





Astronomical fingerprints of galaxies From light spectra to the age of the Universe

Sophie Mikolajczak, Priya Hasan, Miltos Vavoulidis







Frasmus+ Programm





Background information for teachers

Knowledge of Atomic Spectra, Doppler Effect, Hubble Law



Overview of this lesson pack:

Т

Name of the activity	Astronomical fingerprints of galaxies: from light spectra to the age of the Universe
Topics introduced	Spectra, Doppler effect and redshift, expansion of the Universe
Curriculum Connection	GREECE: 11th grade Atomic Physics, Spectra Atomic Physics, Spectra, Doppler Effect and the build up to cosmological redshifts FRANCE: T spé: Doppler Effect, redshift (+ european section) INDIA : Atomic Physics, Doppler Effect
Reference Demonstrator	"Measuring the recessional velocity of distant galaxies: calculating the age of the Universe"
Age of students	17-18 yrs
Duration	2 hours



Overview of this lesson pack:

Type of activity	Interactive Enquiry based Learning	
Description of activity	Teacher activities: Student activities: Making a spectroscope, using it, understanding of Hubble's law	
Equipment requirements	Essential: Laptops/Tablets/Phones, Optional: Spectroscope, Prism, spectral light sources (Na, H, Hg),	
Prior knowledge for students	Light as an electromagnetic wave, Structure of the atom, spectra	



Background and overview of the age of the Universe demonstrator:

These activities introduce the concept of the expansion of the Universe discovered by Edwin Hubble. Students will also learn about light spectra, absorption lines, redshift, and the Doppler effect. Students will be prepared for the demonstrator "Measuring the recess velocity of distant galaxies: Calculating the age of the Universe".



Presentation for students

Teacher guidelines can be found in the notes attached to each slide



Light Spectra



Newton demonstrates decomposition of white light with a prism



Spectra





Light Spectra:

Emission spectra & Absorption lines





Do it Yourself!

Experiment with prism/CD : solar spectrum/making the spectroscope: preproom.org - The Workshop - CD Spectroscope







Spectra in the Lab: For Demos (For Teachers)

Experiment with spectroscope (depends on your equipment)



(usual equipment in France) Take a picture with a phone





Kirchhoff & Bunsen spectroscope



Light Analyzer (need Diffraction Grating) Open Source Physics Singapore Education ***** 86 . E Everyone

Add to Wishlist

App for smartphones



Fortunately, light spectra reveal a lot of information! Light can be considered as electromagnetic waves and so it displays all wave phenomena! Among them, a phenomenon called "the Doppler effect"! It is preferable to first examine the Doppler effect in other, more familiar kinds of waves, e.g. sound waves.

Sheldon claims he is dressed as "the Doppler effect"!

Why does he try to explain it to others making the sound Neeeeoooowwwww?



Why does his costume have black and white stripes with gradually reducing width?

Do you get it? Are you smarter than Penny and her (nonscientist) friends?!...

FRONTIERS The Doppler Effect Sound



https://www.youtube.com/watch?v=WgMxtT_jYf0

update new videos cilick here subscribe thanks for watching



Brass band on train demonstrates Doppler effect







The Doppler Effect From sound to light

Whereas in sound, frequency has to do with <u>pitch</u>, in (visible) light, frequency has to do with the <u>color</u>!

A sound source is playing the note "Fa" and <u>is approaching</u> you. You will listen a lower frequency e.g. the note "Mi"?

or

You will listen a higher frequency e.g. the note "Sol"?

A light source is emitting "green light" and <u>is moving away from</u> you. You will see a lower frequency e.g. "red light"?

or

You will see a higher frequency e.g. "blue light"?



A light emitting moving source not only seems "redder" or "bluer". If its spectrum is not continuum and exhibits emission or absorption lines, those spectral lines will shift to lower or higher frequencies as well!



FRONTIE The Doppler Effect Further considerations

All lines have the same: change in wavelength? or

relative change in wavelength?

(To find the answer, try to complete the following table as in the example of the first row)

Unshifted (nm)	Shifted (nm)	Change (nm)	Relative change
434.0	479.8	45.8	0.1
486.1			
656.3			





The Doppler Effect Further considerations

Lines from different chemical elements have different wavelength shifts. True or False?



FRONTIERS The Doppler Effect Summary





blue shift	approaching galaxy
-	





How is this applied in Astronomy?



The **Harvard Computers** was a team of women working as skilled workers to process astronomical data at the Harvard Observatory in Cambridge, Massachusetts, United States. The team was directed by Edward Charles Pickering (1877 to 1919)







Cepheid Variables as Standard Candles









Test your understanding....



- 1. Are the spectra shifted?
- 2. If yes, is it blue-shifted or red-shifted?
- 3. Which galaxy has the largest velocity?
- 4. What can you conclude about the dynamics of the universe?

FRØNTIERS







The expansion of the universe

https://www.youtube.com/watch?v=t9276Lk_lpg





The Balloon Analogy





Do WE expand?





Quiz

The diagrams show the line spectrum emitted by two galaxies.



- 1. What is the name of the phenomenon?
- 2. How do you know that the galaxies are moving away from us?
- 3. Which galaxy, **A** or **B**, is moving away faster?

FRØNTIER



Hubble's Law states that

- 1. galaxies are moving towards us at increasing speeds
- 2. galaxies are slowing down as the move farther away from us
- 3. the speed at which galaxies are retreating away from us is directly proportional to their distance from us
- 4. the universe is still expanding



Hubble discovered that galaxies farther from us ____

- 1. are smaller in appearance and less bright
- 2. have greater red shifts and are moving away from us at greater speeds
- 3. would take a long time to get to
- 4. are not worth studying since we will never likely travel there



FRONT "Age of the Universe" Frontiers' demonstrator

"Measuring the recess velocity of distant galaxies" Calculating the age of the Universe

HOME • DEMONSTRATORS • "MEASURING THE RECESS VELOCITY OF DISTANT GALAXIES" CALCULATING THE AGE OF THE UNIVERSE

Measure... think... feel... like a real scientist!

