Physics 10263 Lab #6:
Citizen Science - Supernova Hunting

Introduction

This lab is the another "Citizen Science" lab we will do together this semester as part of the **zooniverse.org** project family. This time, we will be searching for objects in the sky that vary, the brightest of which include variable stars (some of which we studied in previous labs), active galactic nuclei and supernova explosions.

Supernova explosions are extremely important for establishing the distance scale in the Universe. Knowing how far away supernovae are helps us figure out what our Universe was like in the past and how it is likely to change in the future. In order to measure such distances accurately, we need to know all we can about these rare and powerful explosions, so we will spend a bit of time learning about supernovae before diving in to the supernova hunting project.

Start by reading the relevant section of your textbook. Use a browser and search for "OpenStax Astronomy," then find Chapter 23.2 and answer the following questions based on that section (we will just be reading the first half of the section). Alternatively, a direct link to the chapter section is **https://bit.ly/2RsLAt7** .

Q1. Why is it that only stars with initial masses greater than about 10 times the mass of the Sun undergo the type of explosion described in this section (a Type II supernovae)?

Q2. Explain why iron fusion in the core triggers a supernova explosion.

Q3. Describe what provides the energy for the explosion once the core of the star has collapsed.

Next, we will move on to Chapter 23.3, which discusses observations of supernovae. Just click on the right arrow "Next" button at the bottom of Chapter 23.2 to get there.

Q4. Explain what is the mechanism that causes the ring that appears in images of Supernova 1987A.

Q5. Roughly 40 days after the initial supernova 1987A explosion, the expanding cloud of superheated gas was still getting brighter, but not because of the energy of the explosion itself. What was the source of this energy? Explain.

Our final textbook section we will read to learn about supernovae involve Type Ia supernovae, which are extremely important in establishing the cosmological distance scale. Please proceed to Chapter 23.5 of your textbook, "The Evolution of Binary Star Systems," to learn about these supernovae and answer the associated questions below.

Q6. Briefly describe the process that causes a nova explosion, a much fainter version of the Type Ia supernovae we will study later.

Q7. Briefly describe the process that results in a Type Ia supernova.

Note that all white dwarfs that undergo this type of explosion have a very similar mass, so these explosions have the potential to make great standard candles. A standard candle is a source of light with a very predictable and well-understand absolute luminosity (or magnitude). If we know the absolute luminosity of an object and can measure its apparent luminosity, determining the distance is a simple matter of solving the inverse square law (recall we did this with Cepheid Variables and stars in the Pleiades cluster).

Q8. The distinguishing spectral characteristic that allows us to determine whether a supernovae is a Type Ia or type II is that type Ia's should have very little or no evidence of Hydrogen atoms in their spectra. Explain why this difference exists between the two types of supernovae.

In our Citizen Science project today, we will be analyzing data from the Zwicky Transient Facility, a project designed to detect events like supernovae explosions very quickly after they first start getting bright. Getting information about a supernova explosion during the very early stages of its brightening is critical to understanding in detail the nature of these explosions and, in turn, accurately predicting their brightness so that we calculate an accurate distance.

Astronomers are trying to understand whether a Type Ia supernova occurs when either (a) two white dwarfs merge together or (b) when a white dwarf receives too much mass from a companion (which is in an earlier part of its evolution, still with a Hydrogen envelope like our Sun). For brief animations of these two types of explosions, see **https://go.nasa.gov/2NFtL92** and scroll down to the relevant video clips.

For an example of how the science of supernovae can be impacted by quick observations of the early stages of an explosion, please read **https://bit.ly/2NGAoYR**, and answer the questions below about the article.

Q9. Astronomers believe that detecting Hydrogen in the spectrum of an exploding type Ia supernova would favor the "mass transfer from companion" model over the "white dwarf merger" model. Explain why.

Q10. In this particular article, the light curve of the explosion led Astronomers to believe this is in fact a "white dwarf merger." What, then, is their explanation for the presence of Hydrogen in the spectrum?

The significance of these studies is that each supernova that can be detected early and studied closely tells us more about how to determine the true brightness of these explosions and therefore the true distance to the galaxies that contain them.

So now we will do a little bit of hunting for supernovae (and other kinds of things that vary in the sky) using the Zwicky Transient Facility (ZTF). Go to **https://bit.ly/2TBxx7a** in order to access this Citizen Science project. You will have to log in to the Zooniverse project in order to keep accurate stats on how much data you have examined. Just use the same log in you used for our previous project, the Variable Star Zoo.

Click "Learn More" and watch the first video to learn about this project, then answer the following:

Q11. Describe the two types of real varying objects (as opposed to bogus objects) that we will be detecting with the ZTF.

Next, under the “Classify” tab, click on the Tutorial link to learn how the classification process works and then click on the “Field Guide” and read through the examples of different kinds of things we will see. Then answer the following:

Q12. What kind of object typically has a lot of points plotted on its light curve? Found under “Using the light curve…” tab.

Q13. If a light curve for an objects is longer than about 200 days, there will often be a large gap in the data. What is the cause of this? Also found under “Using the light curve…”

Q14. What are two indicators in the image and the light curve that suggest an image you are looking at is a newly discovered supernova? Also found under “Using the light curve…”

Now you are ready to get started classifying images and finding supernovae and other light sources in the sky that vary. You should classify at least 50 images. Once you have completed your contribution to the project, show your lab instructor your profile page (click your username on the top right, then select "Home").

The little ring around the circular icon can be hovered over to indicate how many data sets you have completed for any given project (each part of the ring is color-coded for a different project, so you have to find the right project to hover over). The number below the ring is the total number of data sets for all projects combined.

<u>You will need to submit a screen shot showing your progress clearly, like below.</u> My progress on this particular project is 72 classification. My total number of classifications on all projects is 774. I'm only interested in the 72. You must have at least 50 classifications on this project.

Your TA is looking for a number of at least 50 in the white box with the colored border.