consumer-grade digital cameras to produce accurate photometric magnitudes. We present a short history, the completed products, and lessons learned from this team.

Why Teams?

Most citizen science projects involve volunteers in the data collection process. Yet, science education research shows that people learn best when they are collaboratively involved in the entire scientific process. Citizen Sky (CS) is setup to do just that. Participants are organized into teams with a goal to produce a professional product. In most cases this will be a scientific paper submitted to a 2011 issue of a peer-reviewed journal dedicated to CS projects. But in other cases it can be products that address other aspects of the scientific method such as background investigation, dissemination of results, etc.

The training and coordination needed for this stage of the Citizen Sky project was kicked off in September at the 2nd Citizen Sky Workshop held at the California Academy of Sciences where a 3-day workshop on data analysis and scientific paper writing was held. Video of this workshop, along with other tutorials written by CS staff, is available at the CS web site, `http://www.citizensky.org`.

History

The DSLR Documentation and Reduction team was formed by CS staff member Brian Kloppenborg in late 2009 with the goal of creating an easy-to-use set of tutorials defining the use of Digitial Single Lens Reflex (DSLR, or similar RAW) cameras for astronomical photometry. Additionally, the team wished to create guidelines on how one can characterize the photometric properties, and determine how to get the best results from a DSLR camera.

Shortly after it's creation, the team grew to be the largest team on the CS website with over 60 members. About 10 key members pushed the first set of tutorials for the CS website to completion in Feb. 2010. The tutorials have recently undergone a significant number of revisions to help with the readability and clarify steps that troubled our participants.

Using a DSLR for Photometry

In it's simplest form photometry answers the question "how bright is it." Amateur astronomers either estimate the brightness of stars visually, with dedicated photometers, or with CCD cameras. A DSLR camera is very similar to a CCD in that it converts photons from stars into a digital signal which is interpreted by a computer. If the image data is stored in RAW pixel format (i.e. not a compressed JPEG file), one can easily get at the count values which tell us something about the brightness of the star.

The DSLR Documentation and Reduction team has produced several documents to teach a first-time observer how to use their camera to extract photometric magnitudes from their photos. We have found that one only needs a few simple things:

- **A Camera**. Although our team title has "DSLR" in it, any camera that can produce images in a RAW format, has a wide enough field of view, and has semi-manual focus and exposure control will do.
- **Something to hold your camera steady**. A photo tripod will do.
- **A photometric analysis software package**. Our tutorials describe three whose price ranges from free to a few hundred dollars.
- **A computer capable of running the software**
- **An unobstructed view** of your target star and at least three "standard" comparison stars.

A typical DSLR photometer. Image Credit: Tom Pearson

Cameras: A Tool for Classroom Astrophysics

The prevalence of modern imaging technology makes it possible to use cameras as astrophysics investigation tools. Using a DSLR or similar camera your students can explore:

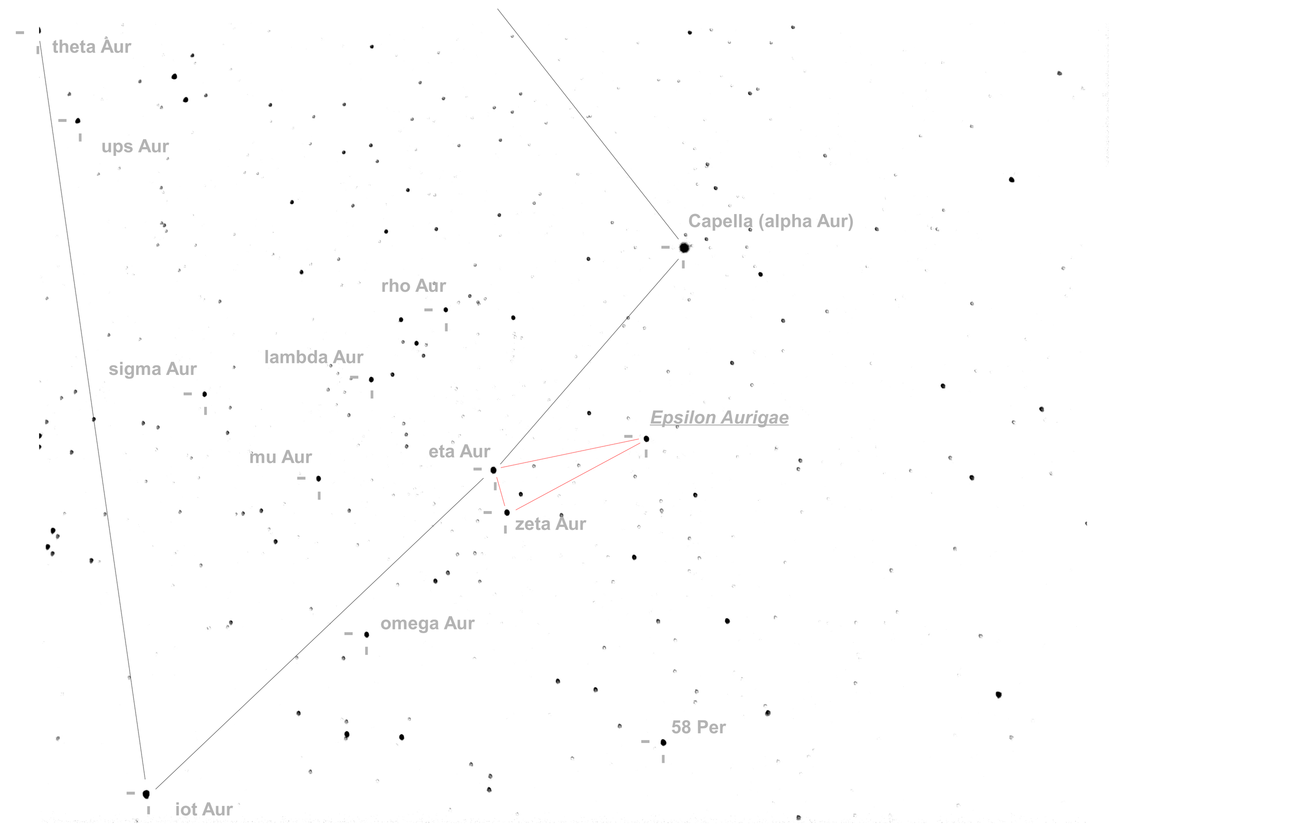
- **Variable Stars:** Using the aforementioned tutorials your students can determine important physical properties of the stars.
- **Rotation of the Earth:** Star trails at their finest. With just one 60-second exposure your students can identify the location of the Celestial Poles. This simple experiment also shows the motion of the stars as a function of latitude.
- **Motion of the Planets:** Over an entire quarter/semester your students can measure the motion of planets against the background stars.
- **Phases of the Moon:** Students can record nightly moon shape, possibly with background stars to document motion
- **Constellations:** By imaging several constellations, your students can "discover" the Zodiac and relate these to sun signs, star names and maps.
- **Messier objects:** Bright fixed non-comets cataloged by Charles Messier were a nuisance to him but a chance for students with camera to tour the universe.
- **Solar Sunset Motion:** Students can record the changing azimuth of sunset night to night, month to month.

If you are interested in developing labs or curriculum involving DSLR-like cameras, please contact us.

Completed Products

The DSLR Documentation and Reduction Team has completed three primary products: high quality sample data sets, tutorials for using three different photometric reduction programs, and a spreadsheet for reducing data into calibrated photometric magnitudes. Below we highlight features of these products:

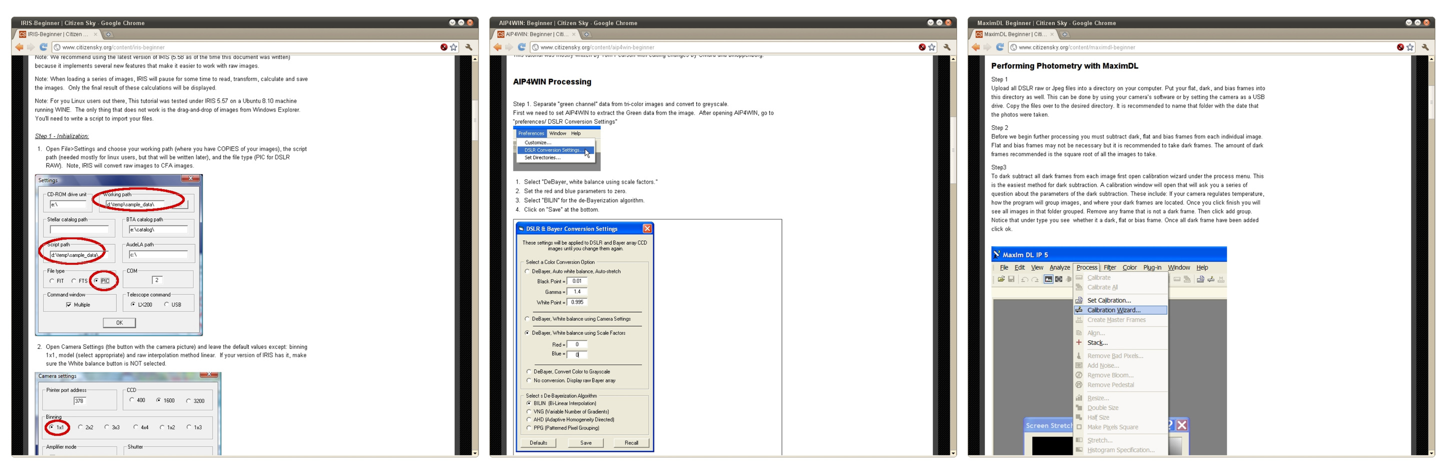
Data Sets



A sample DSLR field of view (colors inverted) showing a section of the constellation Auriga, ϵ Aurigae, and 12 comparision stars. Graphic by team member Heinz-Bernd Eggenstein

Early on we realized that a frequent source of frustration for first-time DSLR photometrists would be poor data quality. With this in mind, we included a sample set of high-quality, low air mass data which could yield 10 milli-mag precision (if calibrated properly) along with our first tutorial release. This data includes dark, flat, and sky frames and permits a first-time user to learn the reduction steps without the frustration of bad data. In our second release we included a set of high air mass data with similar precision.

Photometric Reduction Tutorials



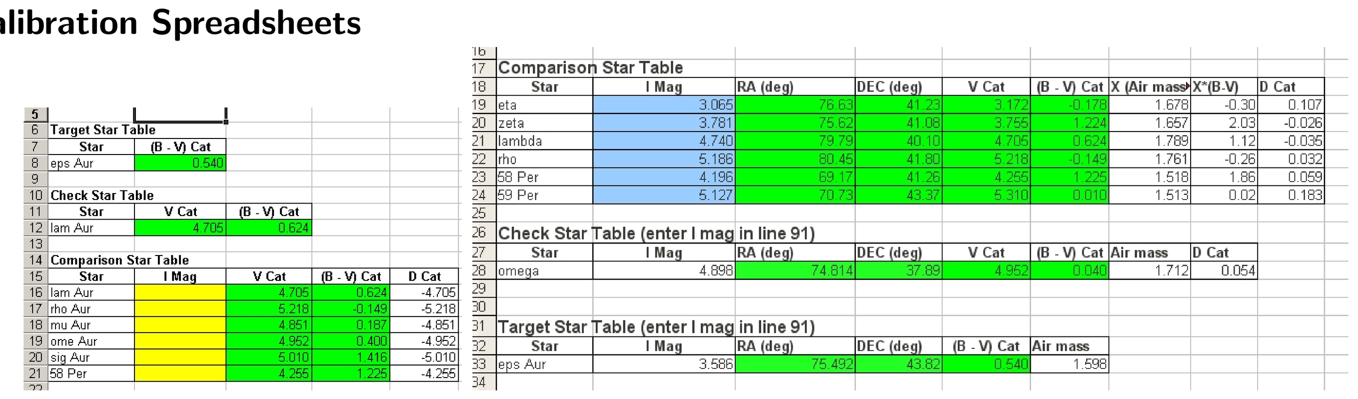
(a) IRIS (b) AIP4WIN (c) MaximDL

Screenshots of our three main tutorials primarily written by DSLR Documentation and Reduction Team members, Grigoris Maravelias, Roger Pieri, Heinz-Bernd Eggenstein, Tom Pearson, and Nick Long. Visit `http://www.citizensky.org/content/starting-analysis` for more information

The first step in the data reduction process is to extract instrumental magnitudes from the RAW camera frames. To do this, our participants would need easy-to-follow instructions for one of several photometric software packages. We elected to write tutorials for three popular programs (IRIS, AIP4WIN, and MaximDL) which range in price from free to a few hundred dollars and run on multiple operating systems. After the tutorials were written, our team "newbies" tested and revised the text to clarify hard-to-follow steps.

We have organized the tutorials into three groups: Beginner, Intermediate, and Advanced. The Beginner level presents the bare-minimum information to produce calibrated photometric magnitudes. The Intermediate level explains why specific steps are required and elaborates on common errors encountered in the reduction process. The Advanced tutorials (presently being written) presents the theory behind the reduction process and introduces the participant to full uncertainty analysis. It is our hope that the participants using the Advanced tutorials will attempt to write their own reduction software based upon the theory we present.

Calibration Spreadsheets



(d) Beginner Spreadsheet (e) Intermedate Spreadsheet

After one has instrumental magnitudes, one needs to calibrate their data. This process can be very complicated, but we have reduced it to be as simple as filling in a few blanks. There are two versions of the spreadsheet. The simplest version is meant to be used on stars that are within 30 degrees of the zenith whereas the more complicated version can be used to within 20 degrees of the horizon. With good data, photometric precisions of 0.01 mag can be achieved.

Acknowledgements

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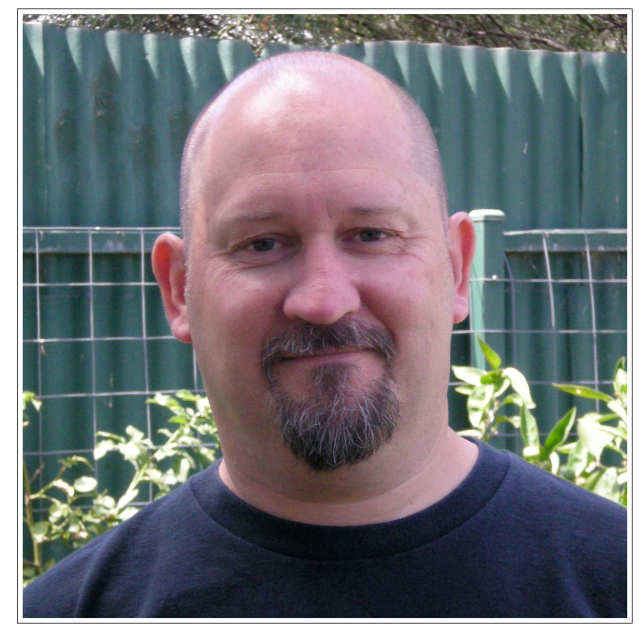
Leading a Team

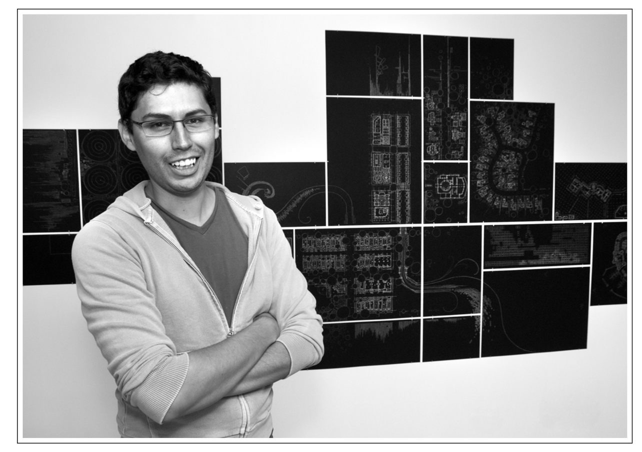
Leading a team of citizen scientists is no easy task. A typical team will have a few very active members who are well versed in the tasks at hand and need little help to complete the them, members who are completely new to the project, and many seldom active members who wish to contribute but need guidance. To further complicate the issue, the talents of individuals are very heterogeneous, some have families, some have demanding jobs, and even others are retired.

We have asked several team leaders to discuss the lessons learned from running their teams. Their replies are below:



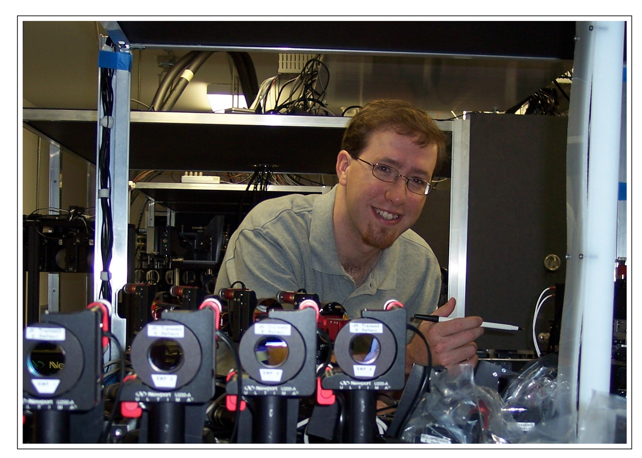
David Benn,
VStar Software Development Team Leader
"Understand your strengths and limitations and defer to the people in your team with knowledge and experience you lack. In my case, software development, motivation, hunger for knowledge, and passion are my strengths, while domain knowledge of variable stars and the analysis thereof is something I've had to learn about."

Joan Chamberlin,
Southern Gems Team Leader
"It's important to remember that citizen scientists have families and jobs that can often slow down progress if the person who is needed for a task can't help for a while. In retrospect, I would try to find two people for each job, in case one was occupied for a long time with personal matters. Long spells of inactivity on the team page can dampen enthusisam and the team can lose momentum."



Nico Camargo,
Aesthetic Solutions Team Leader
"In order to have a successful team it is key to have a clear mission, and reachable goals. Making sure your teammates get involved is also very important because members will gain and potentially get inspired from each other's work and enthusiasm."

Chris Stephan,
20/20 Vision Team Leader
"I am a 25 year veteran science teacher for middle school grades. Leading the 20/20 Vision Team has reminded my of some of my most successful experiences in teaching. A handful of these team members have been turned on to a new hobby. They are actually making observations of variable stars and submitting them for use by professional astronomers. It's like passing on a passion of mine. I am excited to no end. A science teacher couldn't ask for more."



Brian Kloppenborg,
DSLR Doc. and Reduction Team Leader
"Unlike a leader in a typical CS team, I'm both the leader and the professional liaison. Serving both roles while working on my Ph.D. has been quite challenging. I think it is because of this that my team remains dormant for long periods of time and then suddenly springs back into action to accomplish tasks. Yet even with this factor, we continue to be one of the most productive teams. I think this comes from a simple, well-defined objective coupled with a mix of highly skilled and first-time participants. This way the former can write documentation while the latter can test, learn, and ask questions."

A General Consensus

Leading a team is not necessarily an easy task and starting a team can seem daunting. If you are considering starting and leading a team, consider the following guidelines:

- Have clearly defined, reachable goals
- If your end product is lofty, create smaller obtainable objectives
- Learn your team members strengths and weaknesses
- Beginners are very important. At the very least, they make your end product more clear.
- The draft copy of a document often comes quickly, revisions will likely take much longer
- Keep in mind that your team will encounter periods of frustration and emotions may run high. Remind your team that they are working towards a common goal and that everyone is needed to succeed.

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