Education and Heritage in the era of Big Data in Astronomy
Proceedings IAU Symposium No. 367, 2020
R. M. Ros, B. Garcia, S. R. Gullberg, J. Moldon & P. Rojo, eds.
doi:10.1017/S1743921321000739

NASE Workshop: Eclipses and Gravitation Lenses

Rosa M. Ros[1], Beatriz García[2], Ricardo Moreno[3], Noorali T. Jiwaji[4] and Mahdi Rokni[5]

[1]NASE president, Polytechnical University of Catalonia, Barcelona, Spain, email: rosamariaros27@gmail.com

[2]NASE vicepresident, ITeDA (CNEA, CNCE, UNSAM) & UTN, Mendoza, Argentina,

[3]NASE Secretary, Retamar School, Madrid, Spain,

[4]Open University of Tanzania, Dar es Salaam, Tanzania.

[5]ITAU, Bushehr, Iran,

Abstract. Astronomy is connected with the every day experiences of the people, since the observation of simple and repetitive phenomena, as the succesion of days and nights, untill events of high impact, as the total solar eclipses. In this sense, the Astronomy is a fascinating activity and can be used to inspire interest in sciences in general. In this contribution, we introduce the Network of Astronmy School Education as part of the IAU proposals connected with teaching training programs, and we highlight several examples on the specific topic of the eclipses: their importance and connection with the culture, that can capture students attention if we use the workshops as part of the classes.

Keywords. education of astronomy, eclipses, gravitational lens, NASE program

1. Introduction

The Network for Astronomy School Education, NASE, is a Working Group of the IAU-Commission 1. In the period 2010-2020 NASE has organised 205 training courses for secondary school teachers in the language of their countries. Currently NASE is present in 50 countries in Africa, America, Asia and Europe.

The program promotes Astronomy Education mainly at secondary and high school and in some cases at other levels, in order to:

(*a*) Encourage interest in science.
(*b*) Promote teaching innovation.
(*c*) Stimulate scientific vocations.

These three objectives are achieved by promoting innovative classroom activities, models and direct observations, trying to stimulate not only interest and reflection, but also the excitement and surprise in its execution, highlighting values and attitudes such as:

- Humility (it is necessary to recognize that in some cases we are wrong)
- Prudence (it is necessary to check and to verify)
- Rigor (it is not possible to be superficial)
- Constancy (it is not good give up)

In all the cases, the activities take into account the impact on the ecosystem, through special emphazis on climate change and light pollution.

In general, NASE presents all the main topics related with Astronomy and Astrophysics in the school, from the most common ones as eclipses and Moon phases, to those much more motivating such as exoplanets, neutron stars, black holes, pulsars and habitability zones among others.. The program attempts to make that students enjoy the emotion of understanding of the phenomena and the inter- and multidisciplinarych aracteristics of the Astronomy. Under this framework, this proposal not only gives information about science, but also intends to educate future generations for a new era of great discoveries.

Finally, as this symposium was coordinated with the total solar eclipse of December 14th, 2020, visible in Chile and Argentina, NASE prepared this workshop about some educational aspects on this topic and highlight its science and observational aspects.

2. Eclipses as gravitational lenses

Eclipses and transits are a special phenomena that offer humanity the opportunity to get knowledge from the Universe. In particular, the eclipse of May 29th, 1919, was the occasion showed that Einstein relativity theory was correct. Arthur Eddington measured the deviation of the position of stars whose rays passed close to the Sun. It confirmed Einstein's prediction about the geometric modification (curvature) of space, caused by the presence of the Sun (Ros, 2008)

The workshop shows a simple model of the visibility of a star almost aligned with the Sun during an eclipse. The Sun acts as a gravitational lens that curves the space around it and hence the light path from from the stars to the Earth. In 1936, Einstein published a short calculation showing that if two objects at different distances coincided exactly in the sky (are aligned), the image of the farthest would form a ring. He predicted that a foreground star could magnify the image of a background star. He was skeptical that-such a mirage could ever be seen and he dismissed the lineup as too unlikely to be of interest. In the last decades this topic became more and more important, because gravitational lensing enables high-precision mapping of dark matter distributions in galaxies and galaxy clusters, and, in this sense there are also demonstrations that can be used in the classroom (Huwe, 2015).

2.1. *Gravitational lens effects*

Light always follows the shortest possible path between two points. But if a mass is present, the space becomes curved and the shortest path between two points is a curve in the same way that when we are moving on the planet surface the minimum distance between two cities over the terrestrial sphere is an arc and not a straight line (Fig. 1) (Moreno, 2017).

Gravitational lenses produce four different effects:

Position changes and Multiplication: The deflector curves the light from the source and shifts the apparent position of the source (star or quasar). It also produces two or more images (Fig. 2). The gravitational lenses are not perfects lens and can produce multiple images and in some cases can produce the Einstein Cross.

Deformation and Magnification: When the source is an extended object (i.e. a galaxy), the result is a set of bright arcs. If the system is perfectly symmetrical, the rays converge and the result is a ring, knowing as the Einstein Ring (Fig. 3).

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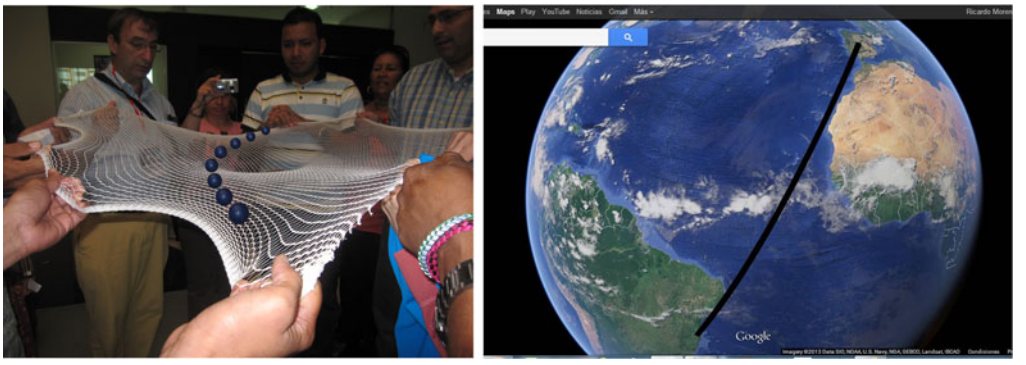

Figure 1. a)The path of a ball on a curved surface is not a straight line b) The path between two points on the globe is a curve.

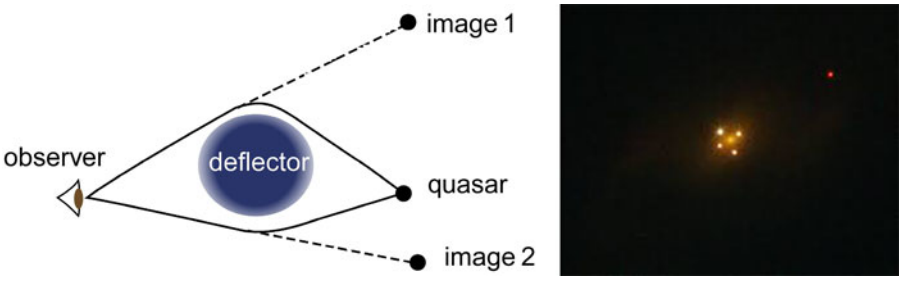

Figure 2. a) Bending of light from quasar by a deflector; b) Galaxy UZC J224030.2 032131, Credit Hubble Telescope NASA/ESA.

Figure 3. a) Bending of light from quasar by a deflector b) Galactic Cluster CL0024+1654 c) Galaxy LRG 3-757, Credit Hubble Telescope NASA/ESA.

2.2. *Simple model of gravitational lensing*

The proposed activity offers the production of a simple model of a gravitational lens using a glass goblet such a wine glass. The optical effects obtained with this piece of glass are similar to a gravitational lens. To develop this model there are two options:
1) the foot of a glass of goblet (Fig. 4), which acts as the deflector (star or galaxy or cumulus of galaxies in the Universe) and a grid paper, to see the effect of the lens; and
2) the glass of goblet with a traslucent liquid inside (which acts as deflector) and a light that crosses the glass (that will follow the path that indicates the deformation of space) (Fig. 5) (Moreno, 2017).

The foot of a glass goblet on a paper shows how the straight lines on the paper change to curved lines around the central point of the foot. Using both models, we can get easily arcs, Einstein rings and and with just a little difficulty the Einstein cross. After the demonstation, it is posible came back to the eclipse of 1919, or in general to all the eclipses. The changes in the astronomical coordinates of a very well know star that can

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Figure 4. a) The foot of a goblet on a graph paper showing the b) Einstein rinng by means of the foot of a glass.

Figure 5. a) The glass of goblet with a liquid inside and the light of the mobile phone b) Images mutiplied where the central light appears in other places in a shape similar to a cross or a ring (the central light is actually not possible to observe when the deector is an opaque body).

be observed near the Sun is an evidence of the action of the Sun on space, the Sun is acting as a gravitational lens (Ros, 2008).

3. Conclusions

Eclipses are a fascinating field in Astronomy and a shocking phenomenon for society, wich can be used in education not only as a natural phenomena, but also as one of the oldest recorded events visible from the Earth without technology. The example of gravitational lens presented here is innovative not only as part of NASE program, but also as part of possible new approaches to science in the schools. In this sense, it is important to introduce in the school the topics that appear in the newspaper and media and try to pesent in some way the concepts in an adequate level. As was shown in this contribution, it is possible to teach and learn by doing, and it is necessary to start training new teachers for new students who in the near future will demand new teaching methods within the framework of knowledge that is expanding dramatically.

References

Huwe, P. & Field, S. 2015, Modern Gravitational Lens Cosmology for Introductory Physics and Astronomy Students, The Physics Teacher 53(5):266–270

Moreno, R., Deustua, S., Ros R.M. 2017, Expansion to the Universe, 14 steeps to the Universe. Astronomy course for teachers, (Rosa R.M. & García B. ed.), 2nd edition, NASE, UAI, 139, 141 *Antares*

Ros, R.M. 2008, Gravitational lens in the classroom, *Physics Education*, 43, 5, 506, 514.

https://doi.org/10.1017/S1743921321000739 Published online by Cambridge University Press