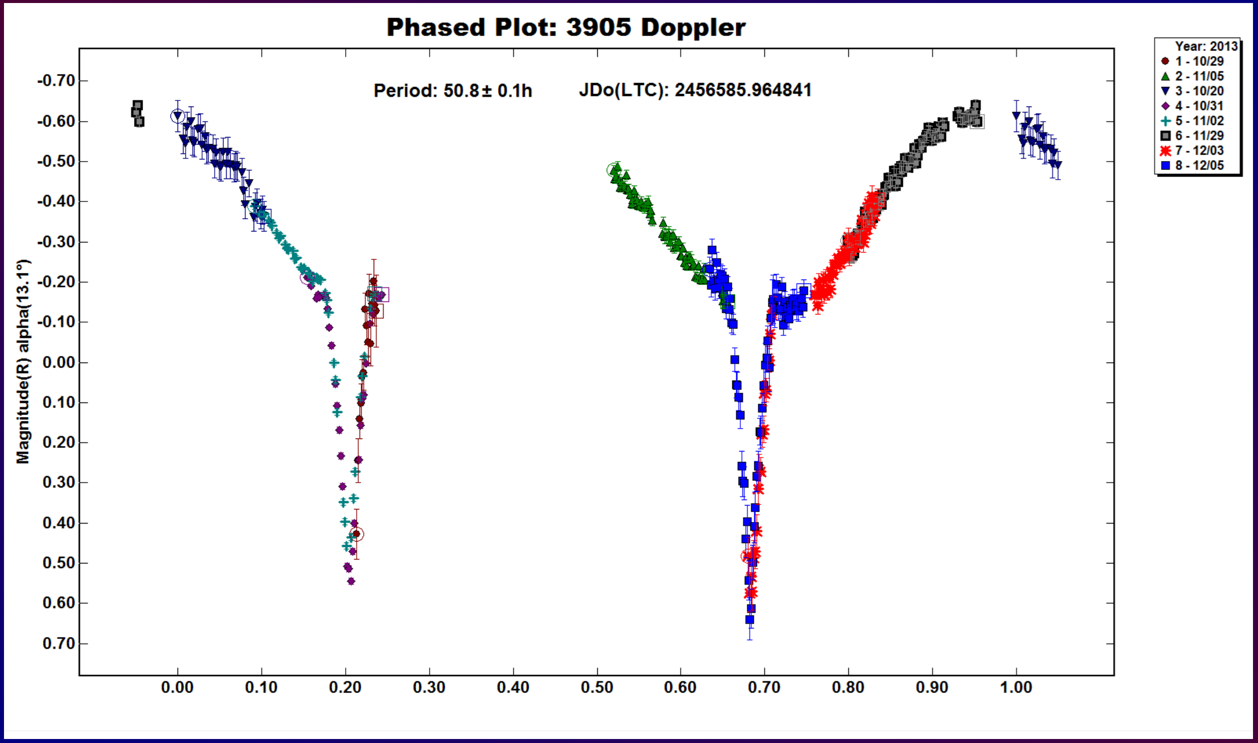
Introductory Course at UMD with Remote Observing - “Astronomy in Practice”



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Astronomy Dept., UMD

2016 GROWTH Education Workshop

Overarching Goal

Involve non-astronomy students in real astronomical research so that they develop a better understanding of how astronomy, and thus science overall, really works.

Talk Outline

- Course Opportunity and Target Student Population
- Educational Goals
- Course Organization and Structure
- Project Execution
- Results: Projects and Course Success

Course Opportunity and Target Student Population

- New “Scholarship in Practice” courses at UMD provided the opportunity to develop this course – our department wanted one because all students are required to take two.

- Asteroids are perfect target objects for student research since the required observations and analysis are straightforward, yet new results are possible because of >100,000 unstudied asteroids.

Course Opportunity and Target Student Population

Target student population:

- Non-astronomy major, may not be science major
- May have only algebra-level math
- May not have any astronomy background

Course Opportunity and Target Student Population

Example population from most recent course offering (46 students):

- Mostly sophomore/junior
- 33% URMs (including women)
- 25% female
- average GPA of class: 2.9
- 43% computer science, 13% undecided, 9% biology, 7% engineering
- Many are (or became) astronomy minors

Educational Goals

The course satisfies learning goals at multiple levels:

- Instructor's astronomical knowledge goals
- University's goals for Scholarship in Practice courses

Educational Goals: Instructor's Goals

Students will have:

- An understanding of our place in the solar system and how asteroids fit into the solar system.
- An understanding of how astronomers study asteroids.
- An understanding of the skills necessary to make astronomical observations.
- An understanding of how astronomical observations are analyzed to yield physical results.

Educational Goals: Scholarship in Practice Course Goals

The University's goals for these courses are for the student to:

- Demonstrate an ability to select, critically evaluate, and apply relevant areas of scholarship.
- Articulate the processes required to bring about a successful outcome from planning, modeling and preparing, to critiquing, revising and perfecting.
- Demonstrate an ability to collaborate in order to bring about a successful outcome.
- Produce an original analysis...that reflects a body of knowledge relevant to the course.

Educational Goals

The course project designed to accomplish all of these learning goals was for the students to:

- Choose an asteroid to observe
- Conduct the observations of the asteroid
- Reduce their data to differential magnitudes
- Analyze the differential magnitudes to find a rotation period for the asteroid
- Submit a paper on their results to the *Minor Planet Bulletin*

Course Organization and Structure

- Two 75-min lecture periods per week
- One 120-min lab per week (during the day)
- 16-week semester
- 48 students (24 in initial offering), split into two lab sections
- Students worked in teams of 4 throughout semester on nearly all aspects of course

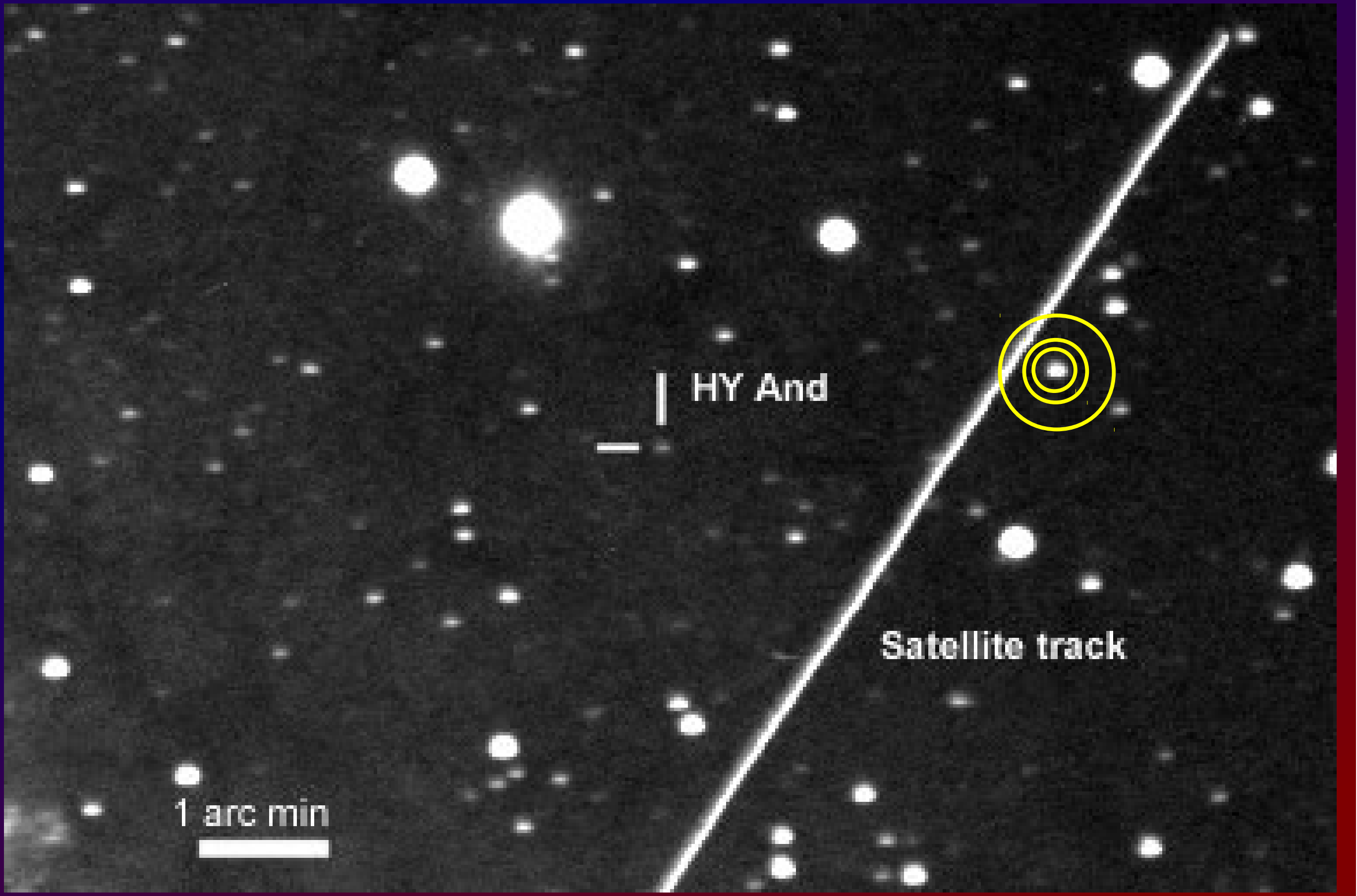
Course Organization and Structure

The course was taught in a “flipped” format. The daily structure for the students was as follows:

- Watch video before lecture
- Take quiz on material from video, before lecture
- In lecture, do active learning activities (usually in groups) to explore, reinforce, and test understanding.
- At the end of each lecture, write a 1-paragraph essay answering a problem related to the day's topic. Usually done individually, with critiquing and revision.

Certification 17: Oct. 27, 2015

An asteroid is in the target aperture below. Will this aperture photometry accurately measure the brightness of the asteroid on this image? If so, explain how. If not, explain why not, and how the asteroid's measured brightness would compare to its true brightness.



Course Organization and Structure

- No homework
- 2 midterm exams, 1 final exam
- 4 “status reports” on the project, with both written and oral components
- 1 final paper for submission to the *MPB*

Course Structure and Organization: Course Outline

The course material had to be presented to the students in time for them to be prepared for each stage of the project:

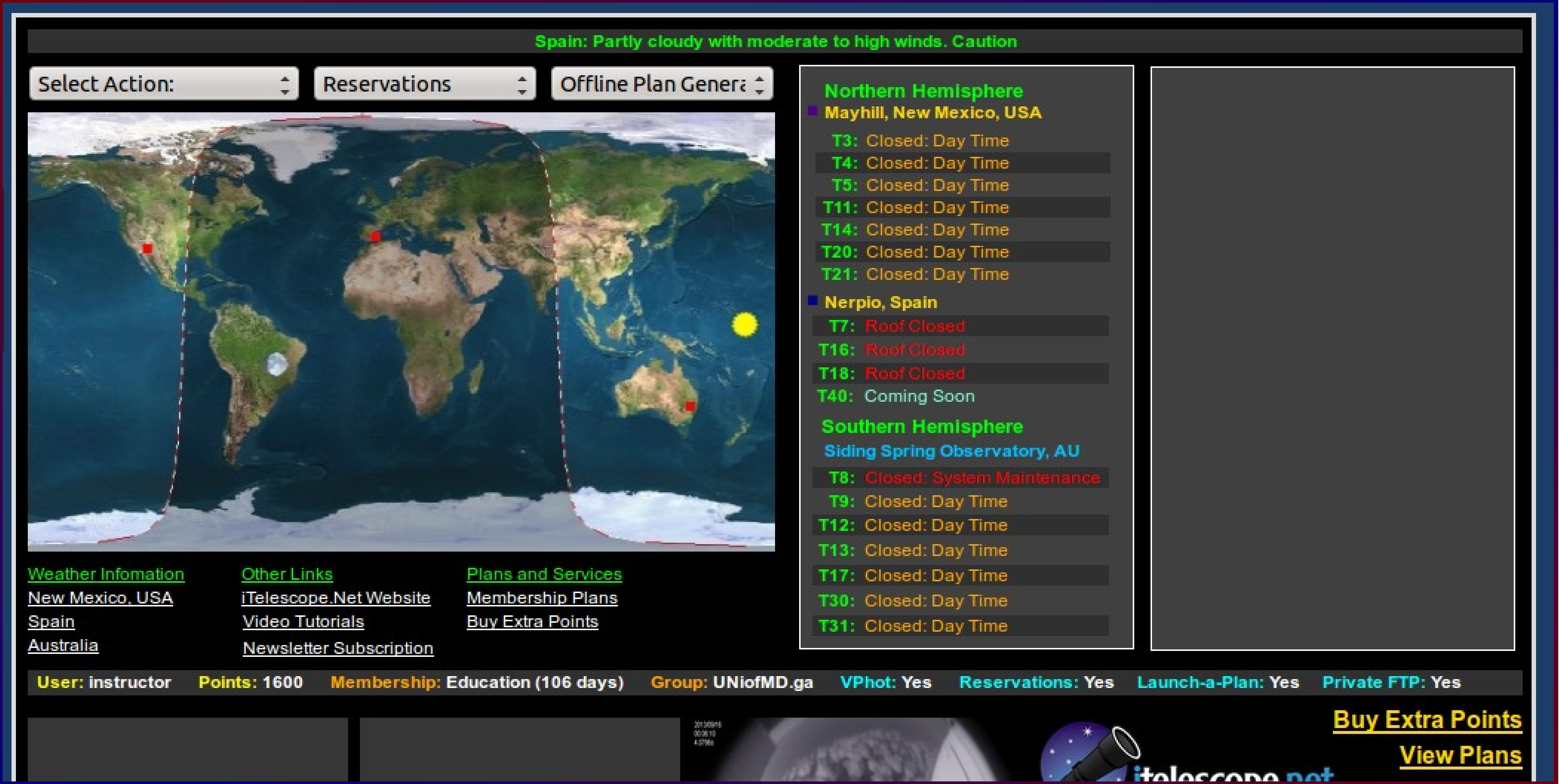
- Choose an asteroid to observe
- Conduct the observations of the asteroid
- Reduce their data to differential magnitudes
- Analyze the differential magnitudes to find a rotation period for the asteroid
- Submit a paper on their results to the *Minor Planet Bulletin*

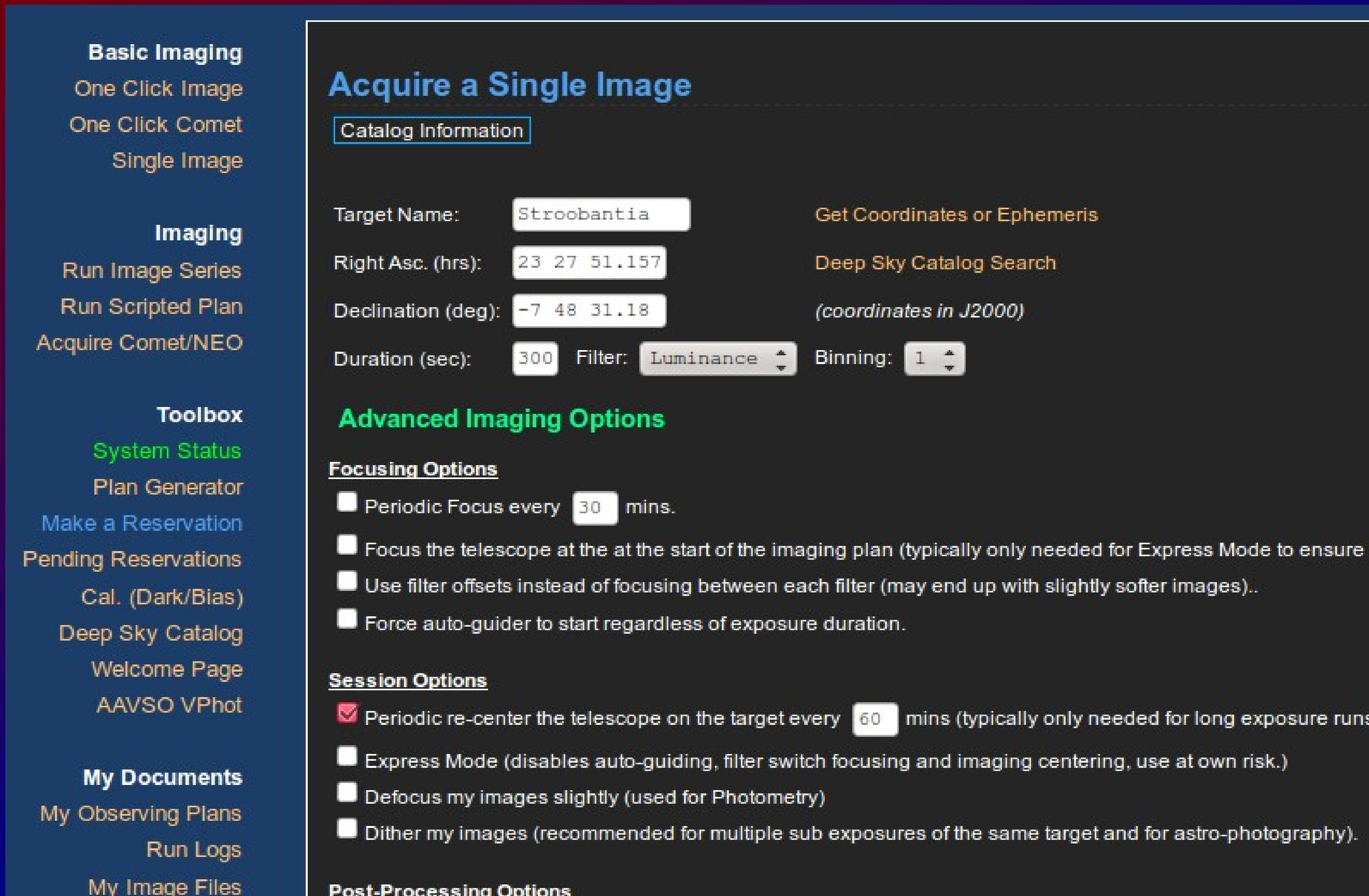
Course Structure and Organization: Course Outline

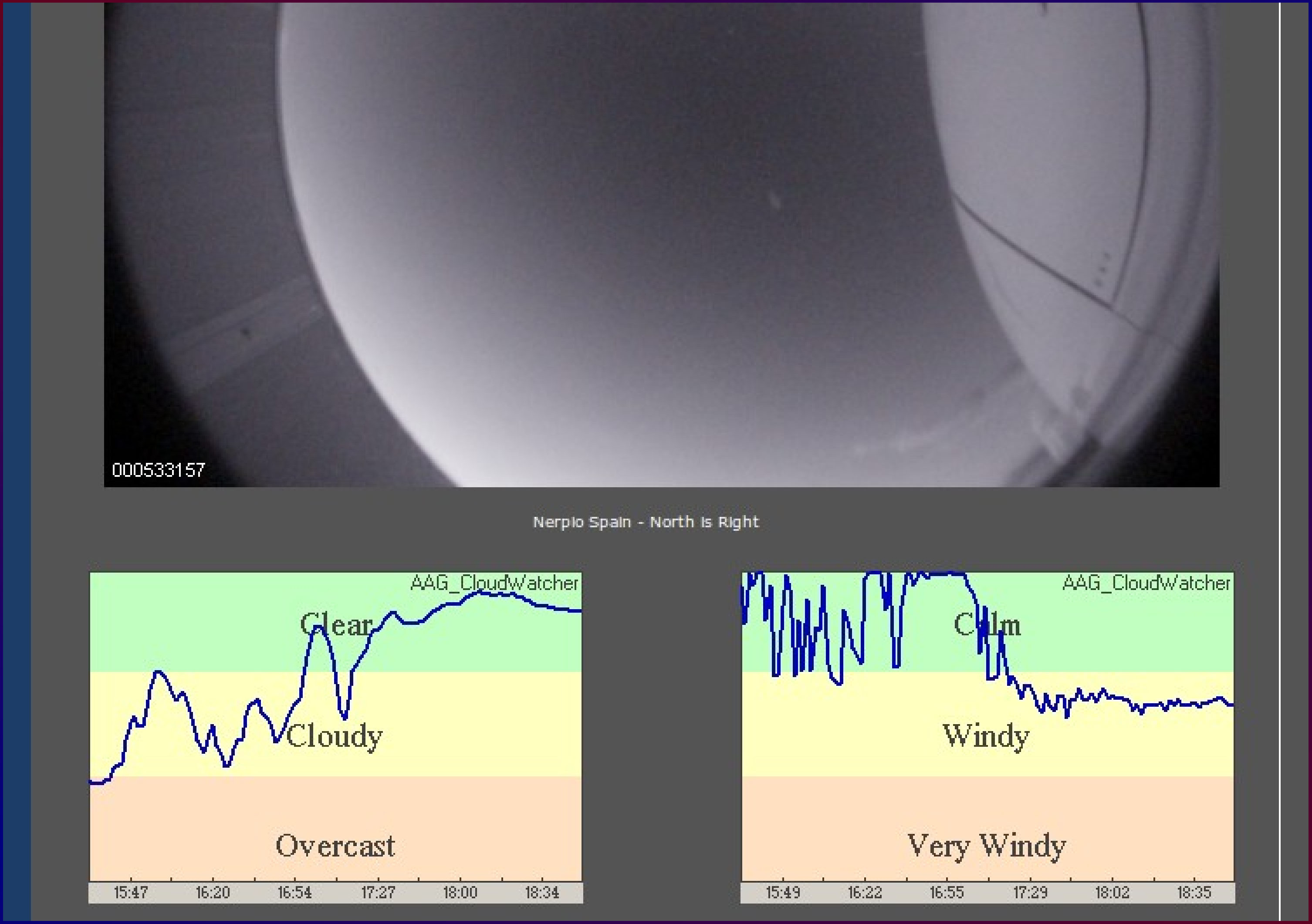
- Motivation: where asteroids are in the solar system and why it's scientifically valuable to study them
- Celestial coords, sidereal time, predicting asteroid visibility
- How telescopes and CCDs work and how to use them
- Typical asteroid characteristics
- Asteroid lightcurves and how to find rotation periods using them
- Photometry and magnitudes
- Gravity, orbits, formation of solar system

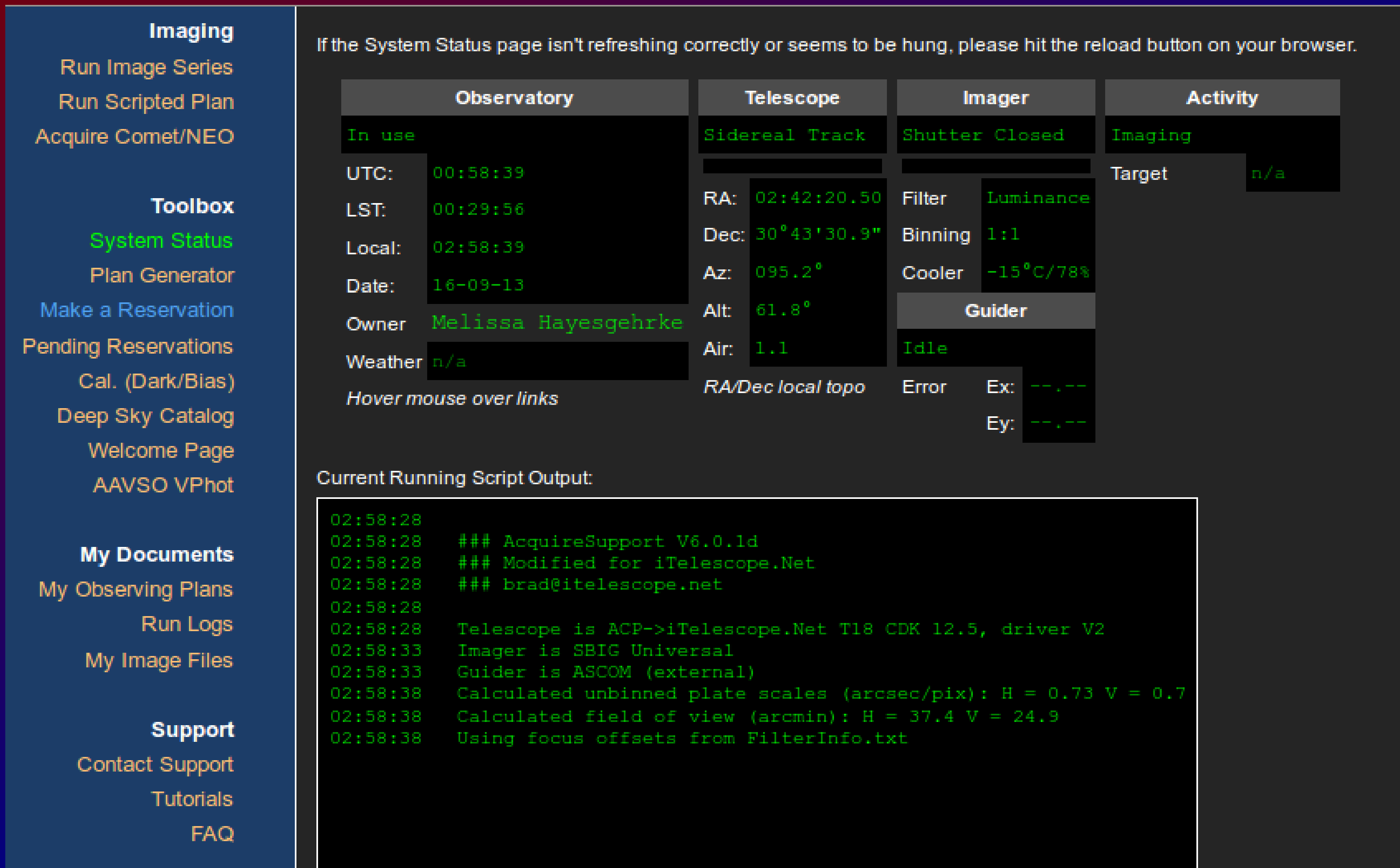
Project Execution: Remote Telescopes

- Observations made using iTelescope.net
- At education rate, cost approx. ~$1/min of exposure time ($1500 – 3000/semester)
- Two 17” CDK telescopes with ~8 Mpix CCD, ~30' x 45' FOV
- One in Spain, one in New Mexico
- Controlled remotely with GUI
- User specifies RA, DEC, filter, exposure time, binning
- Automatic weather shut-down and altitude limits
- Data processing pipeline applies dark and flat corrections


Spain: Partly cloudy with moderate to high winds. Caution
Select Action:
Reservations
Offline Plan Genera
Northern Hemisphere
Mayhill, New Mexico, USA
T3: Closed: Day Time
T4: Closed: Day Time
T5: Closed: Day Time
T11: Closed: Day Time
T14: Closed: Day Time
T20: Closed: Day Time
T21: Closed: Day Time
Nerpio, Spain
T7: Roof Closed
T16: Roof Closed
T18: Roof Closed
T40: Coming Soon
Southern Hemisphere
Siding Spring Observatory, AU
T8: Closed: System Maintenance
T9: Closed: Day Time
T12: Closed: Day Time
T13: Closed: Day Time
T17: Closed: Day Time
T30: Closed: Day Time
T31: Closed: Day Time
Weather Infomation
New Mexico, USA
Spain
Australia
Other Links
iTelescope.Net Website
Video Tutorials
Newsletter Subscription
Plans and Services
Membership Plans
Buy Extra Points
User: instructor Points: 1600 Membership: Education (106 days) Group: UNiofMD.ga VPhot: Yes Reservations: Yes Launch-a-Plan: Yes Private FTP: Yes
Buy Extra Points
View Plans


Basic Imaging
One Click Image
One Click Comet
Single Image
Imaging
Run Image Series
Run Scripted Plan
Acquire Comet/NEO
Toolbox
System Status
Plan Generator
Make a Reservation
Pending Reservations
Cal. (Dark/Bias)
Deep Sky Catalog
Welcome Page
AAVSO VPhot
My Documents
My Observing Plans
Run Logs
My Image Files
Acquire a Single Image
Catalog Information
Target Name: Stroobantia
Get Coordinates or Ephemeris
Right Asc. (hrs): 23 27 51.157
Deep Sky Catalog Search
Declination (deg): -7 48 31.18
(coordinates in J2000)
Duration (sec): 300 Filter: Luminance Binning: 1
Advanced Imaging Options
Focusing Options
Periodic Focus every 30 mins.
Focus the telescope at the at the start of the imaging plan (typically only needed for Express Mode to ensure ir
Use filter offsets instead of focusing between each filter (may end up with slightly softer images)..
Force auto-guider to start regardless of exposure duration.
Session Options
Periodic re-center the telescope on the target every 60 mins (typically only needed for long exposure runs,
Express Mode (disables auto-guiding, filter switch focusing and imaging centering, use at own risk.)
Defocus my images slightly (used for Photometry)
Dither my images (recommended for multiple sub exposures of the same target and for astro-photography).
Post-Processing Options


000533157
Nerpio Spain - North is Right
AAG_CloudWatcher
Clear
Cloudy
Overcast
15:47
16:20
16:54
17:27
18:00
18:34
AAG_CloudWatcher
Calm
Windy
Very Windy
15:49
16:22
16:55
17:29
18:02
18:35


Imaging
Run Image Series
Run Scripted Plan
Acquire Comet/NEO
Toolbox
System Status
Plan Generator
Make a Reservation
Pending Reservations
Cal. (Dark/Bias)
Deep Sky Catalog
Welcome Page
AAVSO VPhot
My Documents
My Observing Plans
Run Logs
My Image Files
Support
Contact Support
Tutorials
FAQ
If the System Status page isn't refreshing correctly or seems to be hung, please hit the reload button on your browser.
Observatory
In use
UTC: 00:58:39
LST: 00:29:56
Local: 02:58:39
Date: 16-09-13
Owner Melissa Hayesgehrke
Weather n/a
Hover mouse over links
Telescope
Sidereal Track
RA: 02:42:20.50
Dec: 30°43'30.9"
Az: 095.2°
Alt: 61.8°
Air: 1.1
RA/Dec local topo
Imager
Shutter Closed
Filter Luminance
Binning 1:1
Cooler -15°C/78%
Guider
Idle
Error Ex: --.--
Ey: --.--
Activity
Imaging
Target n/a
Current Running Script Output:
02:58:28
02:58:28 ### AcquireSupport V6.0.1d
02:58:28 ### Modified for iTelescope.Net
02:58:28 ### brad@itelescope.net
02:58:28
02:58:28 Telescope is ACP->iTelescope.Net T18 CDK 12.5, driver V2
02:58:33 Imager is SBIG Universal
02:58:33 Guider is ASCOM (external)
02:58:38 Calculated unbinned plate scales (arcsec/pix): H = 0.73 V = 0.7
02:58:38 Calculated field of view (arcmin): H = 37.4 V = 24.9
02:58:38 Using focus offsets from FilterInfo.txt

Project Execution: Observing

- I reserved telescopes ~3 mo in advance in order to get continuous, 8-hr blocks that I assigned to teams
- Students self-organized observing responsibilities within teams
- Students prepared ephemerides and finder charts
- We pre-planned procedures for what to do if bad weather occurred.
- Students texted each other to keep observations going
- I tried to be online/on-text when starting each session
- iTelescope.net has help line

Project Execution: Observing Success for Fall 2015

- 1 “night” = 8 hr block
- 24 nights originally scheduled (12 Spain, 12 NM)
- ~5 nights of data, not continuous, for 4 of 6 target asteroids
  – **we had horrible weather!!!**
- Students volunteered for ~4 extra nights, not continuous,
  ~3 nights successful
- 322 images usable for analysis for 4 asteroids

Project Execution: Photometric Analysis

- Students used *MPO Canopus* to do photometry and analyze lightcurves to find rotation period
- Typical software package used by most authors in *MPB*
- Software automates procedure for matching star field to star catalog, choosing comparison stars, and phasing lightcurve to search for rotation periods.

Project Execution: Photometric Analysis

- All parts of software analysis were discussed conceptually in class and students were tested on understanding.

- Students had to sanity-check analysis done by software

- Students had to check quality of analysis, in particular if comparison stars were bright enough and nonvariable

- Students had to decide about plausibility of lightcurves and rotation periods, and check for aliasing

Project Execution: MPB Paper

- Students reported on their progress with “their” asteroid at four points during the course, with both written and oral reports.

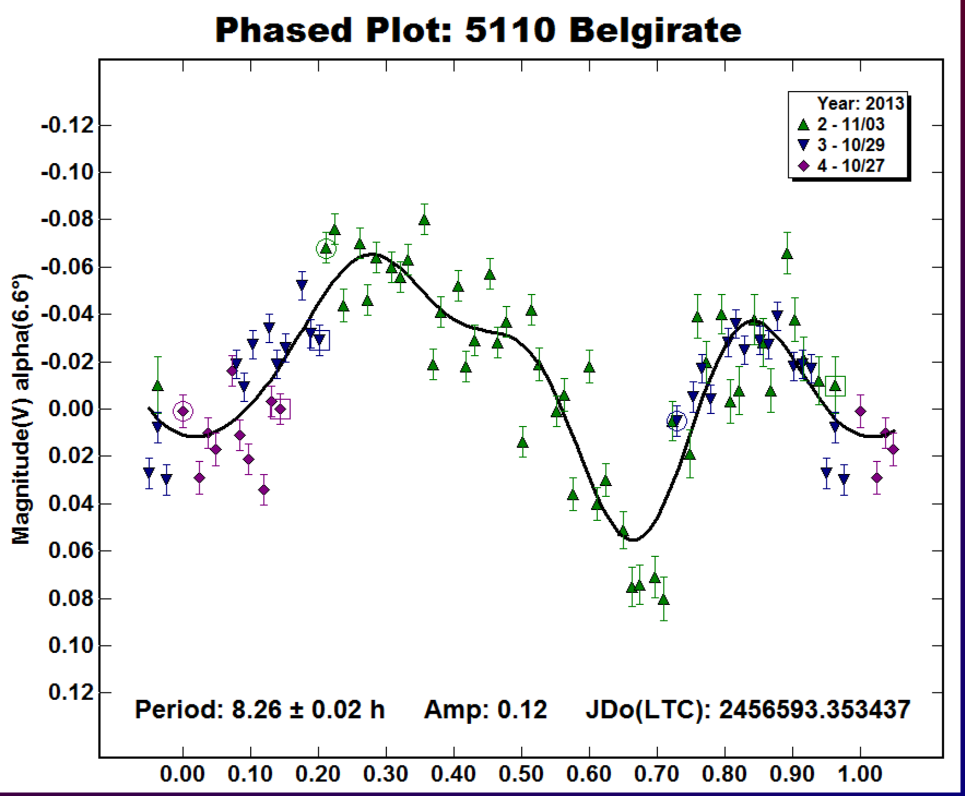
- Students wrote papers (one per asteroid) following the *MPB* format; papers are typically 1 – 2 pages.

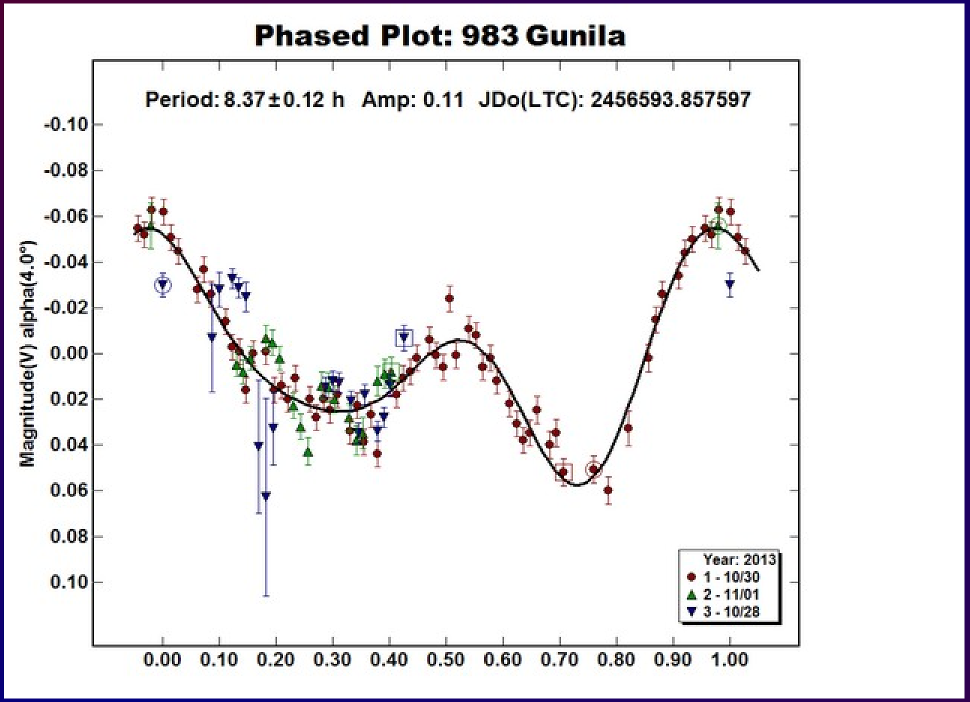
- Many rounds of editing and revising went go through me – final paper must be ready to submit to *MPB*.

Results: Project

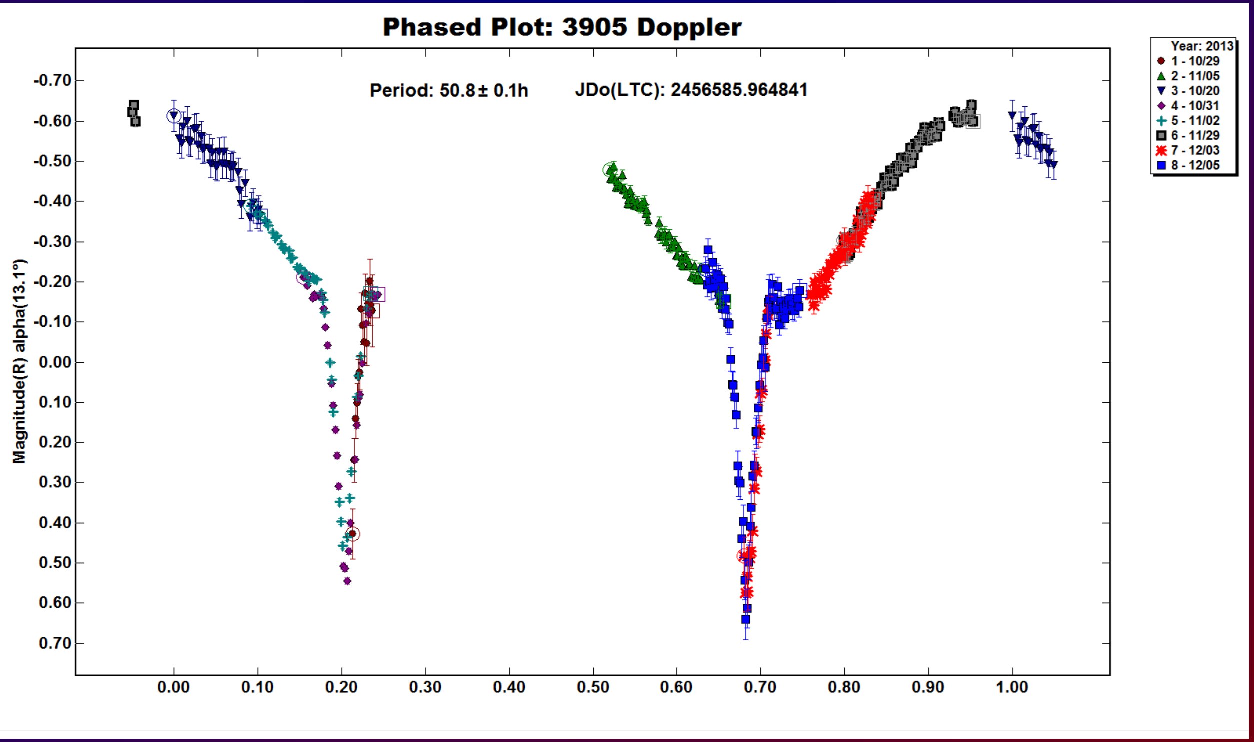
12 previously-undetermined rotation periods - weather caused 3 targets to be abandoned. 1 previously-unknown eclipsing binary* asteroid discovered.

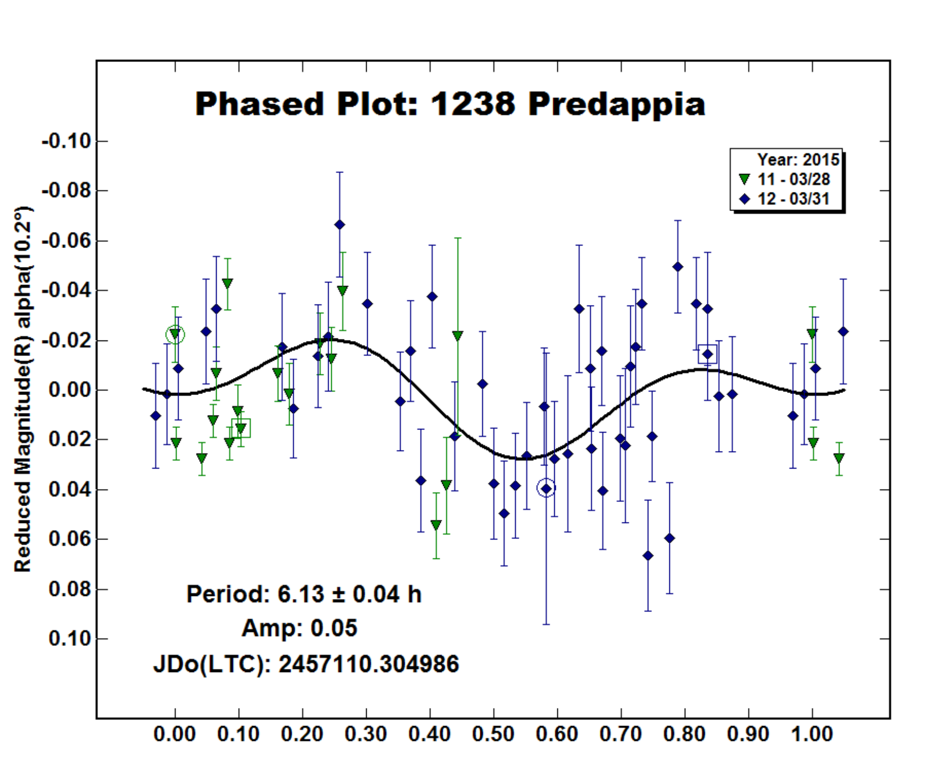
Asteroid	**Rot. Period**	
983 Gunila	8.37 +/- 0.12 h	white:
1238 Predappia	6.13 +/- 0.04 h	fall 2013
1654 Bojeva	10.5559 +/- 0.0137 h	
2296 Kugultinov	8.4332 +/- 0.0224 h	pink:
2343 Siding Spring	2.405 +/- 0.003 h	spring 2015
3000 Leonardo	7.524 +/- 0.021 h	
3905 Doppler*	50.8 +/- 0.1 h	green:
5110 Belgirate	8.26 +/- 0.02 h	fall 2015
5181 SURF	6.111 +/- 0.001 h	
6518 Vernon	4.911 +/- 0.001 h	
11268 Spassky	5.645 +/- 0.003 h	
16813	8.2934 +/- 0.0035 h	

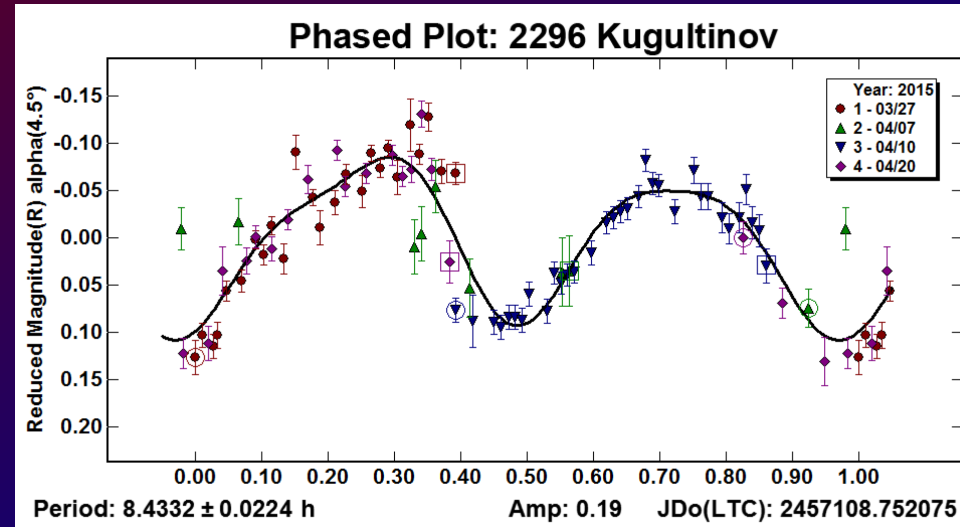

Phased Plot: 5110 Belgirate
Year: 2013
2 - 11/03
3 - 10/29
4 - 10/27
Magnitude(V) alpha(6.6°)
Period: 8.26 ± 0.02 h Amp: 0.12 JDo(LTC): 2456593.353437

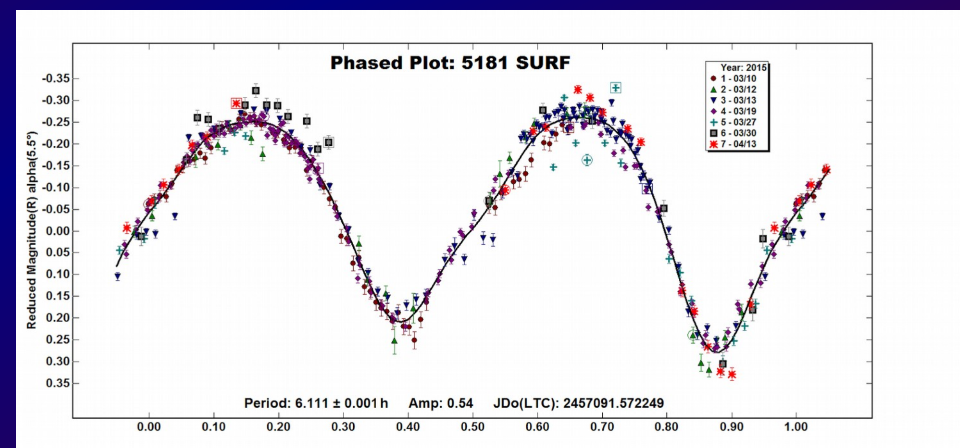

Phased Plot: 983 Gunila
Period: 8.37±0.12 h Amp: 0.11 JDo(LTC): 2456593.857597
Magnitude(V) alpha(4.0°)
Year: 2013
1 - 10/30
2 - 11/01
3 - 10/28

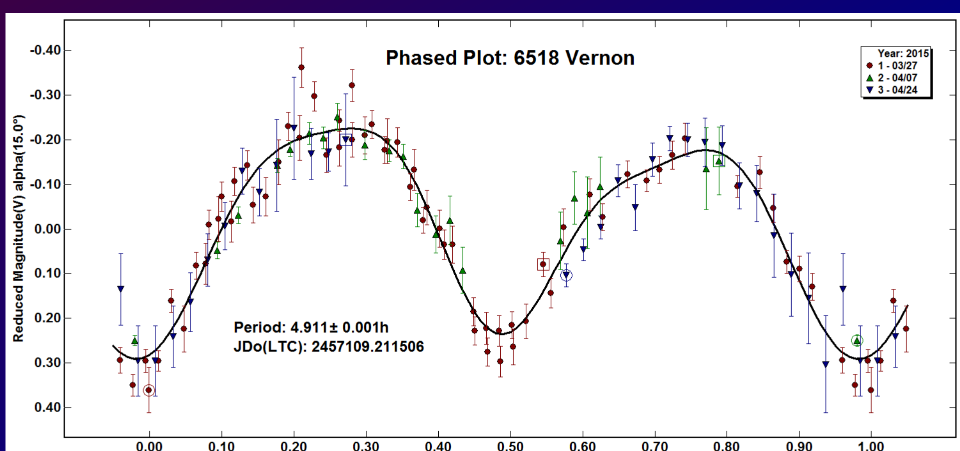
fall
2013

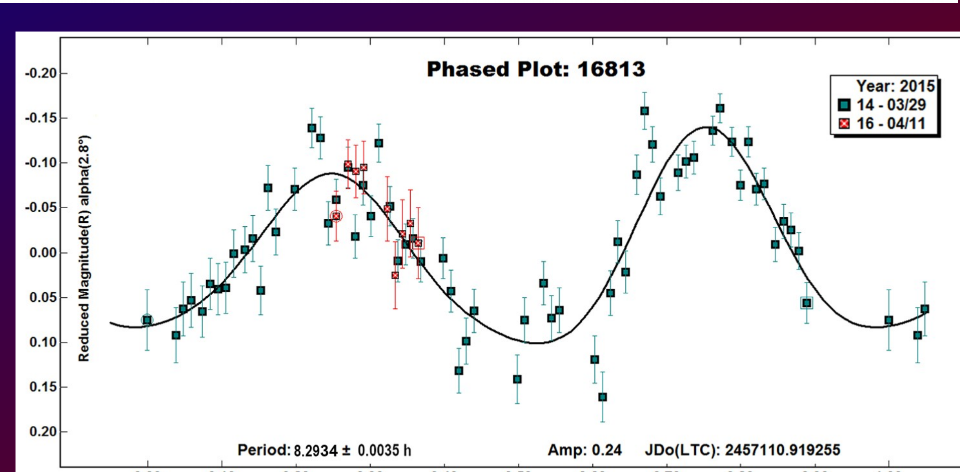

Phased Plot: 3905 Doppler
Period: 50.8± 0.1h JDo(LTC): 2456585.964841
Magnitude(R) alpha(13.1°)
Year: 2013
1 - 10/29
2 - 11/05
3 - 10/20
4 - 10/31
5 - 11/02
6 - 11/29
7 - 12/03
8 - 12/05


Phased Plot: 1238 Predappia
Year: 2015
11 - 03/28
12 - 03/31
Reduced Magnitude(R) alpha(10.2°)
Period: 6.13 ± 0.04 h
Amp: 0.05
JDo(LTC): 2457110.304986

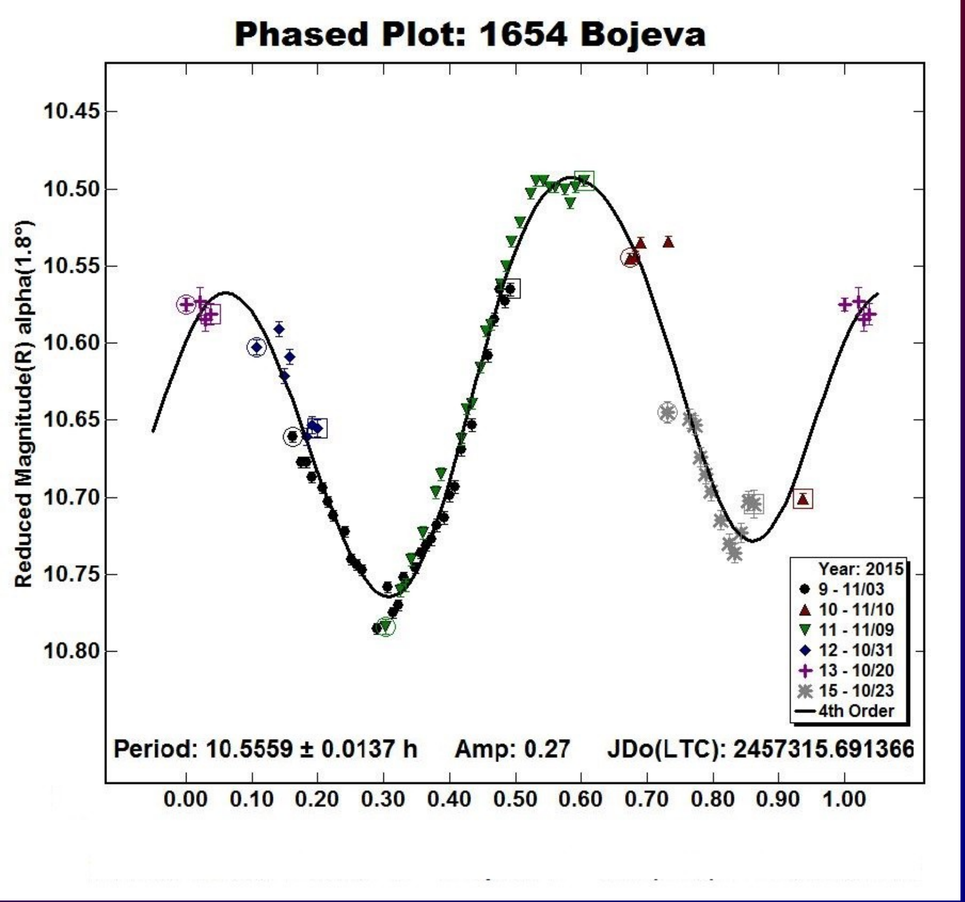

Phased Plot: 2296 Kugultinov
Year: 2015
1 - 03/27
2 - 04/07
3 - 04/10
4 - 04/20
Reduced Magnitude(R) alpha(4.5°)
Period: 8.4332 ± 0.0224 h
Amp: 0.19
JDo(LTC): 2457108.752075

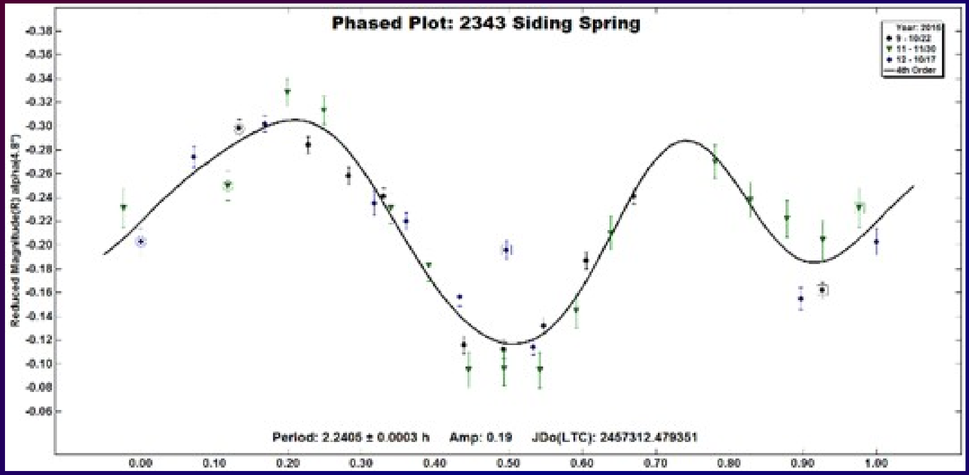

Phased Plot: 5181 SURF
Year: 2015
1 - 03/10
2 - 03/12
3 - 03/13
4 - 03/19
5 - 03/27
6 - 03/30
7 - 04/13
Reduced Magnitude(R) alpha(5.5°)
Period: 6.111 ± 0.001 h
Amp: 0.54
JDo(LTC): 2457091.572249

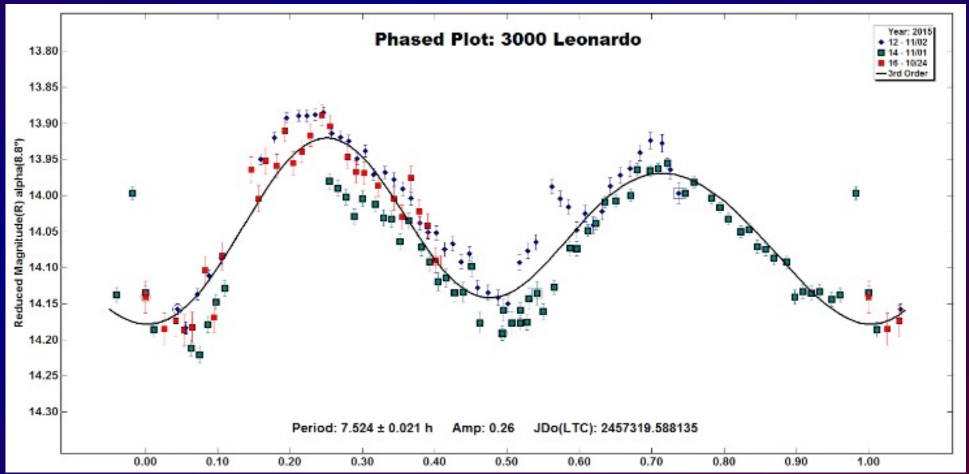

Phased Plot: 6518 Vernon
Year: 2015
1 - 03/27
2 - 04/07
3 - 04/24
Reduced Magnitude(V) alpha(15.0°)
Period: 4.911± 0.001h
JDo(LTC): 2457109.211506

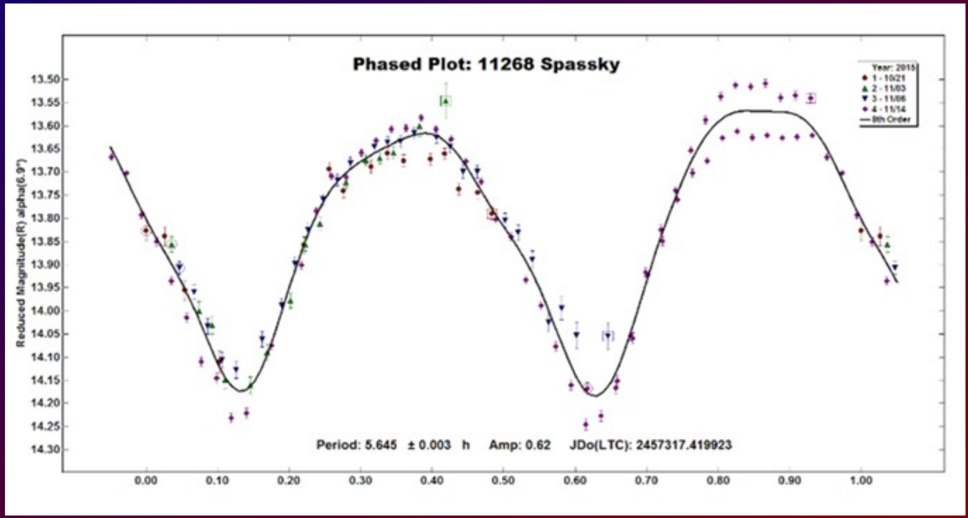

Phased Plot: 16813
Year: 2015
14 - 03/29
16 - 04/11
Reduced Magnitude(R) alpha(2.8°)
Period: 8.2934 ± 0.0035 h
Amp: 0.24
JDo(LTC): 2457110.919255

spring 2015


Phased Plot: 1654 Bojeva
Reduced Magnitude(R) alpha(1.8°)
Year: 2015
9 - 11/03
10 - 11/10
11 - 11/09
12 - 10/31
13 - 10/20
15 - 10/23
4th Order
Period: 10.5559 ± 0.0137 h Amp: 0.27 JDo(LTC): 2457315.691366


Phased Plot: 2343 Siding Spring
Period: 2.2405 ± 0.0003 h Amp: 0.19 JDo(LTC): 2457312.479351


Phased Plot: 3000 Leonardo
Period: 7.524 ± 0.021 h Amp: 0.26 JDo(LTC): 2457319.588135


Phased Plot: 11268 Spassky
Period: 5.645 ± 0.003 h Amp: 0.62 JDo(LTC): 2457317.419923

fall 2015

Results: Project

- 12 papers published in *Minor Planet Bulletin*
- Rotation period results cited in JPL Small Body Database
- *C*ollaborators for 4 asteroids: 2 US and 2 international
- Fall 2013 students made poster for Jan 2014 AAS
- Spring 2015 students made poster for July 2015 AAPT
- In spring 2015 and fall 2015 semesters, students presented their results to the public at an Open Night talk at our observatory.

Results: Course Success

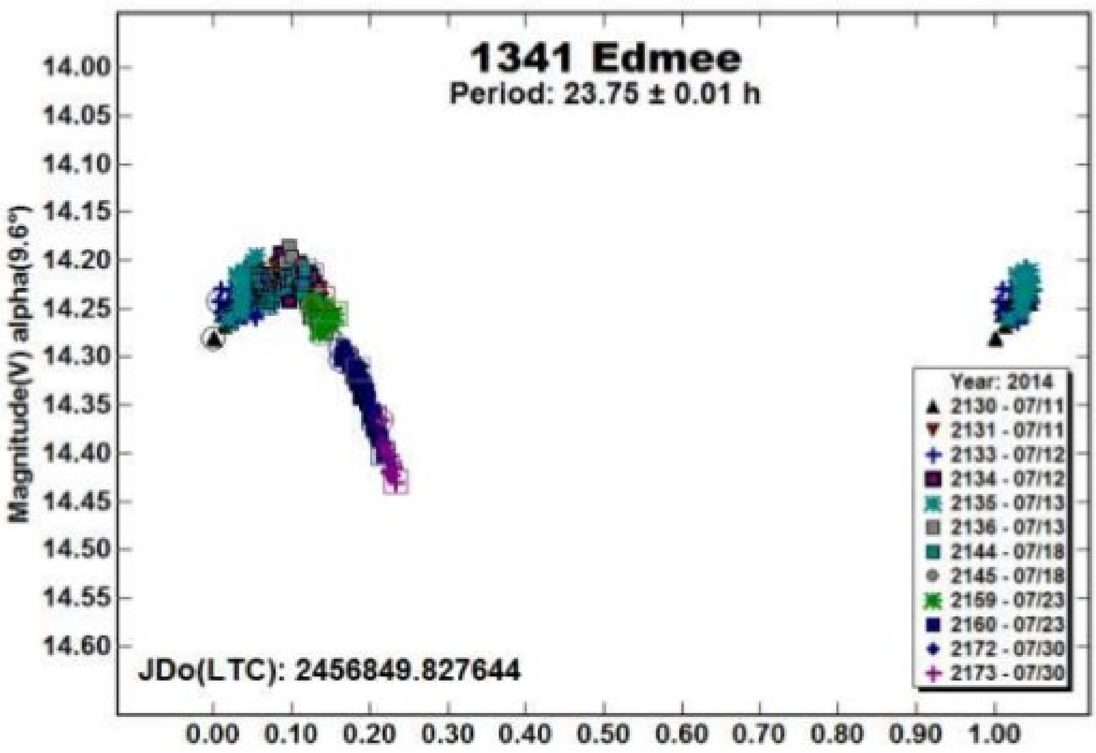
- Large essay on final exam requires students to plan observing strategy for given potential target asteroid, using given telescopes at certain locations – probes understanding of aliasing/time coverage, asteroid visibility, telescopic light-gathering power, etc.

- Students generally quite successful in addressing many of these issues and demonstrating understanding

Results: Course Success

Shorter final exam questions probe understanding of other course concepts and are generally well-answered by the students.

5. (5 pts) The graph below shows the phased lightcurve for the asteroid 1341 Edmee. Note that the asteroid was observed for 6 different nights, for about 6 hours per night. Why is so much of the phased lightcurve of this asteroid still unobserved, even with so much observation time? **Explain your reasoning.** (Please note that there were no weather or equipment problems for any of the nights.) (SPACE FOR ANSWER ON NEXT PAGE)



Results: Course Success

I have made these observations about students in the course:

- They are very excited about making real observations and analyzing their own data.
- They experience dramatic sense of discovery when they see “their” asteroid move in the images.
- They deeply appreciate the chance to make an original contribution to science.
- They can be frustrated when their analysis becomes difficult and a rotation period doesn't appear right away – they sometimes seem to think I know the “right” answer.

Results: Course Success

"I liked being able to observe a real asteroid and be able to have a scientific paper published. This will set me apart from other grad school candidates."

"The only thing I didn't really enjoy was the observations of the asteroid. The hours were often long and we weren't always successful in getting data. Nothing can be done to change this though."

"[I liked] observatory talk. Great public speaking experience. Also being able to finalize our lightcurve."

"I liked the fact that we got to do real hands on research. Not only did this give us a chance to practice astronomy, this also let us see how actual research is conducted."

"[I liked] actually working w/a telescope taking images. That's so much different than any other nonmajor astro class."