Observational Astronomy Syllabus

- Brian Hill home page

Daily Schedule

- A detailed daily schedule is being kept retrospectively (and is attached)

Meeting Schedule

- Tuesdays we meet at the regular class time (11:00-12:25)
- Evening meeting times (block off both, we will only use one each week): Wednesday or Saturday, 8:00-11:00pm

Grading

The course was graded 60% on assignments, 10% on class participation, and 30% on active participation during the lengthy observing sessions. Late assignments (up to 72 hours) received half credit.

References

I will assemble the materials. No textbook is required. This page lists the references I will be drawing from (and is attached).

Goals

- We will start with the celestial coordinate system and the magnitude system
- In our night labs, we will start with manual operation of a German Equatorial telescope
- In subsequent labs, we will learn computer operation of the telescope
- We will do some astrophotography before transitioning to scientific work
- We will obtain our own data for eclipsing binary and exoplanet targets
- You will learn how to process the data into light curves

References

This is a listing of books and apps that are relevant for this course. I will be compiling and distributing handouts so you don't have to aquire any of them.

Very Introductory

For an elementary introduction to the things we will be covering in the first two weeks, pp. 1-22 of the Edmund Sky Guide. It is out-of-print and hard to get.

A nice book that is also out-of-print but is actually available inexpensively is Neale Howard's The Telescope Handbook and Star Atlas. However, it is probably a larger and heavier book than you want to have on your shelf for the rest of your life.

Turn Left at Orion by Guy Consolmagno is very popular. For visual observing with a telescope, it is probably the one best choice. When I picked the Beehive cluster and Tegmine (Zeta Cancri) as our second night's targets, I used *Turn Left at Orion*. When I picked prominent galaxies in Leo and Virgo for our third night's targets, I again used this book.

More Advanced

The only good textbook I am aware of for the scientific work we want to get to is Brian D. Warner, A Practical Guide to Lightcurve Photometry and Analysis, 2nd Edition, 2016.

Exoplanet Observing for Amateurs by Bruce L. Gary is great but a little too specialized. The author has made it available for free after the publisher went out of business.

A Practical Guide to Exoplanet Observing by Dennis Conti covers much the same material with a focus on AstroImageJ for data processing. Despite the fact that it doesn't disentangle the theory of what is going on from the specifics of AstroImageJ as clearly as I would like, overall it is the best choice for learning differential photometry. Also, I have used Dennis's materials three times when teaching other AAVSO astronomers differential photometry, and so I know that it can be a super-effective jump-start straight into the current methods used for variable star observation.

I will spend most of a class explaining the theory behind astronomical image processing. Then in the following two classes we will use AstroImageJ to process Dennis's 336-image dataset for Wasp-12b.

Star Charts and Apps

Most of the introductory books contain star charts. The best starter for a book of charts for someone working at a telescope and doing visual observing is the oxymoronically-titled Pocket Sky Atlas, Jumbo Edition. The paperback-sized "pocket" edition was very popular despite being awfully small for field use at night, so they came out with the "jumbo pocket" edition. Someone with more money and space might want to try to acquire a copy of the out-of-print Sky Atlas 2000.0, Deluxe Laminated Edition.

However, only purists use paper charts nowadays. Replacing them is a proliferation of apps that compute the positions of the stars anytime and anywhere.

A really nice, inexpensive, and simple app is Sky Guide. It is the one I use when I don't want to worry about any settings. I just turn it on and point. There is a free version for iOS. Some features are in-app purchases. Unfortunately Sky Guide is not available on other platforms. There is an app by the same name on Android. It is made by some other company and gets lousy reviews.

SkySafari 7 Plus is a nice choice for planning observations, especially if you have an iPad to run it on. I make a lot of use of Sky Safari 6 Pro which I run on a Mac laptop. SkySafari is capable of running the Gemini computer on the College's Losmandy mount. In the long-run that is what we want to have set up.

For this course, I have TheSkyX installed on my Mac laptop. You will get to see how that is used for computer control of the telescope. TheSkyX is capable of controlling all the other parts of the system (camera, filter wheel, auto-guider, and focuser), which is what makes it ideal for the differential photometry work we will be doing by the last few weeks of the course. It is too complex and expensive to have each of you install and use it. Once TheSkyX has acquired the images, we will transfer them to your computers for analysis.

Daily Schedule

Back to course home

Week 1 — Celestial Coordinates and Telescope Mount — Polar Alignment — Easy Visual Targets

- Tuesday, March 15: The daily and annual motion of the stars — The RA/DEC Coordinate System — The Magnitude System — Some high points of these topics
- First Reading for Wednesday: The Losmandy G11 User Manual
- Evening Meeting: Wednesday, March 16 at 9:30pm (moon phase almost full — very poor for seeing faint objects but good for working with equipment for the first time) — We will be getting hands-on experience with all the parts of the mount that you covered in the reading — The counterweight shaft, counterweights, and counterweight safety — The dovetail plate and the saddle — Balancing the scope in RA — Balancing the scope in DEC — Polar alignment with the polar finder scope — Adjusting the altitude and azimuth of the mount — Adjusting RA and DEC setting circles with a bright star — Star Chart for March 16 — Easy and spectacular visual targets: Orion Nebula, Pleiades

Week 2 — Key Properties of Telescope Optics — Push-To Operation with Setting Circles — Visual Observation of Open Clusters and Double Stars

- First Assignment due Tuesday, March 22: Star Charting
- Tuesday, March 22 — Correct and Augment Charting Assignment — Degrees, arc-minutes, arc-seconds — Handy Sky Measures — Types of Telescopes and Telescope Math — Focal Length — Pinhole Camera Focal Length — Telescope Focal Length — The f/ ratio — Meade LX200 — Eyepiece Focal Length — Magnification — Apparent Field of View — Finally, two properties of eyepieces we didn't have time to get to: Exit Pupil Diameter = focal length of eyepiece divided by f/ and (2) Exit Pupil vs. Eye Pupil (see Assignment 2)
- Evening Meeting: Wednesday (9:30-12:30) (dusk 7:33pm, moon phase 3rd quarter — great!) — Completed our work on using setting circles to find targets — Aligned on Sirius — Targetted the Beehive Cluster easily — Re-aligned on Sirius — Targetted Tegmine unsuccessfully (rats!) — Finder charts for Beehive and Tegmine

Week 3 — The Electromagnetic Spectrum, Diffraction and Interference — Go-To Operation with the Gemini-2 — Visual Observation of Galactic

Targets

- For Tuesday, March 29 Assignment 2 - Optics
- Tuesday, March 29 — Electromagnetic Spectrum — Metric Prefixes — Rule of Thumb for Resolution 120/A (A in mm, resolution in arc-seconds) — Fundamental Formula for Resolution 1.22 λ / A with λ = 550nm — Seeing — Essential Camera Properties: Pixels, Sensor Size — Camera Resolution in Arc-Seconds per Pixel — Bayer Mask — ASI 2600 MC Pro — Assignment 2 - Optics - Solution
- Evening Meeting: Wednesday or Saturday (dusk 7:40pm, moon phase new — great! — weather bad Wednesday and Saturday, but clearing on Sunday! — Traipsing Through the Virgo Galaxy Cluster — Royal Astronomical Society Finest NGC Checklist — Go-To Operation of the Losmandy G11G with the Gemini-2

Week 4 — Theory for CMOS Image Calibration — Astrophotography of a Galactic Target

- Third Assignment due Tuesday, April 5: Understanding Resolution, Diffraction, and Interference
- Tuesday, April 5 — Resolution, Diffraction, and Interference in the JWST (we watched from 1m15s to 3m30s in this video only) — Types of variable stars and transients (Cepheids, Lyrae, Eclipsing Binaries, Exoplanets, Supernovae, M Dwarfs) — The conversion of photons to electrons and the conversion of electrons to ADUs in a CMOS sensor — The meaning of the slope and y intercept in the graph of ADU counts as a function of the number of electrons — How darks, biases, and flats are used to calibrate lights — Aperture-annulus photometry — Comp stars, target stars, and differential photometry — Fitting light curves and examining residuals
- Evening Meeting: Wednesday (dusk 7:47pm, moon phase waxing crescent, almost first quarter — ok to poor) — We chose NGC 4565 "The Needle Galaxy" in Coma Berenices as our first target and I processed it with PixInsight — PixInsight is not an app you will be learning to use in this course — You will have enough to do learning AstroImageJ — My PixInsight procedure — Resulting NGC 4565 Image (not bad for our first work of the term!)

Week 5 — Start Analysis of WASP-12b with AstroImageJ — Obtaining Eclipsing Binary Data

- Assignment 4 for Tuesday, April 12: Refer to annotations in this Excerpt from Dennis's Conti's Practical Guide to Exoplanet Observing
- Tuesday, April 12 — Assignment 3 - Interference - Solution — Start Analysis of Transient

Targets Using AstroImageJ — Calibrate Lights, Darks, Flats and Biases using AstroImageJ — Inspect Images Using Virtual Stack — We are following my AIJ step-by-step directions

- Evening Meeting: Saturday (dusk 7:53pm, moon phase waxing gibbous, almost full — very poor) — We will choose a bright eclipsing binary from the April 2022 ephemeris or an RR Lyrae variable from the Wils, Lloyd, Bernhard RR Lyrae Catalog and get our first light curve — A specific possibility is the eclipsing binary W Ursae Majoris — Skyview W Ursae Majoris Finder Chart

Week 6 — Finish Analysis of WASP-12b with AstroImageJ — Obtaining Exoplanet Transit Data

- Assignment 5 for Tuesday, April 19: Follow my AIJ step-by-step directions up to and including the section titled "Plate-Solving Using Astrometry.net"
- Tuesday, April 19 — Finish Analysis of Transient Targets Using AstroImageJ — Generate Seeing Profile — Apply Multi-Aperture Measurement Method — Plot Results
- Final Evening Meeting: Saturday (dusk 8:00pm, moon phase waning gibbous, almost third quarter — great!) — We will do an exoplanet transit of WASP-14b collecting lights will go from 10pm to 2am, after which we will do flats, darks, and biases — ETD Ephemeris and Finder Chart for WASP-14b

Week 7 — Finish Light-Curve Analyses of Data Taken in Weeks 5 and 6

- Assignment 6 is a W UMa light curve due Thursday, April 28 at 6pm
- Tuesday, April 26 — What has been deduced about W UMa and WASP-14b — Used much of class time to continue the Analysis of W UMa data — My analysis of our WASP-14b data from night of 2022-04-2324 — Zayd's analysis of our W UMa data