FRONTIERS
Bringing Nobel Prize Physics in the Classroom

creating a
Visual Identity text Referring to Gravitational waves Orientation

A digital educational scenario designed by:

Marina Molla, Isabel Borges, Daniela Zampieri & Athanasia Dreveitsou

DCU
ELLINOGERMANIKI AGOGI
NUCLIO
EGO EUROPEAN GRAVITATIONAL OBSERVATORY
IASA
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Background information of teachers

Athanasia Drevenitsou: Primary School Teacher in Greece, M.Ed., author of scientific articles & educational material.

Marina Molla: Primary School Teacher, Scientix Ambassador, EdChatEU Facilitator, Diversity Officer of the Northeast Hub of the Europlanet Society.M. in Local History-Interdisciplinary Approaches.

Daniela Zampieri: Middle School Teacher (11-13yr), instrumental function of new technologies.

Isabel Borges: Physics and Chemistry Teacher, Min-Edu. & Teacher Educator. Science on Stage Portugal NSC Coordinator, author of educational material and teacher training programmes, ESERO.

Overview of this lesson pack:

Name of the activity	**C**reating a **V**isual **I**dentity text **R**eferring to **G**ravitational waves **O**rientation
Topics introduced	Gravitational Waves, Black holes, Michelson detector, interferometers, spacetime, chirp, research-steps, investigation, identity texts, Multi-literacies (digital and writing skills, creativity & literacy in Physics).
Curriculum Connection	**PORTUGAL**: This activity can be taught to 3th and 4th grade students when covering the unit Astronomy. The adapted activity can be taught to 7th and 8th grade students, when covering the curricula units Earth in Space and Sound, Light & Waves. **GREECE:** This activity can be taught to the the 5th grade of Primary School students, when covering the unite “7. Light” of the Physics Subject - on the occasion of reading the texts "Black Holes: they are not black ... and above all they are not black" & “Mirrors: from the ancient times until today” . Students are introduced through these activities in the noise hunting of Gravitational Waves and the importance of black holes as messengers of the universe, while the mirrors are correlated to the mirrors used in VIRGO interferometer. Secondly another connection is unit 8 “Sound” and Unit 9 “Engineering” on the occasion of forces. **ITALY:** This activity can be taught to the third grade students, when covering the Astronomy and it is linked to the curriculum, especially to observe, model and interpret the most important celestial phenomena with third grade students
Reference Demonstrator	From the Michelson-Morley experiment to the gravitational-wave detection - Discovering and building a Michelson interferometer, Gravitational Waves - Noise Hunting, Virgo Virtual Visits
Age of students	8 - 13 (Primary & Middle School)
Duration	21 didactical hours (the project will be implemented interdisciplinary by Science and Language teacher, ICT teacher , English teacher and P.E. teacher)

Overview of this lesson pack:

Type of activity	interdisciplinary & Inquiry based Learning and hands on activities, online activity, Multiliteracies, self-efficiency.
Description of activity	Teacher-students activities: ● **introducing Identity texts** with the aim to empower students, develop their literacy and storytelling skills and use it as metagnostic activity at the same time ● **intriguing students curiosity** about Gravitational waves using multiple stimuli ● **Hands on Gravitational Waves & Black Holes** ● **Creating & Modelling of GWs & Black Holes** ● **Learning to write a scientific article**
Equipment requirements	computers, wifi connections, fabric, balls, Interactive White Board, Michaelson detector, torch, scissors, paper, cartons, glue, pencils
Prior knowledge for students	Basic knowledge regarding to: Energy, Light, materials

Background and overview of the discovering alien worlds demonstrator:

From the Michelson-Morley experiment to the gravitational-wave detection - Discovering and building a Michelson interferometer

This demonstrator introduces the concept of waves, interference, and the wave nature of light. Students are introduced to the history of the Michelson interferometer and the Michelson-Morley experiment, a groundbreaking experiment that led to Einstein's theory of special relativity. In an historical overview, they will learn how, more than a hundred years later, the same instrument was used to detect gravitational waves, thus confirming one of the main predictions of Einstein's general relativity. Students will experiment with a real small-scale Michelson interferometer, a powerful instrument that uses light interference to measure distances with high precision. They will learn about the basic properties of light interference and the working principle of an interferometer. Real images from the sites of the LIGO and Virgo instruments will be used to explain how modern-day interferometers are used to detect gravitational waves. Students will present their work to the class and discuss their results.

Gravitational Waves - Noise Hunting

The discovery of Gravitational Waves provided humankind with a new window to the universe, allowing us to probe extreme cosmic phenomena and testing nature at its limits. This scenario provides a step by step introduction to gravitational waves and their detection, introduces the concept of detector sensitivity and through a game-based approach, introduces students to the different noise parameters that affect detector performance.

Virgo Virtual Visits

This demonstrator introduces the concept of waves, interference, and the wave nature of light. Students are introduced to the history of the Michelson interferometer and the Michelson-Morley experiment, a groundbreaking experiment that led to Einstein's theory of special relativity. In an historical overview, they will learn how, more than a hundred years later, the same instrument was used to detect gravitational waves, thus confirming one of the main predictions of Einstein's general relativity. Students will experiment with a real small-scale Michelson interferometer, a powerful instrument that uses light interference to measure distances with high precision. They will learn about the basic properties of light interference and the working principle of an interferometer. Real images from the sites of the LIGO and Virgo instruments will be used to explain how modern-day interferometers are used to detect gravitational waves. Students will present their work to the class and discuss their results.

Learning Objectives

Students after the activities will be able to:

- ★ talk about GWs
- ★ explain GWs in their own words in discussions with peers
- ★ talk about Black Holes
- ★ represent GWs & Black Holes with spontaneous draws/models
- ★ represent the effect of GWs through role-playing (body moves)
- ★ create scientific articles
- ★ use digital tools and: a) design platforms, b) create avatars, c) insert hyperlinks & screen-shots into digital platforms
- ★ feel self-confident and self-efficient by presenting their work to the others
- ★ reflect their knowledge & thoughts
- ★ collaborate and be part of a team
- ★ participate in Physics contests
- ★ contribute to research & Citizen Science in the future.

Presentation for students

Teacher guidelines can be found in the notes attached to the following slides

Let's Start our Research Journey … !!!

students’ ideas

The teacher will try to detect students’ ideas about Black Holes by asking them to draw simple pictures and come back to this at the end of the project with the students to reflect on this.

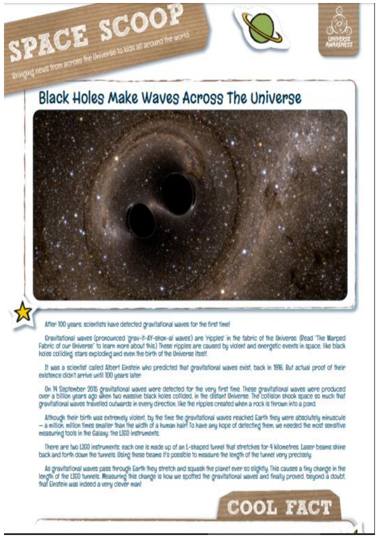
Children’s Ideas in Science

Edited by Rosalind Driver, Edith Guesne and Andrée Tiberghien

https://books.google.gr/books?id=GS_IAAAAQBAJ&pg=PR3&source=kp_read_button&redir_esc=y#v=onepage&q&f=false

students’ activities: orientation

1) **Intriguing students by using multiple stimuli.**
Students **read** Space Scoop Astronomy News for Kids: “Black Holes Make Waves Across The Universe” http://www.spacescoop.org/en/scoops/1605/black-holes-make-waves-across-the-universe/ and “The Warped Fabric of Our Universe” https://www.unawe.org/kids/unawe1331
Students **watch** the video “Gravitational Waves Hit The Late Show” followed by animated videos https://www.esa.int/ESA_Multimedia/Images/2016/02/Gravitational_waves and images https://www.esa.int/ESA_Multimedia/Images/2015/09/If_our_eyes_could_see_gravitational_waves.
Thus they are introduced in first step of the research inquiry – question positioning.
They wonder what GW are, which is the role of the laser, what is the space-time, what does “space-time ripple” mean etc.


SPACE SCOOP

Black Holes Make Waves Across The Universe

COOL FACT


SPACE SCOOP

The Warped Fabric of Our Universe

COOL FACT

students' activities: investigation

2) Then, the teacher and the students agree to conduct an investigation. In particular, students are asked to create their own avatar representing themselves as researchers conducting a Gravitational Waves survey and specifically, they hunt their noises. So, they create their own digital platform which is actually their digital laboratory where they come through all the research-steps. This procedure is enhanced by the creation of their digital identity text which is actually this platform.

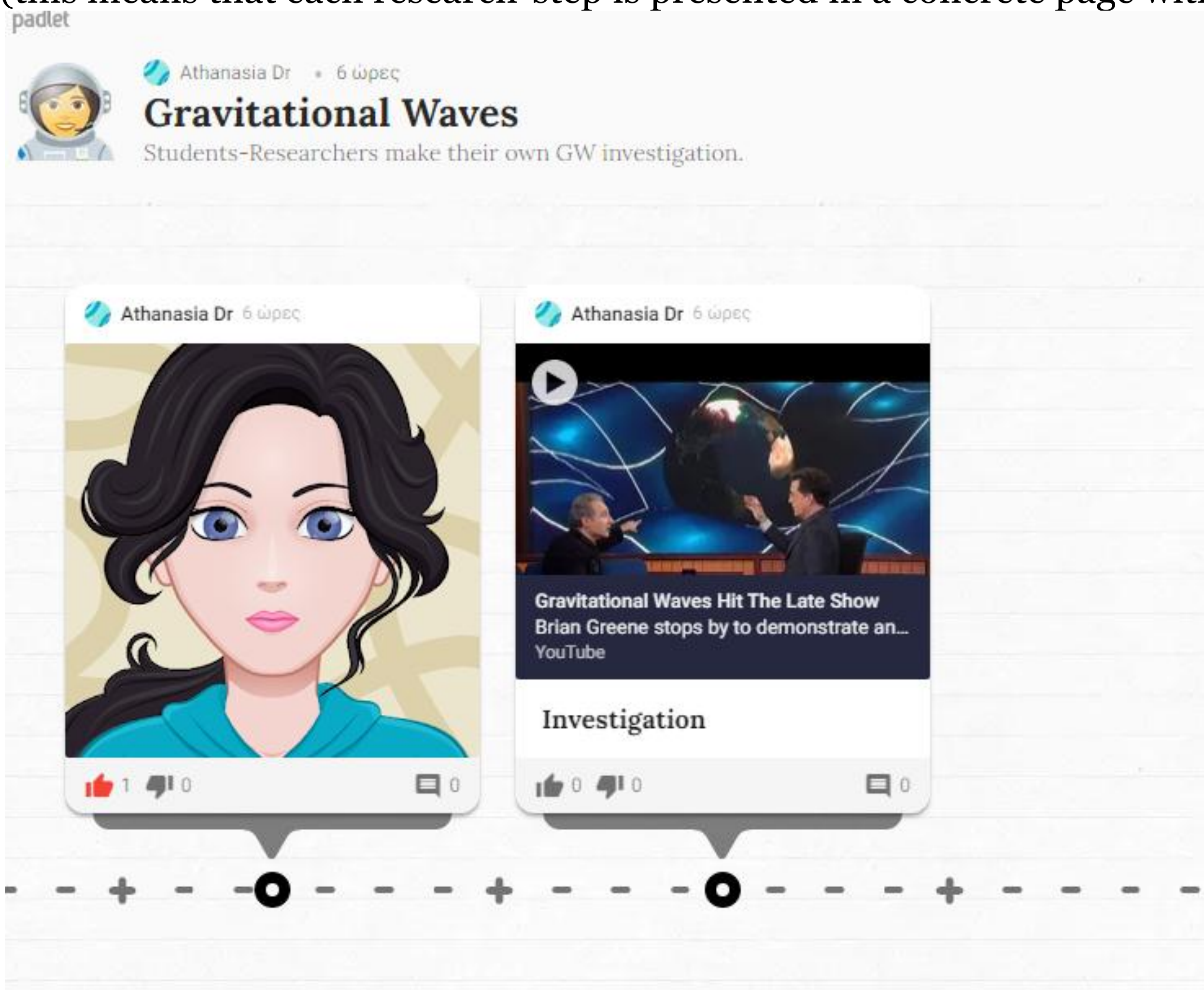
Research questions:

a) Why are gravitational waves important?
b) How can we detect gravitational waves?

3) Students enter the site of avatar maker https://avatarmaker.com/ so as to create their avatar representing them as researcher conducting the investigation. [a girl scientist selected to avoid gender-stereotypes]

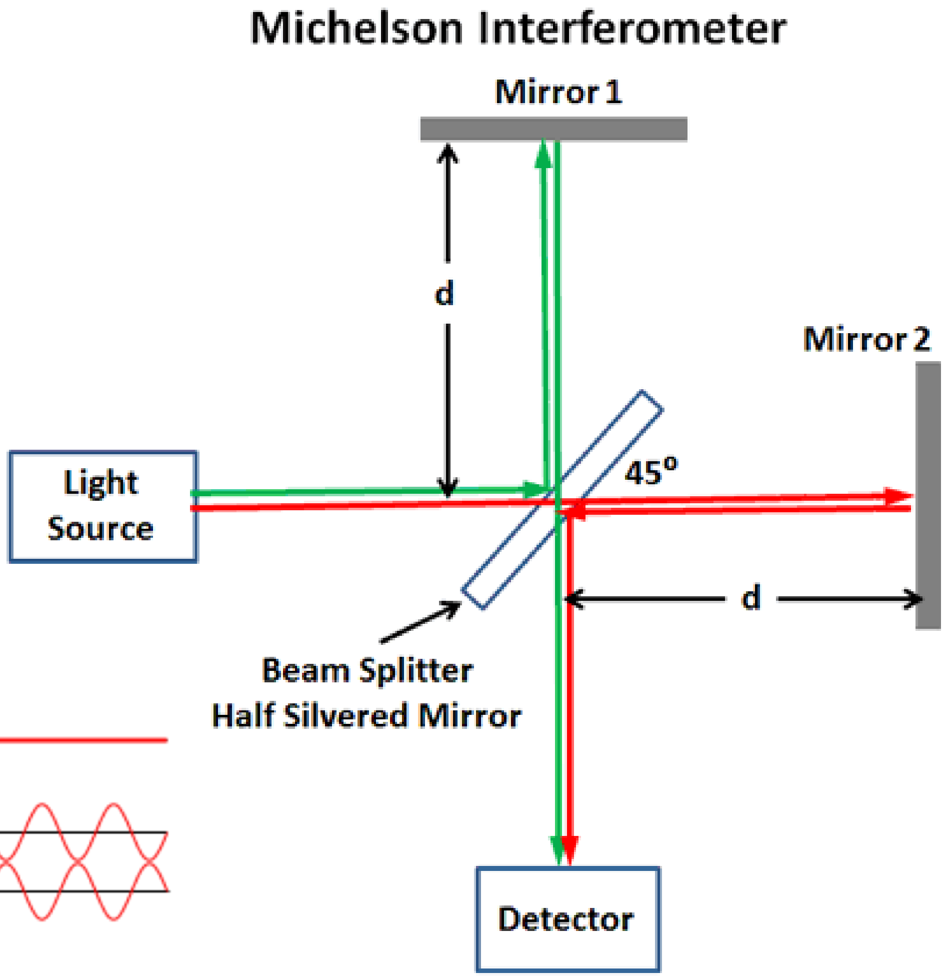
Students' activities: investigation

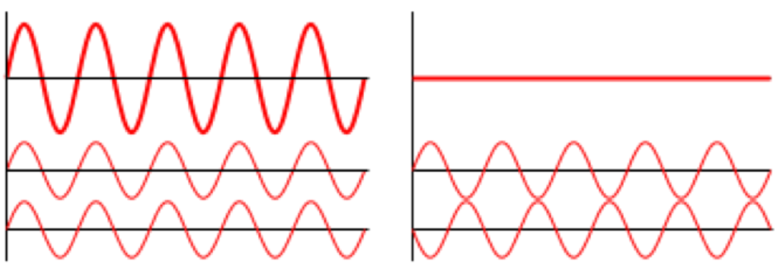
4) Learners create their **digital platform / laboratory** through the digital tool Padlet https://padlet.com/athanasia_kitty/dlr2aahmxme11gki (the teacher has already created an account and students just enter the site). The form they select is "timeline" in order to organize their research-process in chronological order (this means that each research-step is presented in a concrete page with order).



Students’ activities: investigation

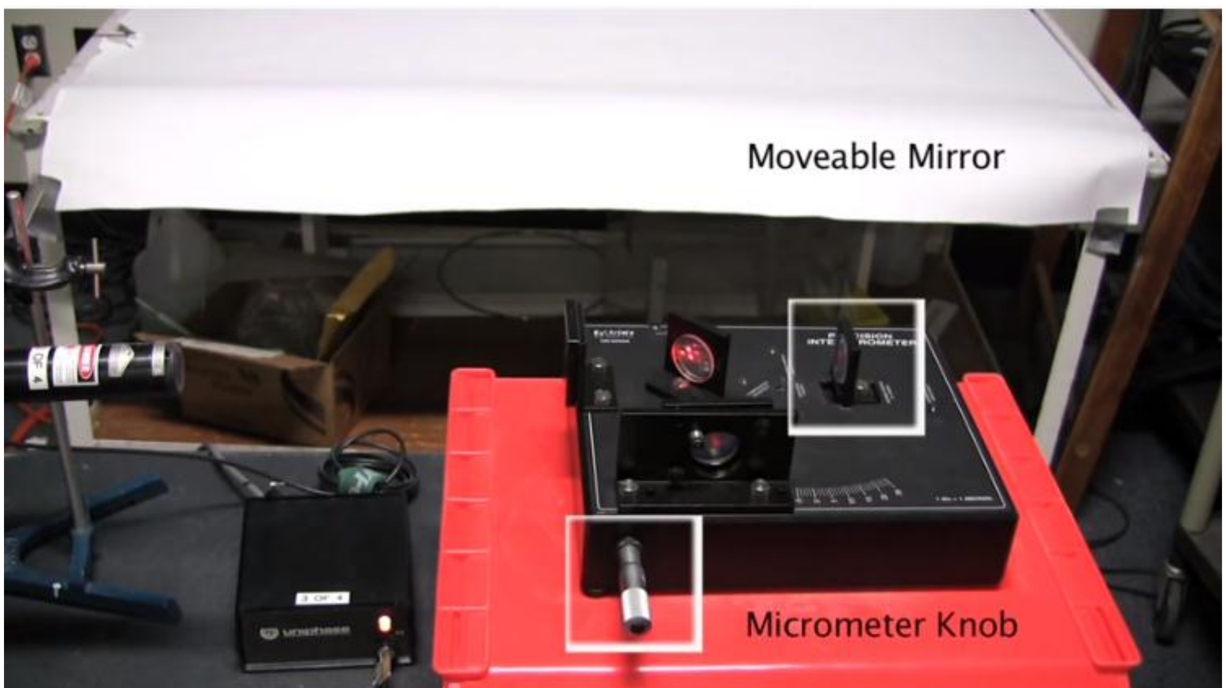
5) Selection of tools & methods: They search the Internet with the supervision of their teacher about detectors that identify GW signals. They choose the Michaelson detector.





Students' activities: experiments

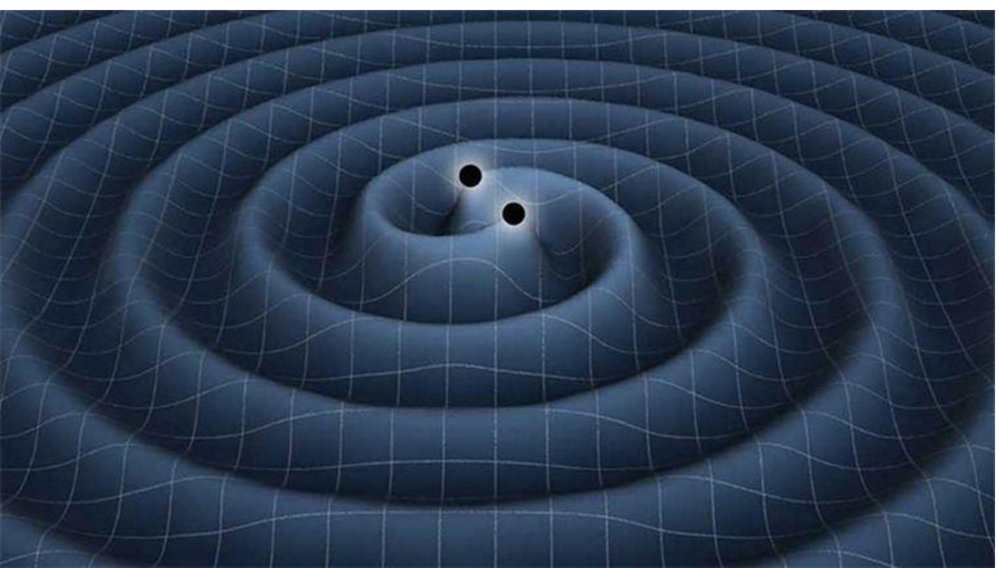
6) Experiments: Students use the Michaelson detector with their teacher and do real experiments in their classroom. The process of this experiment should be recorded – video capturing & photo-shooting – and this data will be inserted in their digital laboratory (platform). [They gradually form their digital identity text]. This source https://www.youtube.com/watch?v=j-u3IEgcTiQ also help them achieve the experiment.



It is worth noting that students need tangible evidence close to their senses, so as to understand and become aware of what are actually GWs. So, the following activities focus on serving visual, touching and acoustic stimuli that prove the existence of GWs.

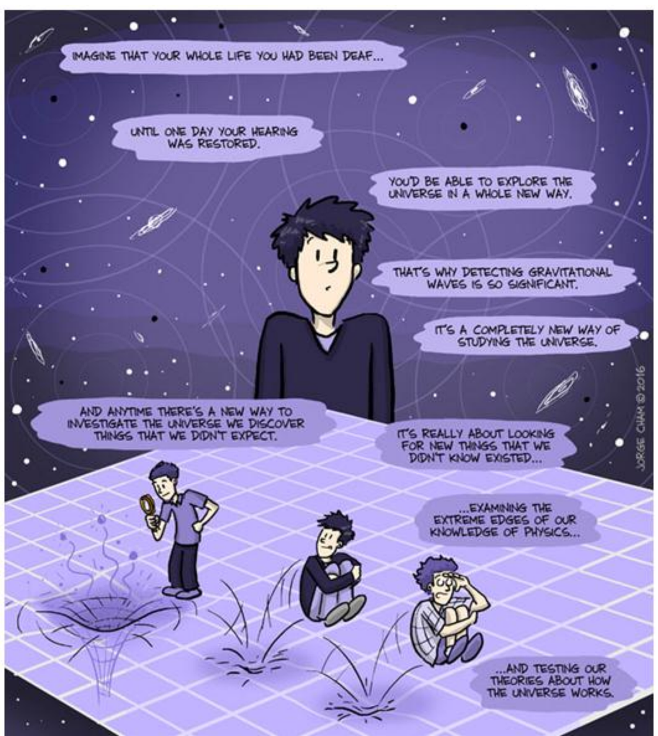
Students' activities: experiments

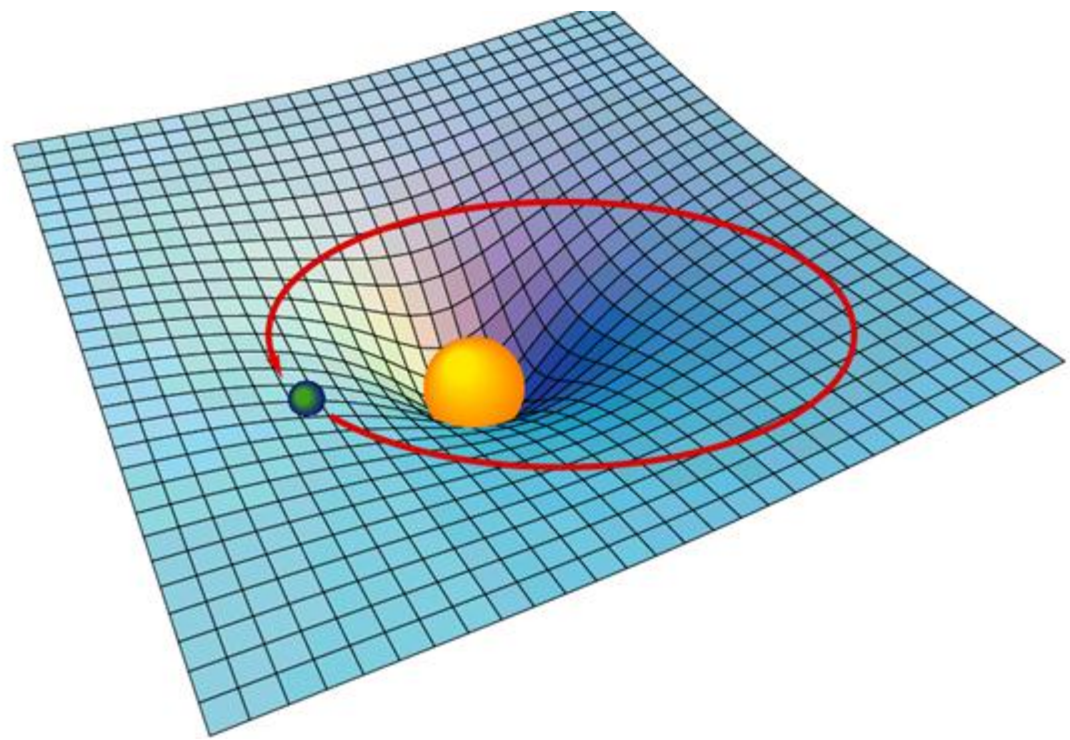
7) So, after detecting GWs, students return to their research-questions and try to approach and visualize the GWs. Thus, the teacher proposes them to play a game so as to provide them with tangible evidence of the GW. The educator uses a fabric https://www.google.com/url?q=http://www.scienceinschool.org/2013/issue27/blackholes&sa=D&ust=1595497698538000&usg=AFQjCNFx8IamYWVzuyXSX9KLtSe2ckXOww and balls to represent universe and the orbit of the planets / black holes.



Students’ activities: experiments

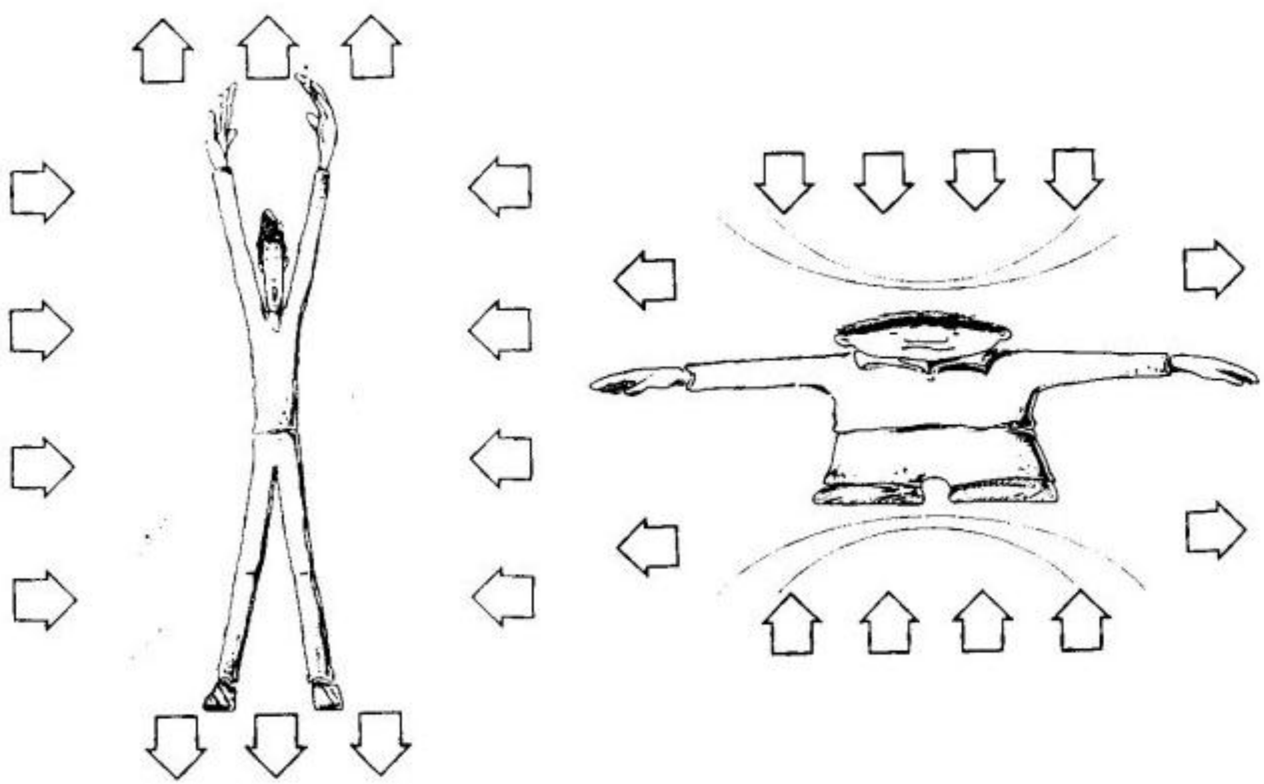
He/She also shows the first 2 pictures of this link: http://inspiringscience.rdea.gr/delivery/view/index.html?id=e4577e282ee5435cb08127bffcc7becb&t=p representing space-time. and the video: https://www.youtube.com/watch?v=s06_jRK939I depicting black holes, so as to preserve a useful feedback for the students, after their game with the fabric. (The whole procedure is recorded and the teacher takes photos of their students’ game and they are included in the digital identity texts/digital laboratory, while the pictures offered are also inserted into the platform).





Students' activities: experiments

8) Thereafter, trying to understand what is the effect of a GW passing through a body, the educators shows students the picture with the human body stretching and squishing through the link: http://inspiringscience.rdea.gr/delivery/view/index.html?id=b1c3501fd91341c7a1afc5cdd9dff455&t=p (The picture is also copy-pasted on the digital laboratory). Then, they play a role-play game; a student pretends to be the GW and another child the body affected by GW.



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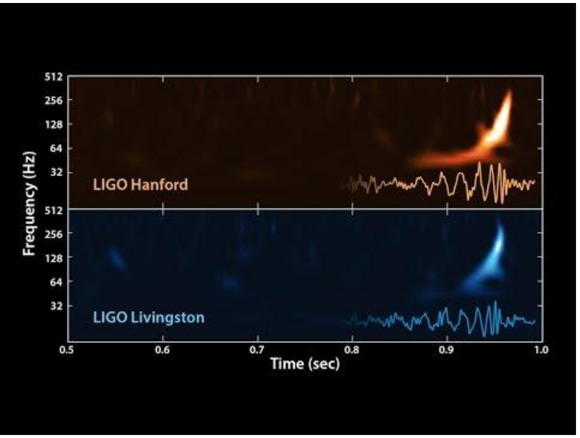
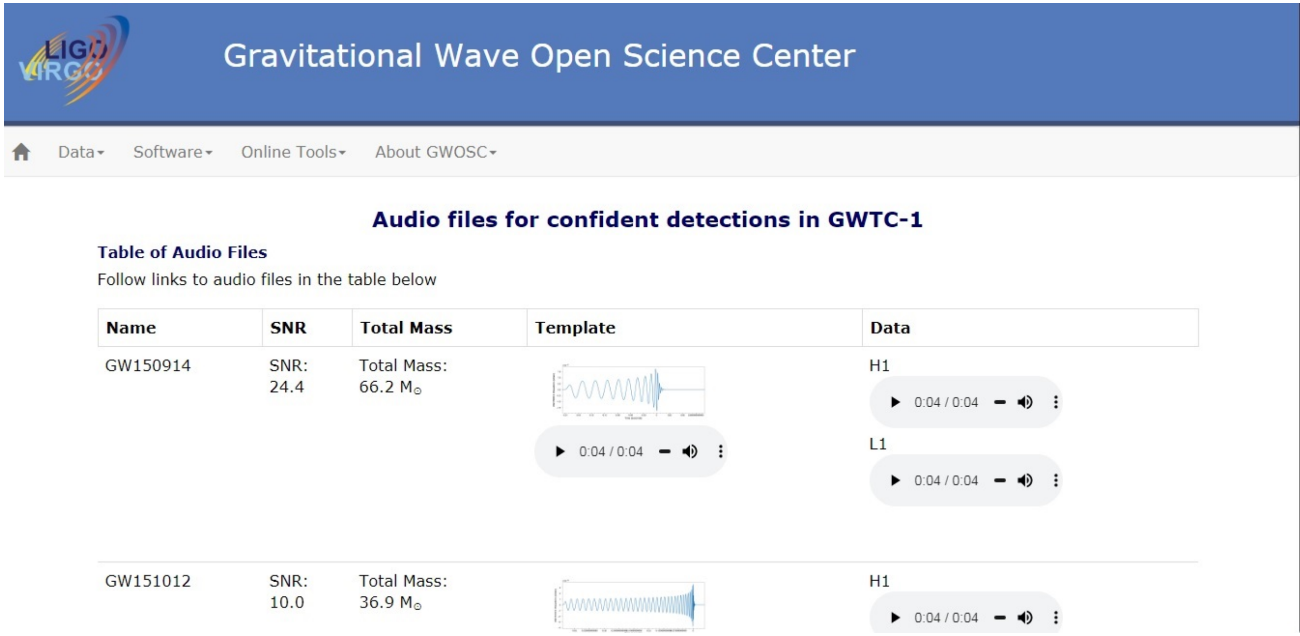
Students' activities: experiments

9) After that, children wondering about with which other senses is it possible to approach GWs will come up with the noise of the GWs; they listen to the chirp and discuss what they hear. Also, they listen to the changes of the sound of GWs. They insert the sounds to their digital platform.

https://www.gw-openscience.org/audiogwtc1/

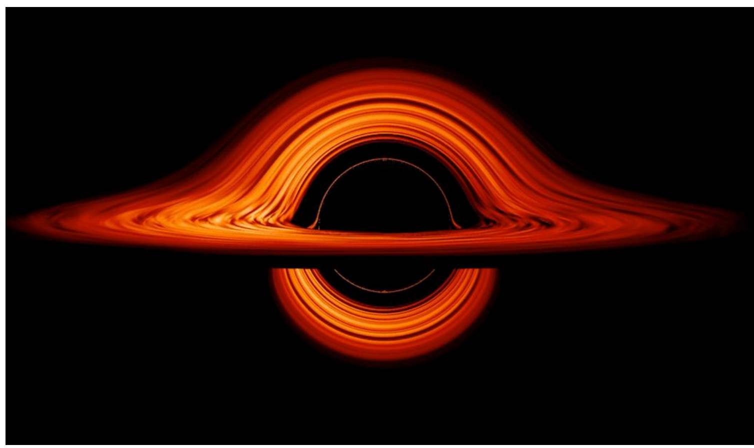




students’ activities: experiments

10) **Hands on Black Holes:** after watching and learning from NASA’s [Visualization Shows a Black Hole’s Warped World] Stydents will experiment with selected activities from the **“Black Hole Activities Booklet”** https://www.unawe.org/static/archives/education/pdf/Black_Hole_booklet.pdf :

- Paper model of black hole bending light.
- Detecting a Black Hole through Accretion

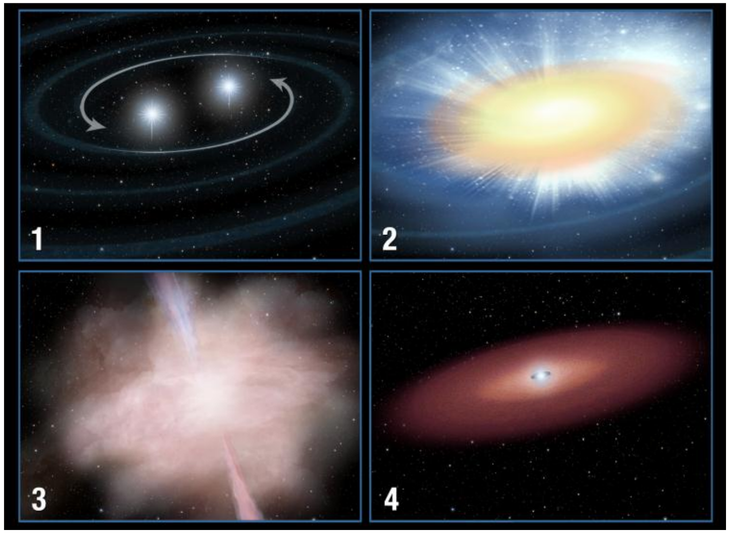


Students' activities: connection to real science

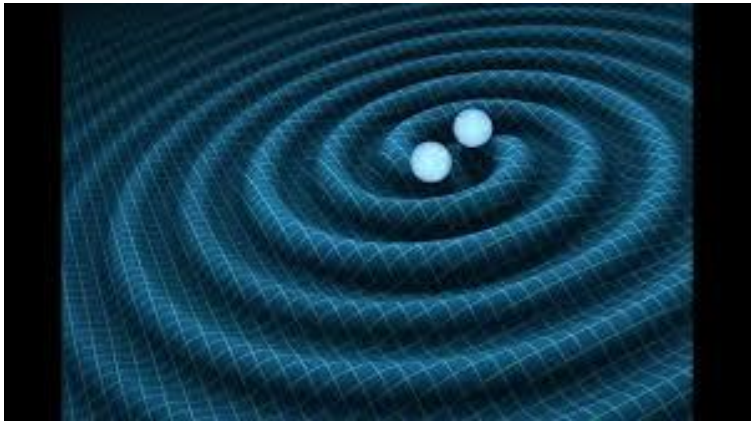
11) Teacher and students discuss about current means of detecting GWs – interferometers. They all decide to come into contact with VIRGO and do an online tour to the facilities, so as to connect real science with the already acquired knowledge (support of the English teacher). They also learn that this interferometer has the same use with the Michaelson detector.

students' activities: creativity

12) Then, students are asked to draw/make a model of GWs and post them on the digital platform, in an effort to visualize their new knowledge (support of the teacher of Arts).



https://www.ligo.org/science/Publication-S6OpticalResults/index.php

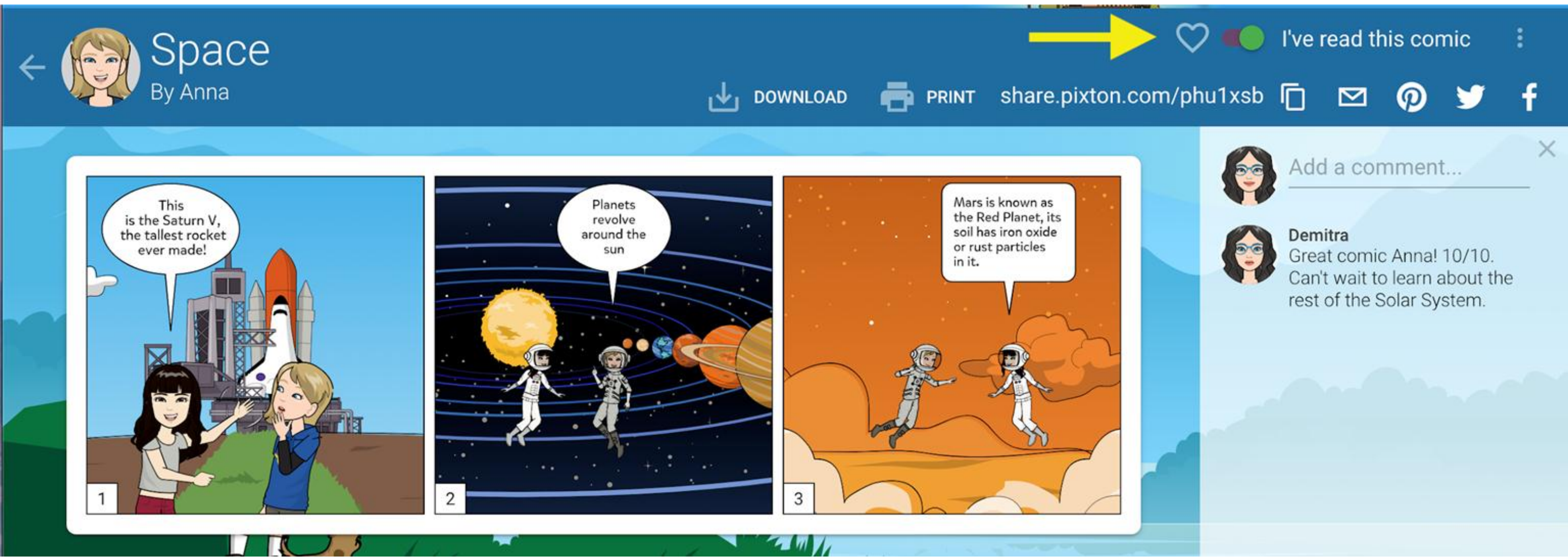


https://www.aei.mpg.de/63046/Gravitational_Wave_Modelling

https://www.sciencealert.com/ligo-discovers-backwards-spinning-black-holes-in-yet-another-set-of-gravitational-waves

Students' Activities: Creativity

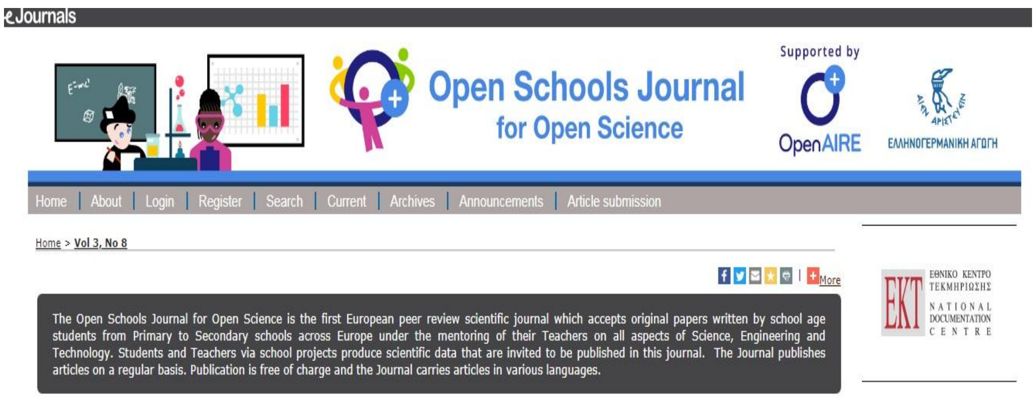
13) Finally, they write their own ***digital identity texts*** using Pixton, Story-Bird or Story-Board to depict/reflect their experience and explain on their own words what GWs and black holes are. These are inserted into the digital platform through (hyperlinks and) screenshots. All the digital identity texts will be edited into a ***booklet***, that will be posted in the **blog** of their school and shared through ***educational channels.***



The Booklet and digital identity texts will be **presented** in the ***whole school community*** and shared through educational **channels**, so that they show their work and **share their new knowledge.**

Students' activities: creativity

14) Students write and their own scientific articles regarding to their experience and work. They will post them on the newspaper of their school and publish it https://ejournals.epublishing.ekt.gr/index.php/openschoolsjournal/index



Open Schools Journal For Open Science

<u>Usability & Potential:</u> a) This educational scenario might be expanded and be part of an e-Twinning program associating the learning product with other schools. b) Students searching for the factors affecting detectors come up with the glitches and they play the game "Gravity Spy – Glitch Hunting".

eTwinning

Thank you very much for your attention!!!

Any Questions?