



BLACK HOLES FOR EVERYONE

by Andreana Kovačević Ćurić and Paulo Mesquita Fonseca







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Background information for teachers

Overview of this lesson pack:

Name of the activity	BLACK HOLES FOR EVERYONE
Topics introduced	Newton's gravity, Density, General Relativity, Photometry, Stellar Evolution, Compact Objects (White Dwarfs, Neutron Stars and Black Holes), Units, Eclipsing Binary Stars and Telescopes
Curriculum Connection	PORTUGAL: astronomy, density, gravity and Newton's mechanics GREECE: BOSNIA AND HERZEGOVINA: Gravity, Newton's mechanics, density
Reference Demonstrator	Black Holes in My School
Age of students	12-15
Duration	6 hours

Overview of this lesson pack:

Type of activity	Combination of lectures, hands on activity and researching
Description of activity	Teacher activities: The teacher has to prepare questions for students (on the beginning of lecture), lectures with video materials, demonstration, repeating knowledge (some kind of social game to make a more interesting class) and then calculation of the limit mass of the compact object (stellar black holes). It is very important to divide students in 4 groups or more, it depends on the equipment teacher has in the classroom. After calculation is done and comments made, the teacher has to give students time and opportunity for them to use the web to investigate what Space Telescope Chandra does. Also, they can compare types of black holes according to information from that site and can read and make comments about ways of investigating those objects. Student activities: Student should be very active in class and divided in groups. It is maybe the best for them to work as couples when they calculate the mass of black holes. If they repeat knowledge by social game, then, it is better to work/repeat in groups. Also, it would be nice if they be a part of demonstrations such as curvature of space - time and analysing density and making stellar evolution, etc. It is not good for them if they just watch the teacher how to perform those demonstrations.
Equipment requirements	internet connection laptops/computers (installed SalsaJ, etc.) prepared social game and stuff for demonstration (balloons, balls, sand, food colores, sphere with same radius but different density, stretching sheet/material)
Prior knowledge for students	Newton's gravity (basic), Density and basic astronomy (Solar System)

Lesson plan/ Activity in science clubs The Teacher:

 starts the lesson with the presentation of a apelative image/vídeo of universe and give oriented questions to be able to initiate a discussion about what is in the universe;





wikipedia

Lesson plan/ Activity in science clubs The Teacher:

- 2. Introduce topics of:
 - general about stellar evolution;
 - equilibrium of gravity and radiation;
 - elements form at the Universe;
 - density of an compact object;
 - Newton's gravity;
 - the concept of gravity according to General Relativity;
 - photometry;
 - units (light-years, seconds, astronomical unit, kg...);
 - eclipsing binary stars.

Lesson plan/ Activity in science clubs





Lesson plan/ Activity in science clubs

The Teacher:

3. guide students to make hands on activities related with density, curvature of spacetime theory of general relativity;

4. Orient students to make research about stellar black holes.

5. Students are introduced to a method of detecting black holes in eclipsing binary systems – systems formed by a visible star and an eclipsing companion. Real images will be used to look for changes in the starlight that might result due to the presence of a companion

6. Guide students to perform calculation of the limit mass of the compact object (stellar black holes).

7. Discuss the calculation made and talk about Space Telescope Chandra.

The student:

- 1. Answer questions to initiate their lesson, like:
- What do you think observable the Universe contains?
- What do you like the most about the Universe?
- 1. Make some research about the Universe and about stellar black holes.
- 1. See demonstrations and talk about their research and repeat knowledge (some kind of social game to make a more interesting class);

Do hands- on-activities related with density (can use different spherical objects of different material, iron, wood, plastic, plumb, silver..., and put them in water; or calculate the density of various objects; simulate the space time curvature with that sferes in a cloth.

The student:

4- Use salsa J to measuring Brightness.

Do hands on activity - calculation of the limit mass of the compact object (stellar black holes).

5- Present results. Students can present their work to the class and discuss how they compare with the most accurate results that astronomers have.

6- Use the web of The Space Telescope Chandra and compare types of black holes according to information from that site and can read and make comments about ways of investigating those objects.

BLACK HOLES FOR EVERYONE

FRONTIERS Bringing Nobel Prize Physics in the Classroom



NOBELPRISET I FYSIK 2020 THE NOBEL PRIZE IN PHYSICS 2020





Roger Penrose

"för upptäcklen att bildandet av svarta hål är en robust förutsägelse av den allmänna relativitetsteorin"

"for the discovery that black hole formation is a robust prediction of #nobelpgizeral theory of relativity"



Reinhard Genzel



Andrea Ghez

"för upptäckten av ett supermassivt kompakt objekt i Vintergatans centrum"

"for the discovery of a supermassive compact object at the centre of our galexy"



COURTESY NOBELPRIZEORG

What do you like the most about the Universe? What do you think the observable Universe contains?





Life Cycle of a Star



https://www.youtube.com/watch?v=PM9CQDIQI0A



The Origin of the Solar System Elements





Astronomical Image Credits: ESA/NASA/AASNova

Graphic created by Jennifer Johnson





Density is the mass of an object divided by its volume. How can you investigate density?





Galena, a lead ore, is one of the densest common minerals.

Gravity



What do you know about gravity? Why is gravity important? Why do planets rotate around the Sun?



GENERAL RELATIVITY



Demonstration of curvature space - time; Demonstration of density of objects;





Demonstration of density vs. compact objects

Observed Mass Ranges of Compact Objects



How Black Holes Connect to General Relativity



"Matter tells space how to curve. Space tells matter how to move." John Wheeler

This simple sounding idea is fundamental to the id of what a black hole actually is and the effect the have on the Universe around them.

The most common analogy used to describe the effect that mass has on the fabric of spacetime, is that of placing objects on a stretched rubber shee The larger the object the deeper the 'dent' and th more extreme the curvature it creates. Thus a marble creates a small dent, whilst a cannonball creates a much deeper 'hole' in the sheet.

In our analogy, a planet may be a marble, a star a apple. A black hole would be a cannonball.

Photometry

Astronomers use the term "photometry" to refer to the precise measurement of the apparent brightness of astronomical objects in particular specified ranges of electromagnetic wavelength in and near the optically visible band.

-CCDs - A light-sensitive electronic detector that converts an image into electronic signals which can be stored, displayed, etc.: used in digital cameras, telescopes, etc.



Units

The International Astronomical Union (IAU) is responsible for maintaining and approving a special set of units in astronomy, formally defined in 1976.
The astronomical unit is a conventional unit of length equal to 149 597 870

700 m exactly.

The unique symbol for the astronomical unit is au.

The IAU also defines other astronomical units: the astronomical unit of time is

1 day (d) of 86,400 SI seconds (s) (SI is the International System of Units)

and the astronomical unit of mass is equal to the mass of the Sun,

1.9891×1030 kg.

The parsec (pc) is equivalent to about 30.857×1012 km, or about 206,000 aus, and is itself defined in terms of the au – as the distance at which one Astronomical Unit subtends an angle of one arcsecond. Alternatively the lightyear (ly) is sometimes used in scientific papers as a distance unit, although its use is mostly confined to popular publications and similar media. The lightyear is roughly equivalent to 0.3 parsecs or 9,460,730,472,580.8 km or 63,241 au.

Julian Date (JD) Calculator and Calendars

https://www.aavso.org/jd-calculator

Eclipsing binary stars

Eclipsing Binary Stars





What is black hole?

A black hole is a region in space where the pulling force of gravity is so strong that light is not able to escape. The strong gravity occurs because matter has been pressed into a tiny space. This compression can take place at the end of a star's life. Some black holes are a result of dying stars.



https://www.youtube.com/watch?v=e-P5IFTqB98

BLACK HOLE INFOGRAPHIC



companion star

accretion disk

accretion stream

X-RAY BINARY SCHEMATIC

jet

Investigation of the limit mass of the compact object



THANK YOU!