

Due: Fri Sep 26 2014 12:00 PM EDT

Question

1 2

## Instructions

### Lab 1: Introduction to Skynet

Read the lab before attending lab. You might find it easier to navigate if you expand only one or two sections at a time.

The following orientation and summary videos are available to you in case you miss lab or want to review them when completing the lab:

[Introduction to Skynet](#) (36:26)

[Morehead Telescope](#) (14:24)

[Remote Operations Room](#) (11:43)

[PROMPT Telescope](#) (5:25)

[Introduction to Afterglow](#) (27:41)

**You are permitted 100 submissions per question. Use some of these to save your work.**

**If you do not save your work periodically, you risk losing it when WebAssign times you out. WebAssign does this after a few hours for security reasons.**

**Do not open multiple copies of this assignment, or multiple WebAssign assignments, or you risk losing your answers upon saving or submitting.**

**Enter all calculated values to at least two significant digits.**

**Do not add units when entering numerical responses. WebAssign will not accept your response.**

**Do not use special characters when naming files. WebAssign will not accept your file.**

*Since all celestial objects, except for the sun, spend half of the year in the daytime sky, only about half of the objects in this lab will be observable at any given time of year. Consequently, it is usually impossible to get all of the points that are available. But do not worry: This is the case for everyone in your section. It will be accounted for before you receive your grade.*

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1.  Question Details

UNCastro101L1 1.IL.001. [2817385]

## LAB 1 — INTRODUCTION TO SKYNET (WEEK 1)

### GOALS

In this lab, you will:

- Observe astronomical objects with the University of North Carolina's (UNC's) PROMPT telescopes in Chile and Australia and with other telescopes around the world in UNC's Skynet Robotic Telescope Network.
- Adjust the brightness and contrast levels of astronomical images to better view detail in them.
- Measure angles between and across objects in your images.
- Identify objects in your images that are moving through that part of the sky.

## + EQUIPMENT

Computer with Internet connection

## + BACKGROUND: A. PROMPT TELESCOPES - 1. PROMPT, CTIO, and SSO

Dr. Dan Reichart and his students began [building](#) the **Panchromatic Robotic Optical Monitoring and Polarimetry Telescopes (PROMPT)** in 2004, at the **Cerro Tololo Inter-American Observatory (CTIO)** in the Chilean Andes.

CTIO is one of the premier observatories in the world.



*Five of the eight PROMPT-Chile telescopes, with our Milky Way galaxy and the planet Venus in the background.*

Dr. Reichart and his students added a second PROMPT site in 2013, at the Siding Spring Observatory (SSO) in Australia.

It is night in Australia when it is day in the United States.

The PROMPT telescopes are unique in that they are run by computers instead of by humans. Such telescopes are called robotic telescopes.

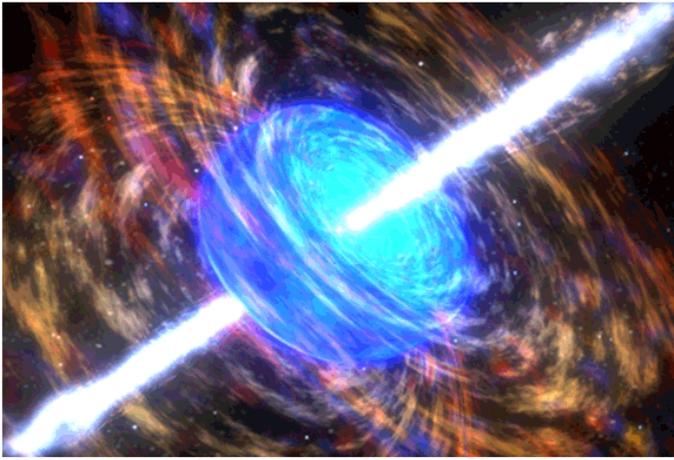
Each evening, the telescopes' [domes open](#) automatically and the telescopes prepare to take their first observations.

Computers also monitor the weather. If it becomes too cloudy, too humid or wet, or too windy, they close the domes.

You can view [PROMPT-Chile and CTIO](#) interactively. You can view and listen to [individual PROMPT telescopes](#). (At night, both of these may appear dark, depending on the amount of moonlight.)

## + BACKGROUND: A. PROMPT TELESCOPES - 2. PROMPT and GRBs

Dr. Reichart's group built PROMPT to observe cosmic explosions called **gamma-ray bursts (GRBs)**. GRBs are the death cries of massive stars and the birth cries of black holes.



*Artist's conception of a GRB in progress*

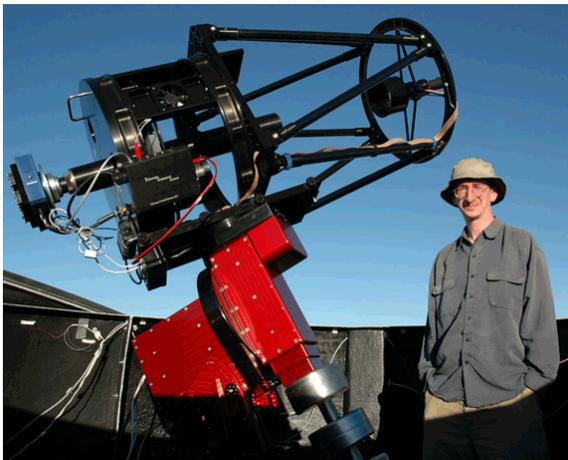
GRBs are the biggest bangs since the Big Bang. They are so luminous that they can be observed with relatively small telescopes, even if very far away. However, they fade quickly, often lasting only minutes. Consequently, PROMPT was built to be fast, not big.

In 2005, UNC undergraduate Josh Haislip and Dr. Reichart used one of the PROMPT telescopes to discover the most distant explosion in the universe then known—a GRB that was 12.9 billion light years away. Since the universe is only 13.8 billion years old, this star died when the universe was only 6% of its current age. This was over 8 billion years before Earth even formed!

When not observing GRBs, which is over 90% of the time, PROMPT is used by other researchers across the state, country, and world, by students of all ages—graduate through elementary—and by the general public.

#### **+** BACKGROUND: A. PROMPT TELESCOPES - 3. How a PROMPT Telescope Works

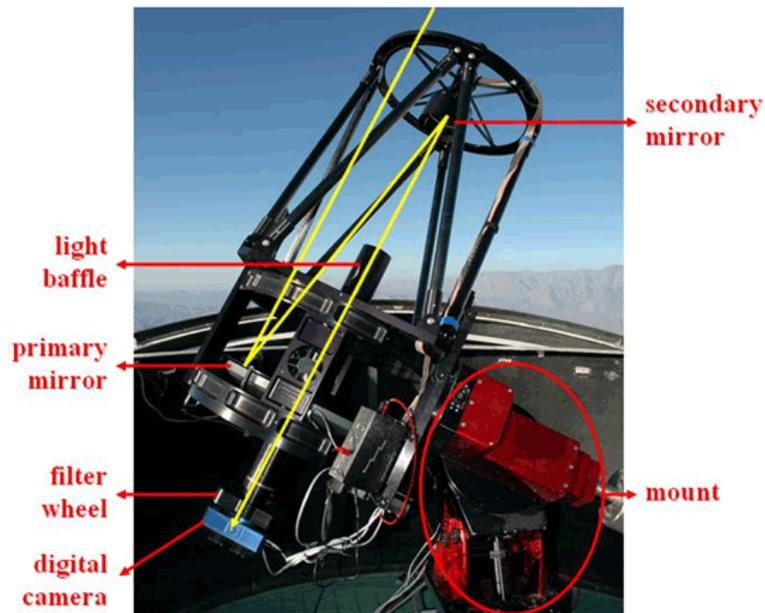
Here is one of the PROMPT telescopes up close, with Dr. Reichart next to it for scale.



The most important part of a telescope is actually the **mount** on which the telescope sits. Mounts need to be able to point well and track the motion of the sky well, or images will be off-center and distorted.

PROMPT telescopes look different from most telescopes in that they are open, instead of enclosed by a tube. This is so wind, which is sometimes strong at CTIO and SSO, can pass through the telescopes, instead of shaking them, which also distorts images.

When light from space enters one of the PROMPT telescopes, it bounces first off of a 16-inch diameter **primary mirror** and then off of a smaller **secondary mirror**. (The larger the primary mirror, the more light a telescope can collect in the same amount of time.)



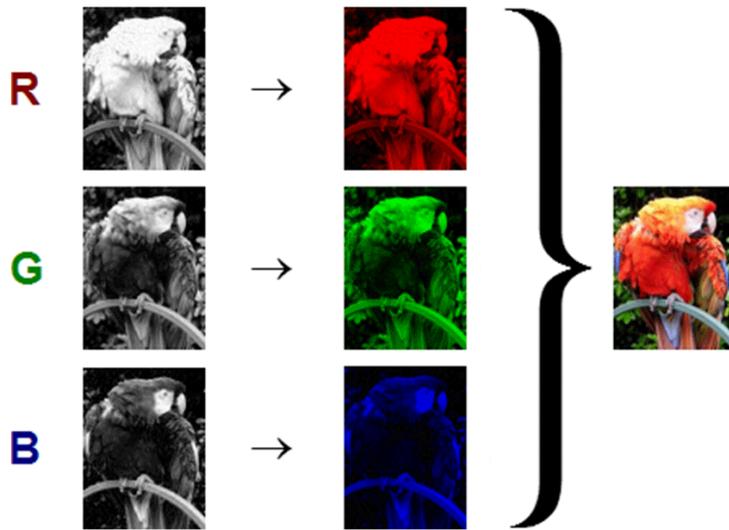
The secondary mirror redirects the light first through a tube called a **light baffle** and then through a hole in the center of the primary mirror. The light baffle helps to prevent stray light from contaminating images.

Once behind the telescope, the light enters a **filter wheel**, which can rotate different colors of glass into the path of the light, so only that color of light can pass through.



Finally, light of the selected color enters a **digital camera** and is recorded. Astronomical digital cameras are called **charge-coupled devices (CCDs)** and are similar to regular digital cameras except that (1) they are designed to work at much lower light levels, and (2) they only take black and white images.

Consequently, if you want to make a color picture with a CCD, you must take three pictures—one using a red filter, one using a green filter, and one using a blue filter—and then combine them into a color picture using a computer.



*Notice how the parts of the photo with a lot of red in their color are brightest in the red filter, parts with a lot of green in their color are brightest in the green filter, and parts with a lot of blue in their color are brightest in the blue filter. White parts of the photo have equal amounts of red, green, and blue and consequently are bright in all three filters.*

**BACKGROUND: A. PROMPT TELESCOPES - 4. PROMPT and Maintenance**

PROMPT is a complicated system. It can fail in many ways, some of which you may encounter this semester.

However, PROMPT's control software—called **Skynet**—is well written and can identify most failures as they occur. If Skynet identifies a failure, either (1) it corrects it itself, or (2) if it cannot, it communicates the failure to Dr. Reichart's group (by both email and text message).

Dr. Reichart's group can correct most failures remotely, and relatively quickly—usually within minutes to hours.

If a failure occurs that cannot be corrected remotely, Dr. Reichart's group works with staff at CTIO or SSO to correct it as quickly as possible. But this usually takes longer—hours to even months, depending on the severity of the failure. Fortunately, such failures are rare.

Otherwise, Dr. Reichart's group travels to these sites to maintain and improve the equipment at least once per year.

Whether due to failure or maintenance, if any of the PROMPT telescopes go offline this semester, we will continue our labs on the remaining telescopes.

**BACKGROUND: B. SKYNET ROBOTIC TELESCOPE NETWORK**

Like PROMPT, Skynet was developed and continues to be improved upon by Dr. Reichart's group.

Skynet is unique in that it can control not only UNC's PROMPT telescopes, but a wide variety of telescopes. In 2013, 18 telescopes spanning three continents participated in UNC's Skynet Robotic Telescope Network.

Telescope	Site	Diameter	Availability	Owner
ARO-30	Astronomical Research Observatory, IL	30-inch	Poor	Astronomical Research Institute, Eastern Illinois University, Hands-On Universe
Dolomiti	Dolomites Astronomical Observatory, Italy	16-inch	Poor	Carlo Magno Zeledria Hotel
DSO-14	Dark Sky Observatory, NC	14-inch	Fair	Appalachian State University
DSO-17	Dark Sky Observatory, NC	17-inch	Poor	Appalachian State University
GORT	Hume Observatory, CA	14-inch	Poor	Sonoma State University
Guilford	Guilford Observatory, NC	16-inch	Poor	Guilford University
Morehead	Morehead Observatory, NC	24-inch	Poor	UNC
PROMPT-1	CTIO, Chile	16-inch	Excellent	UNC
PROMPT-2	CTIO, Chile	16-inch	Excellent†	UNC
PROMPT-3	CTIO, Chile	16-inch	Excellent	UNC

PROMPT-4	CTIO, Chile	16-inch	Excellent	UNC
PROMPT-5	CTIO, Chile	16-inch	Excellent	UNC
PROMPT-SSO-1	SSO, Australia	17-inch	Good	UNC
PROMPT-SSO-2	SSO, Australia	17-inch	Good	UNC
PROMPT-SSO-3	SSO, Australia	17-inch	Good	UNC
PROMPT-SSO-4	SSO, Australia	17-inch	Good	UNC
R-COP	Perth Observatory, Australia	14-inch	Excellent	Perth Observatory
Yerkes-41	Yerkes Observatory, WI	40-inch	Poor	University of Chicago

Telescopes with excellent availability are open for at least part of >75% of nights. Telescopes with good availability are open for at least part of 50% - 75% of nights. Telescopes with fair availability are open for at least part of 25% - 50% of nights. Telescopes with poor availability are open for at least part of <25% of nights.

The availability of some of these telescopes will increase as we continue to better integrate them into Skynet. New telescopes are in the process of being integrated into Skynet as well.

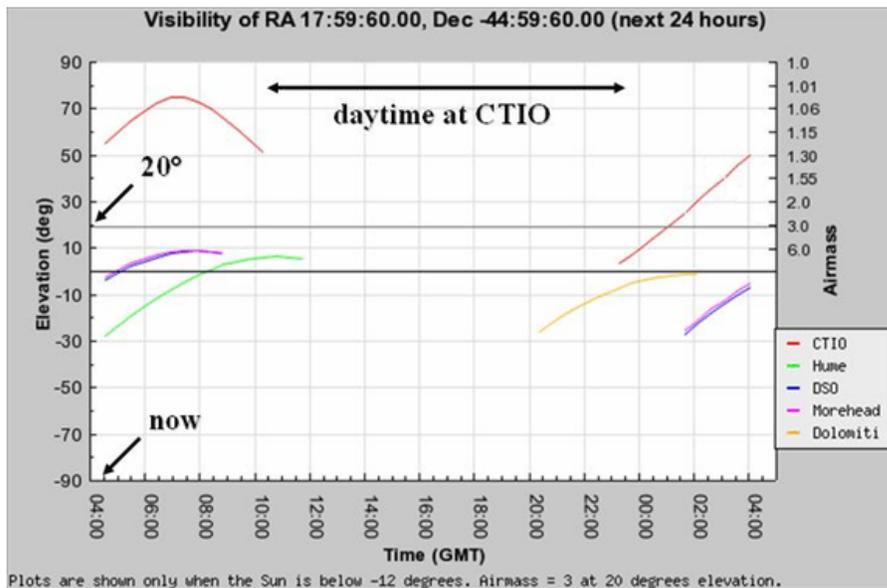
**You are welcome to observe with any of the Skynet telescopes.** Availability and image quality are usually best with the PROMPT telescopes. However, PROMPT is in the southern hemisphere and consequently cannot image all northern sky objects.

**PROCEDURE: A. OBSERVE WITH SKYNET - 1. How to Observe with Skynet**

To observe with Skynet, go to this [website](#). Your instructor will provide you with a username and password.

Next, watch this [tutorial video](#).

**Remember:** For an object to be observable, it must be greater than 20° above the horizon for at least part of the night on at least one of the Skynet sites. For example, in the following observability chart, the selected southern sky object is observable from CTIO, but not from Skynet's northern hemisphere sites.



**Also remember:** The more telescopes that you select, the more likely that Skynet will be able to observe your object quickly. Depending on telescope availability, it will take anywhere from seconds to days to get your images.

Choose Acceptable Telescopes:

[\[Back\]](#)

Morehead

Prompt3

Prompt4

Prompt5

Finally, also remember: Request only one exposure per observation.

Add Exposures

[\[Back\]](#)

Color Band	Num. Exps	Duration (sec)
Open	<input type="text" value="1"/>	<input type="text" value="80"/>

Multiple durations may be specified as a comma-separated list (e.g. 10,20,40)

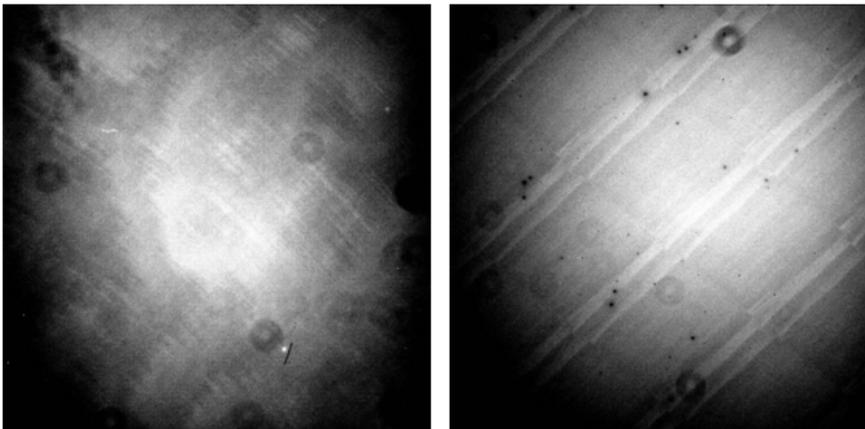
Repeat these exposures  time(s) with  minutes  between groups of exposures.

**+** PROCEDURE: A. OBSERVE WITH SKYNET - 2. How to Check Your Images

In this [tutorial](#), you will learn how to check your images once they have been taken.

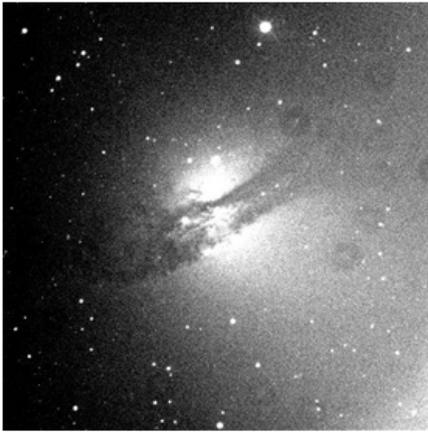
**If any of your images are of poor quality for any reason, re-observe them!**

Images can be of poor quality due to clouds blocking all of the light:

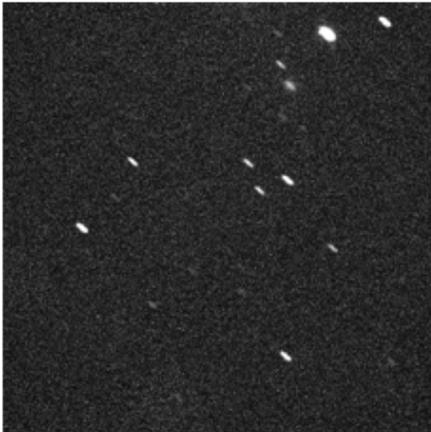


(When this occurs, all that remains to be seen is the response pattern of the CCD and out-of-focus dust on the camera window.)

Due to clouds blocking some of the light (left vs. right):



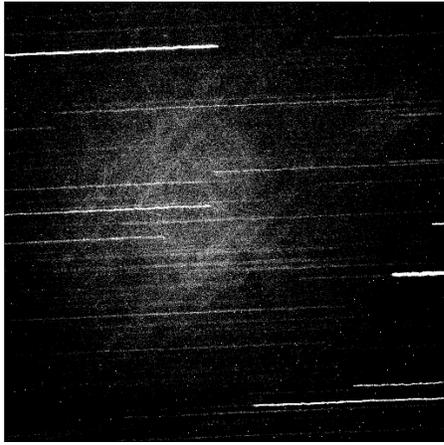
Due to wind or mount misbehavior distorting or streaking the images:



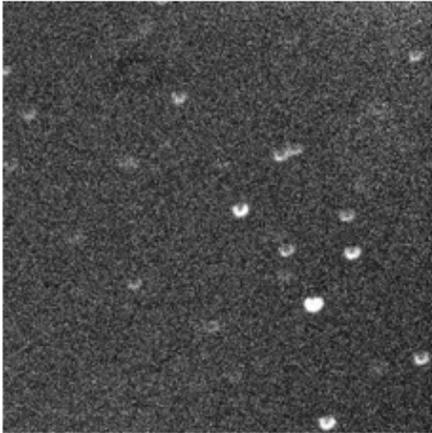
Due to mount misbehavior off-centering the images:



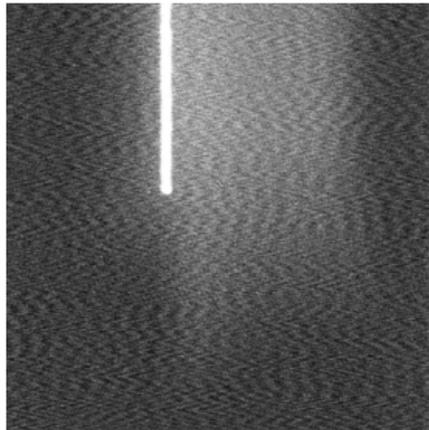
Due to mount not tracking Earth's rotation:



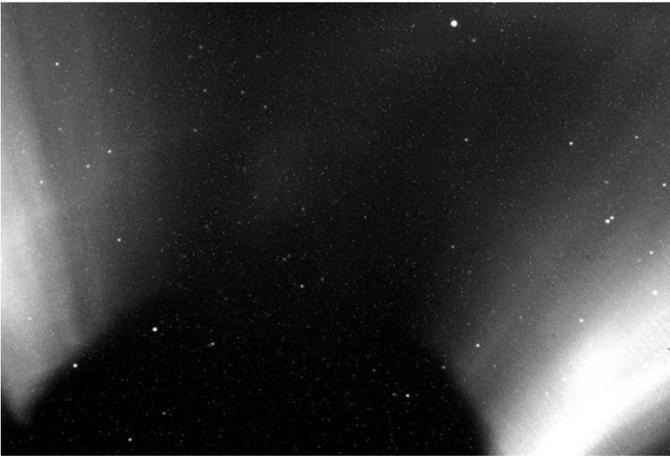
Due to focus misbehavior:



Due to camera shutter sticking:



Due to proximity to the moon or someone leaving a light on at the telescope:



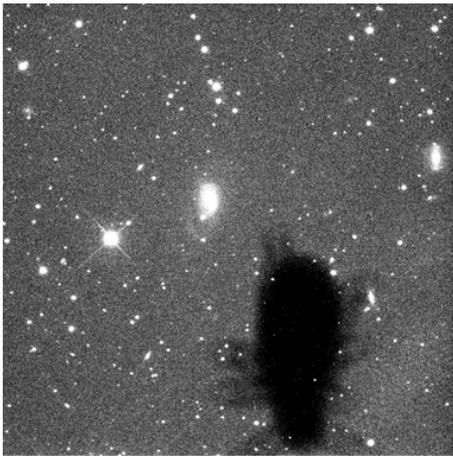
Due to a satellite moving through that part of the sky during the exposure:



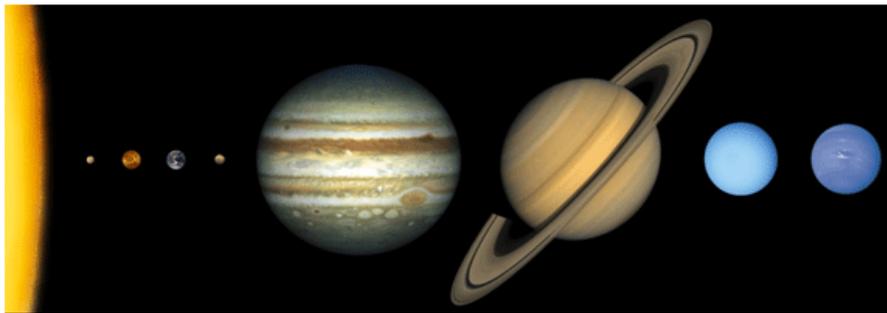
Due to an airplane moving through that part of the sky during the exposure:



And even due to a bug sitting on the camera window!



**PROCEDURE: A. OBSERVE WITH SKYNET - 3. Observe Planets**



*The sun and the solar system's eight planets (left to right: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune).*

**Observe all currently observable planets:** If the observability chart indicates that a planet is not currently observable, do not request an observation of it! If observable from CTIO or SSO, use PROMPT and the following filters and exposure durations.

Planet	Location	Filter†	Exposure Duration (seconds)†
Mercury	Inner Solar System	U	0.03
Venus	Inner Solar System	U	0.03
Mars	Inner Solar System	U	0.1
Jupiter	Outer Solar System	U	0.1
Saturn	Outer Solar System	V	0.1
Uranus	Outer Solar System	V	1
Neptune	Outer Solar System	V	3

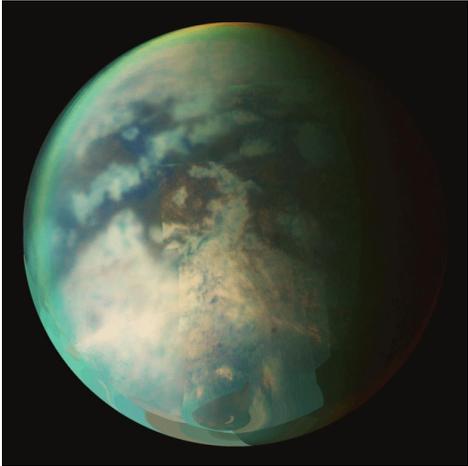
**Check your images:** If any of your images are of poor quality for any reason, re-observe them.

**PROCEDURE: A. OBSERVE WITH SKYNET - 4. Observe Moons**

Aside from Earth's moon, all of the solar system's large and medium-sized moons orbit Jupiter, Saturn, Uranus, or Neptune. Jupiter has four large moons (left to right: Io, Europa, Ganymede, and Callisto), but no medium-sized moons.



Saturn has one large moon (Titan)



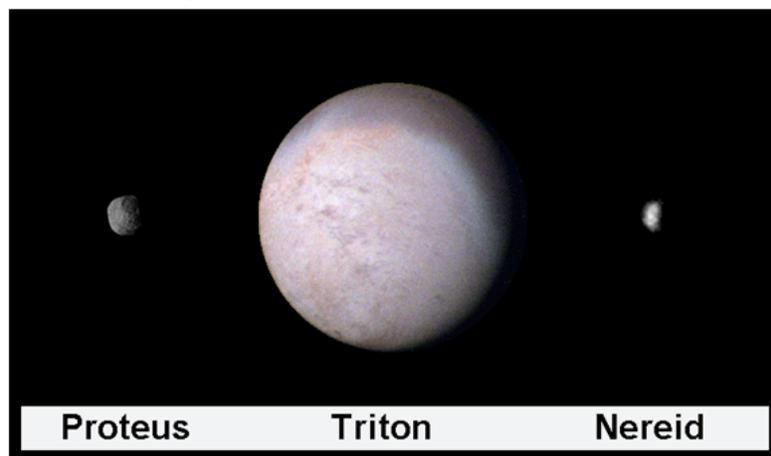
and six medium-sized moons.



Uranus has no large moons, but five medium-sized moons.



Neptune has one large moon (Triton) and two medium-sized moons.



The filters and exposure durations that you used in the previous section to observe Jupiter, Saturn, Uranus, and Neptune are not ideal for observing their moons, which are significantly fainter. However, different filters and exposure durations can be used to better observe and to observe more of these moons. (The trade-off is that the planets will be over-exposed in these images.)

**Observe large and medium-sized moons around all currently observable planets:** To observe a planet's moons, observe the planet, not the moons! The moons should be in the image. If the observability chart indicates that a planet is not currently observable, do not request an observation of it. If observable from CTIO or SSO, use PROMPT and the following filters and exposure durations.

Planet	Location	Filter†	Exposure Duration (seconds)†
Jupiter	Outer Solar System	V	0.03
Saturn	Outer Solar System	Open	0.03
Uranus	Outer Solar System	Open	1
Neptune	Outer Solar System	Open	1

**Check your images:** If any of your images are of poor quality for any reason, re-observe them.

✚ PROCEDURE: A. OBSERVE WITH SKYNET - 5. Observe Dwarf Planets



Earth and its moon and the five dwarf planets and their moons.

**Observe all currently observable dwarf planets:** If the observability chart indicates that a dwarf planet is not currently observable, do not request an observation of it. If observable from CTIO or SSO, use PROMPT and the following filters and exposure durations.

Dwarf Planet	Location	Filter	Exposure Duration (seconds)†
Ceres	Asteroid Belt	V	3
Pluto	Kuiper Belt	Open	80
Haumea	Kuiper Belt	Open	80
Makemake	Kuiper Belt	Open	80
Eris	Kuiper Belt	Open	160

**Check your images:** If any of your images are of poor quality for any reason, re-observe them.

**PROCEDURE: A. OBSERVE WITH SKYNET - 6. Observe Deep Sky Objects**

**Observe one deep sky object from the following list of nebulae:** If the observability chart indicates that a nebula is not currently observable, do not request an observation of it. If observable from CTIO or SSO, use PROMPT and the following filters and exposure durations.

Deep Sky Object	Object Type	Filter	Exposure Duration (seconds)†
<a href="#">Carina Nebula (NGC 3372)</a>	Star Forming Region	Open	20
<a href="#">Lagoon Nebula (M8)</a>	Star Forming Region	Open	20
<a href="#">Orion Nebula (M42)</a>	Star Forming Region	Open	20
<a href="#">Tarantula Nebula (NGC 2070)</a>	Star Forming Region	Open	40
<a href="#">Trifid Nebula (M20)</a>	Star Forming Region	Open	40
<a href="#">Crab Nebula (M1)</a>	Supernova Remnant	Open	80
<a href="#">Eagle Nebula (M16)</a>	Star Forming Region	Open	80

**Observe one deep sky object from the following list of star clusters:** If the observability chart indicates that a star cluster is not currently observable, do not request an observation of it. If observable from CTIO or SSO, use PROMPT and the following filters and exposure durations.

Deep Sky Object	Object Type	Filter	Exposure Duration (seconds)†
<a href="#">47 Tucanae (NGC 104)</a>	Globular Cluster	Open	20
<a href="#">M3</a>	Globular Cluster	Open	40

**Observe one deep sky object from the following list of galaxies:** If the observability chart indicates that a galaxy is not currently

observable, do not request an observation of it. If observable from CTIO or SSO, use PROMPT and the following filters and exposure durations.

Deep Sky Object	Object Type	Filter	Exposure Duration (seconds)†
<a href="#">Centaurus A (NGC 5128)</a>	Elliptical Galaxy	Open	40
<a href="#">NGC 253</a>	Spiral Galaxy	Open	40
<a href="#">Sombrero Galaxy (M104)</a>	Spiral Galaxy	Open	40
<a href="#">NGC 2997</a>	Spiral Galaxy	Open	80
<a href="#">NGC 6744</a>	Spiral Galaxy	Open	80
<a href="#">Southern Pinwheel (M83)</a>	Spiral Galaxy	Open	80
<a href="#">Spindle Galaxy (NGC 3115)</a>	Spiral Galaxy	Open	80

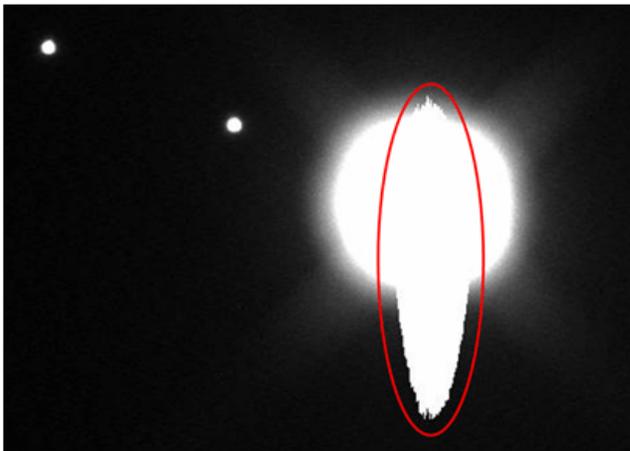
**PROCEDURE: A. OBSERVE WITH SKYNET - 7. Beyond the Labs**

You are welcome to use Skynet to observe any object that you are curious about this semester.

You are also welcome to re-observe these objects with different filters, exposure durations, and maximum airmasses.

The U, u', H $\alpha$ , OIII, and SII filters let the least light through. They are useful for bright objects. The Luminance, Open, and Clear filters let the most light through. They are useful for dim objects. U/B/V/R/I, u'/g'/r'/i'/z', and Blue/Green/Red span the visible colors from near-ultraviolet to near-infrared. The first two are scientific filter sets. The third is designed to mimic the response of the human eye. Not all telescopes are equipped with the same filters.

The longer your exposure duration, the more detail that you may see. However, if you expose for too long, you may over-expose the bright parts of your images.



By lowering your maximum airmass (the default value is 3, the lowest value is 1), you are limiting how much atmosphere Skynet observes through. The less atmosphere that Skynet observes through, the higher quality that your images may be. However, if you lower the maximum airmass too much, fewer telescopes may be able to observe your object and those that can will have a shorter window of opportunity to do so. Consequently, you may have to wait longer to get your images.

Observation Name:  RA: (HMS)  :  :

If interrupted...  DEC:  °  '  ''

Priority:  Max Airmass:  Group:

Max Sun Elevation:  Don't start before (UTC):

Select filters:

U  gprime  Blue  
 B  rprime  Rc  
 V  iprime  Ic  
 R  zprime  Clear  
 I  Open  Halpha  
 Lum  Red  OIII  
 uprime  Green

**LAB 1 — INTRODUCTION TO SKYNET (WEEK 2)****PROCEDURE: B. ANALYZE YOUR IMAGES - 1. Planet and Dwarf Planet Images**

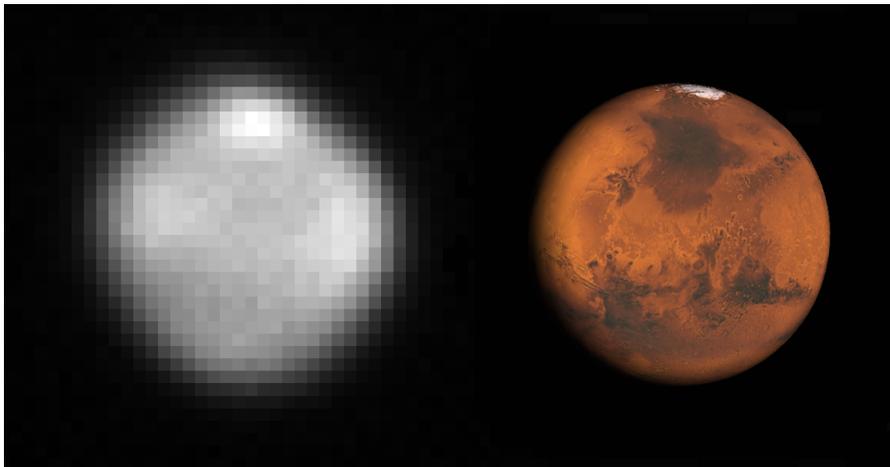
Go to [Afterglow](#).

In this [tutorial](#), you will learn how to view your images in **Afterglow** and how to adjust their brightness and contrast levels to bring out detail in them.

In this [tutorial](#), you will learn how to mark and label objects in your images, and how to save your adjusted, marked, and labeled images as jpg files.

**For the planets that you observed, and for the dwarf planet Ceres if you observed it, use Afterglow (1) to zoom in to the object and (2) to adjust the brightness and contrast levels of your images to bring out as much detail in them as possible. Do not attempt to bring out the moons; we will do that in Section B.4. Save your final images as jpg files.**

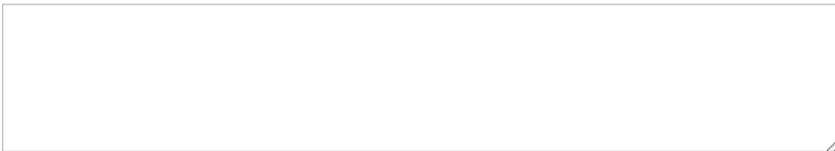
For example, a final image of Mars might look like the image on the left, which was taken when Mars was close to Earth in 2010. The image on the right shows what Mars looked like at this time if observed with a sufficiently large telescope from above our atmosphere. (The atmosphere blurs all incoming light over a scale of typically 1 arcsecond — less at a good site on a good night, but potentially much more at a bad site on a bad night.) Notice how the bright and dark regions coincide.



For each of the following objects that were observable, upload your final jpg image in the appropriate answer box below. (Submit a file with a maximum size of 1 MB. 3 points each)

Object	Image
Mercury	<input type="button" value="Choose File"/> No file chosen
Venus	<input type="button" value="Choose File"/> No file chosen
Mars	<input type="button" value="Choose File"/> No file chosen
Ceres	<input type="button" value="Choose File"/> No file chosen
Jupiter	<input type="button" value="Choose File"/> No file chosen
Saturn	<input type="button" value="Choose File"/> No file chosen
Uranus	<input type="button" value="Choose File"/> No file chosen
Neptune	<input type="button" value="Choose File"/> No file chosen

**Question:** Describe and discuss any detail that you see in each of these images. (3 points for each observed object)



**PROCEDURE: B. ANALYZE YOUR IMAGES - 2. Planet and Dwarf Planet Angular Diameters**

In this [tutorial](#) you will learn how to view information about your image, including which telescope took it and the date and time that it did.

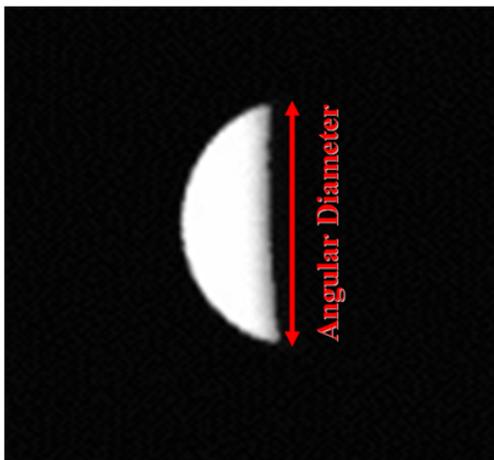
For each final image from Section B.1, use Afterglow to identify which telescope took it and the system (not universal) date and time that it did. Record this information in Data Table 1 below.

In this [tutorial](#), you will learn how to measure angles between and across objects in your images.

For each final image from Section B.1, use Afterglow (1) to set the brightness and contrast levels to "MinMax" so the object is not washed out, and (2) to measure the object's angular diameter to the nearest 0.1 arcseconds and record it in Data Table 1 below.

*Note: For Saturn, measure the angular diameter of its rings.*

*Note: If the object's phase is not full, it will not appear circular. If so, measure its angular diameter along its longer axis.*

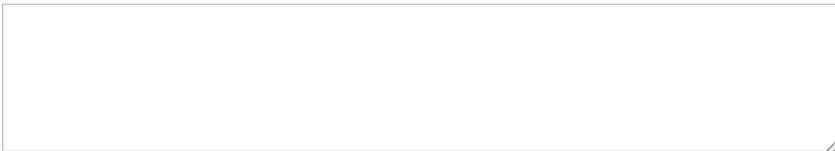


**DATA TABLE 1: MEASURED ANGULAR DIAMETERS (10 points)**

(If not observed, leave blank.)

Object	Currently Observable? (Enter yes or no.)	Telescope	System Date (mm/dd/yy)	System Time (hh:mm:ss)	Measured Angular Diameter (arcsec)
Mercury	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Venus	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mars	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Ceres	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Jupiter	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Saturn's Rings	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Uranus	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Neptune	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Sign your name to attest to the fact that you collected these data yourself.



**PROCEDURE: B. ANALYZE YOUR IMAGES - 3. Stellarium**

Download a free copy of [Stellarium](#).

In this [tutorial](#), you will learn how to use Stellarium to simulate how planets, their moons, and dwarf planets appeared in the sky when Skynet observed them.

**Remember:** For any of your images that you simulate with Stellarium, you must first change Stellarium's location to a city that is near to the telescope that took the image.

Telescope	Nearby Location
ARO-30	Mattoon, United States
Dolomiti	Trento, Italy
DSO-14	Dark Sky Observatory, United States
DSO-17	Dark Sky Observatory, United States
GORT	Santa Rosa, United States
Guilford	Guilford, United States
Morehead	Chapel Hill, United States
Nuannaarpoq	Santa Fe, United States
PROMPT-1	Cerro Tololo Inter-American Observatory, Chile
PROMPT-2	Cerro Tololo Inter-American Observatory, Chile
PROMPT-3	Cerro Tololo Inter-American Observatory, Chile
PROMPT-4	Cerro Tololo Inter-American Observatory, Chile
PROMPT-5	Cerro Tololo Inter-American Observatory, Chile
PROMPT-SSO-1	Siding Spring Observatory, Australia
PROMPT-SSO-2	Siding Spring Observatory, Australia
PROMPT-SSO-3	Siding Spring Observatory, Australia
PROMPT-SSO-4	Siding Spring Observatory, Australia
R-COP	Perth Observatory, Australia
Yerkes-41	Yerkes Observatory, United States

**Also remember:** Change Stellarium's date and time to the system (not universal) date and time that Skynet took the image.

For each final image from Section B.1, use Stellarium to find the object's true angular diameter when Skynet took the image (see *Data Table 1*) and record it to the nearest 0.1 arcseconds in *Data Table 2* below.

*Note: For Saturn, Uranus, and Neptune, Stellarium gives two true angular diameters, one for the planet's rings and one for just the planet. For Saturn, use the true angular diameter of the planet's rings. For Uranus and Neptune, use the true angular diameter of just the planet.*

Calculate the percent error for each of your angular diameter measurements and record it in *Data Table 2* below.

$$\text{percent error} = \frac{|\text{measured value} - \text{true value}|}{\text{true value}} \times 100\%$$

*Note: The vertical lines in this equation mean "absolute value of" or "positive value of". For example:  $|-1138| = 1138$ .*

**DATA TABLE 2: TRUE ANGULAR DIAMETERS (10 points)**

*Note 1: For Ceres, if Stellarium gives 0.0 arcseconds, use 0.5 arcseconds.*

*Note 2: For Saturn, Stellarium gives the true angular diameter of its rings.*

Object	True Angular Diameter (arcsec)	Percent Error
Mercury	<input type="text"/>	<input type="text"/> %
Venus	<input type="text"/>	<input type="text"/> %

Mars	<input type="text"/>	<input type="text"/> %
Ceres	<input type="text"/>	<input type="text"/> %
Jupiter	<input type="text"/>	<input type="text"/> %
Saturn's Rings	<input type="text"/>	<input type="text"/> %
Uranus	<input type="text"/>	<input type="text"/> %
Neptune	<input type="text"/>	<input type="text"/> %

Sign your name to attest to the fact that you collected these data yourself.

**Question:** Present the percent error calculation of the first object in Data Table 2 that you observed. (3 points)

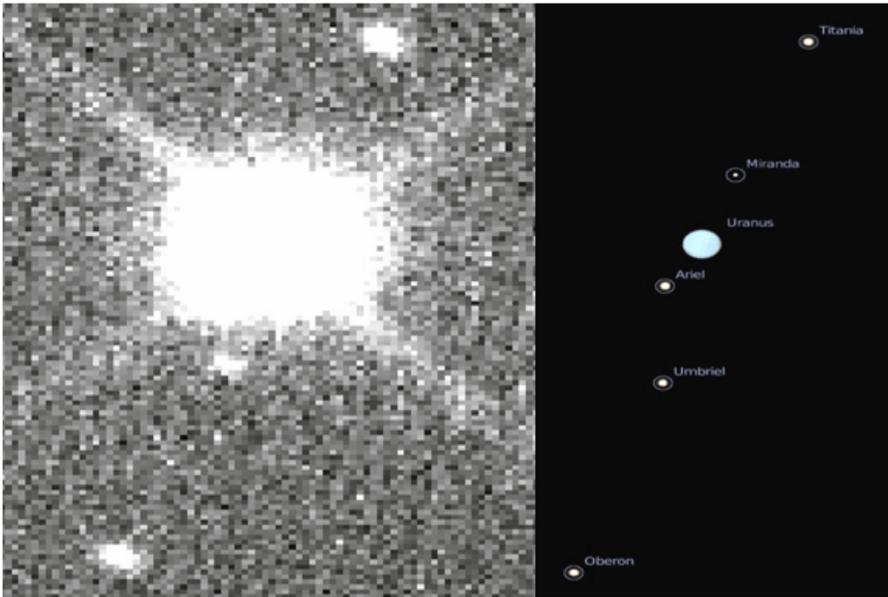
**Question:** Discuss sources of error. In particular, discuss atmospheric blurring and why it causes objects with smaller true angular diameters to have larger percent errors. *Note: "Human error" or "measurement error" or "calculation error" are not valid sources of error. If you find such errors, go back and correct them! If you cannot find them, ask your instructor for help!* (3 points)

**+** PROCEDURE: B. ANALYZE YOUR IMAGES - 4. Moon Identification

**For the large and medium-sized moons that you observed, use Afterglow to adjust the brightness and contrast levels of your images to bring out as many moons as possible. (It is okay if you wash out the planets.)**

In this [tutorial](#), you will learn how to compare your images to Stellarium's simulations of them to identify the moons in your images.

**Remember:** Set Stellarium's location, date, and time to those of your image. After zooming in to the planet in Stellarium, remember to view it equatorially, and then zoom out far enough to match as many of the objects in your image as possible to Stellarium's simulation of them. Keep in mind that moons or other objects that are close to the planet in Stellarium might be lost in the washing out of the planet in your image.



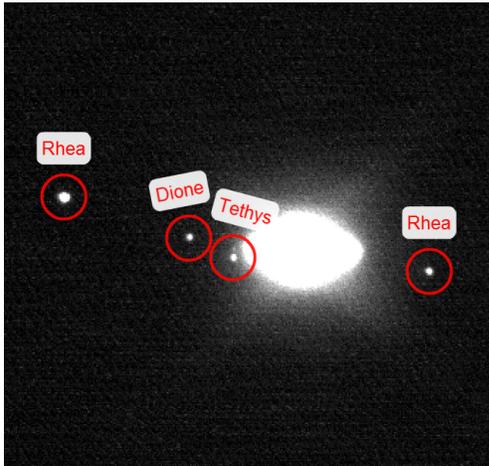
In the Skynet image (left), the moons Oberon, Umbriel, and Titania can be identified using Stellarium (right). However, the moons Ariel and Miranda are too close to Uranus, which is washed out in the Skynet image, to be identified.

**Note:** If you do not see any moons in your image, it is possible that thin clouds blocked enough of the incoming light that you cannot see the moons but you can still see the planet. In this case, you should re-observe.

**Note:** Of Neptune's moons, Triton is the only one that should be bright enough for you to see in your image. It should be very close to Neptune.

For the planetary systems that you observed, use Stellarium to identify as many moons as possible. Be careful not to identify background stars as moons! Use Afterglow to zoom in around the planetary system and label its moons. Save your final images as jpg files.

For example, a final image of Saturn and its moons might look like:



For each of the following planetary systems that were observable, upload your final jpg image in the appropriate answer box below. Enter the system date and time of this observation, so the instructor can check your moon identifications. (Submit a file with a maximum size of 1 MB. 6 points each—3 points for the image and 3 points for correct moon identifications.)

Planetary System	Image	System date (mm/dd/yy)	System time (hh:mm:ss)
Jupiter	<input type="button" value="Choose File"/> No file chosen	<input type="text"/>	<input type="text"/>
Saturn	<input type="button" value="Choose File"/> No file chosen	<input type="text"/>	<input type="text"/>
Uranus	<input type="button" value="Choose File"/> No file chosen	<input type="text"/>	<input type="text"/>

Neptune  No file chosen

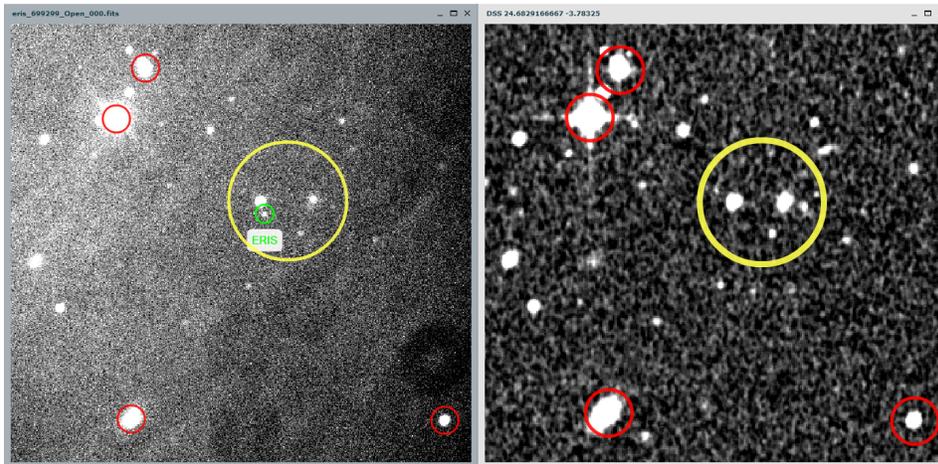
**Question:** Google each moon that you identified to learn more about it. Present one fact about each of these moons. (1 point for each correctly identified moon; 12 points maximum.)

**PROCEDURE: B. ANALYZE YOUR IMAGES - 5. Dwarf Planet Identification**

In this [tutorial](#), you will learn how to compare your images to archival **Digitized Sky Survey (DSS)** images to find objects that are moving through that part of the sky.

**For each dwarf planet that you observed in the Kuiper Belt, use Afterglow and the DSS to find it. Use Afterglow to mark corresponding stars in both your image and the DSS image, including stars close to the dwarf planet. Zoom in and recenter both images if necessary. Use Afterglow to label the dwarf planet in your image. Save both images as jpg files.**

For example, your final images might look like these. On the left is a final image of Eris. On the right is the corresponding DSS image.



**Note:** If you are having difficulty finding a dwarf planet, do the following: Look at the entire DSS image. Find the stars in the very center of the image. Find this same pattern of stars in your image. The dwarf planet should be there.

For each of the following dwarf planets that were observable, upload your final jpg and DSS jpg images in the appropriate answer box below. (Submit a file with a maximum size of 1 MB. 5 points each—3 points for your image and 2 points for the DSS image.)

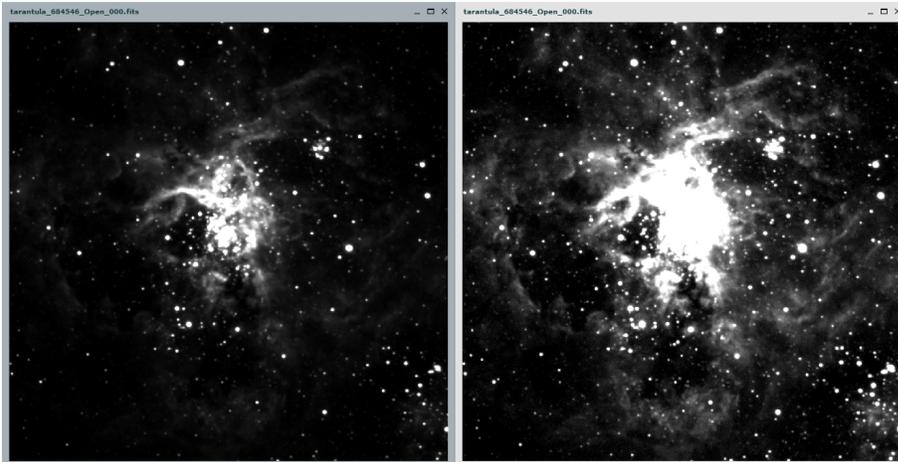
Dwarf Planet	Images	
Pluto	jpg:	<input type="button" value="Choose File"/> No file chosen
	DSS jpg:	<input type="button" value="Choose File"/> No file chosen
Haumea	jpg:	<input type="button" value="Choose File"/> No file chosen
	DSS jpg:	<input type="button" value="Choose File"/> No file chosen
Makemake	jpg:	<input type="button" value="Choose File"/> No file chosen
	DSS jpg:	<input type="button" value="Choose File"/> No file chosen
Eris	jpg:	<input type="button" value="Choose File"/> No file chosen
	DSS jpg:	<input type="button" value="Choose File"/> No file chosen

**Question:** Google each dwarf planet that you observed to learn more about it. Present one fact about each of these dwarf planets. (1 point for each observed dwarf planet)

**PROCEDURE: B. ANALYZE YOUR IMAGES - 6. Deep Sky Object Images**

Of the deep sky objects that you observed, select your favorite nebula, star cluster, and galaxy. For your selected objects, use **Afterglow** to adjust the brightness and contrast levels of your images to bring out as much detail in them as possible. Save your final images as jpg files.

For example, your final image might look like either of these. On the left is an image of the Tarantula Nebula with brightness and contrast settings Min = 10 and Max = 99 (ZScale). On the right is the same image with Min = 10 and Max = 95, which brings out the outer nebula at the expense of saturating the inner nebula.



Upload your final jpg images in the appropriate answer box below. (Submit a file with a maximum size of 1 MB. 2 points each.)

Object	Image
nebula	<input type="button" value="Choose File"/> No file chosen
star cluster	<input type="button" value="Choose File"/> No file chosen
galaxy	<input type="button" value="Choose File"/> No file chosen

**Question:** Google each of these objects to learn more about it. Present one fact about each of these objects. (3 points)

Assignment Details

Name (AID): **Lab 1: Introduction to Skynet (T) (2586384)**  
Submissions Allowed: **100**  
Category: **Homework**  
Code:  
Locked: **Yes**  
Author: **Reichart, Daniel (reichart@physics.unc.edu)**  
Last Saved: **Dec 31, 2013 01:47 PM EST**  
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Randomization: **Assignment**  
Which graded: **Last**

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Before due date  
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After due date  
Question Score  
Assignment Score  
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Question Part Score  
Solution

Mark  
Help/Hints  
Response