Herschel experiment: the discovery of the infrared

The purpose of the International Day of Light is to provide an annual focus to continuously appreciate the central role that light plays in the lives of citizens on the world in the areas of science, culture, education, sustainable development, and in fields as diverse as medicine, communications and energy.
2019 calls us to participate with various activities of a new global call: the celebration of the centenary of the International Astronomical Union (IAU)

NASE's proposal to celebrate the International Day of Light globally, which recalls the day when a laser beam created by the human being was first lit in 1960 and in turn the Centenary of the IAU, wants to highlight those regions of the electromagnetic spectrum that are not detected with the eye, recreating the historical experiment made by William Herschel in 1800, any day of the month of May in 2019.

THE RESULTS MUST BE SENT IN AN EXCEL SHEET TO:

rosamariaros27@gmail.com
beatrizgarciautn@gmail.com

International Day of Light (May 16)
1919- 2019 – 100 years of the IAU

NASE GLOBAL: Infrared Detection

Introduction

What we normally call light is actually a basic form of energy: Electromagnetic Energy. Light is only a small region of these energies, which our eye can detect. Beyond the visible region of the spectrum, which extends from the violet (high energy, high frequency, short wavelength, about 400 nano meters - 1 nm equals 10^{-9} m) to red (low energy, low frequency, long wavelength: 780 nm), there is radiation of enormous importance, either for astronomy or for everyday life.
In Figure 1 it can be analyzed how celestial objects change when they are studied in different regions of the spectrum.

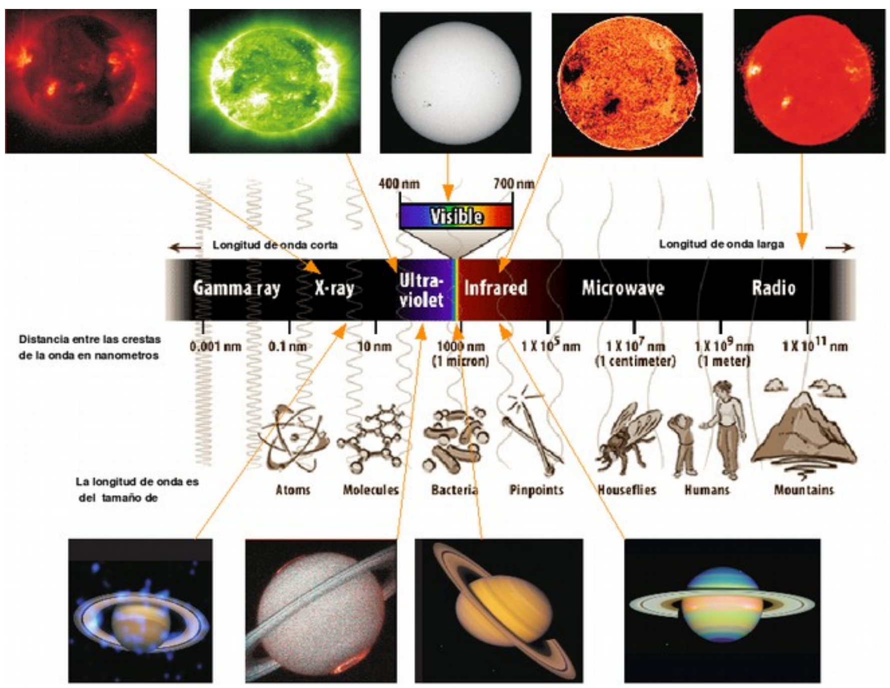
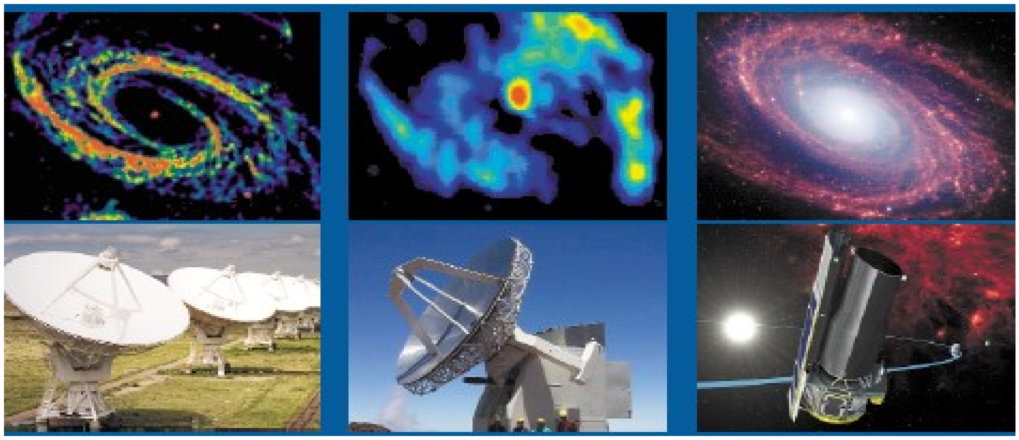


Fig. 1. Electromagnetic Spectrum with objects of wavelength size. The Sun (top) and Saturn (bottom) observed in different wavelengths (false colors).

The spectrum in Astronomy

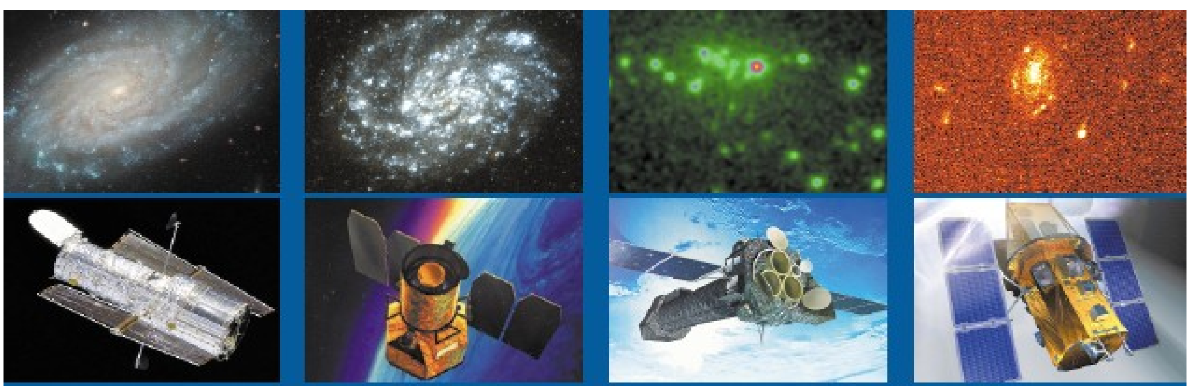
Different types of light give us different clues about the universe and require different types of telescopes.



RADIO WAVES,
Longer wavelengths are detected by large antennas on Earth, such as the Very Large Array in New Mexico. The sky of the radio is dominated by clouds of gas in our galaxy and by the amazing relativistic jets of matter that escapes from quasars in distant galaxies

SUBMILLIMETRIC RADIATION,
A new domain for astronomers, is studied from satellites and from the highest and driest places on Earth, like Mauna Kea of Hawaii. In this band complex molecules are studied in the coldest and darkest clouds in our galaxy, as well as the faint glow of the Big Bang

FAR INFRARED
Can be detected only from space observatories Like the Spitzer Space Telescope. Distant infrared sources are dust grains grouped around the Birth places of stars and planets



VISIBLE or OPTICAL, NEAR IR
The traditional ones of astronomy. Our eyes evolved to see the light of the Sun that can go through the atmosphere of the Earth; in mountaintops above the clouds, modern detectors can also see the near IR. In these wavebands, stars and gas clouds reveal their glory in images of Earth, such as those of the Keck Telescope in Hawaii from space, like those of Hubble and also through binoculars in the backyard of the house

ULTRAVIOLET LIGHT
It is the signature of young hot stars and the violent winds that flow of them. Beautiful new Images from satellites, such as NASA's GALEX, reveal the ultraviolet skeleton of galaxies,
These images are fused with Spitzer's infrared view to complete our image of the formation and evolution of the stars.

X-RAYS
Radiation that is beyond the UV. Each X-ray photon It has hundreds of times the UB radiation energy that causes a Sunburn, but the Earth's atmosphere protects us from them. Space telescopes such as Chandra from NASA and the XMM-Newton from the European Space Agency provide access to the X-ray sky, which shines with the light of exotic objects such as stellar explosions and black holes.

RAYS GAMMA RAYS
The highest energy. Satellites (like the Swift), globes and telescopes on the ground, begin to reveal their secrets. The mysterious gamma rays associated with the most violent explosions in the universe, motivate the rapid advances in this field.

The infrared

The infrared region of the electromagnetic spectrum was discovered by William Herschel (the discoverer of the planet Uranus) in 1800 using a prism and thermometers. He designed an experiment through which it is possible to obtain the visible spectrum, by passing the white light of the Sun through a prism, where the spectrum is displayed 3 thermometers are placed, one in the blue region, another in the red one (both colors detectable by the eye) and the third thermometer beyond red, immediately after. To show that something is happening with the thermometer that is beyond the visible limit of low energy of the spectrum, beyond the red, the room temperature is controlled with a fourth thermometer. In conducting this experiment, Herschel discovered that the temperature that marked the thermometer in that area was greater than that of the environment.

Herschel made other experiments with this radiation, related to heat (the IR is what raises the temperature of objects and any object at any temperature emits in IR) which he called, for that reason, "calorific rays". He discovered that they could be reflected, refracted, absorbed and transmitted like visible light. These "calorific rays" were later called infrared rays ("below" red) or infrared radiation and their discovery allowed the development of several (and today very common) technological applications, such as the infrared LEDs of the remote controls, thermography and , of course, infrared detectors to observe the cosmos.

The bodies that are at low temperature do not emit in the visible region of the spectrum, but in longer lengths, of lower energy. For example, our body and that of animals emit infrared radiation that we do not detect with the eye, but that we can perceive as the heat emitted by the organism. Thermal imaging (thermography) is a technology which has become exploited in clinical medicine, with uses ranging from general health care to detecting circulatory ailments and tumors.

The Figure 2 presents on the left a thermal profile showing the contrast between various sites on a human head, with the ear canal and temple being closer to the normal core body temperature than the more exposed ear lobe and nose, and to the right shows the patient's hands slowly warming up after being cooled in water. The technique is used to test for conditions which lead to poor circulation.

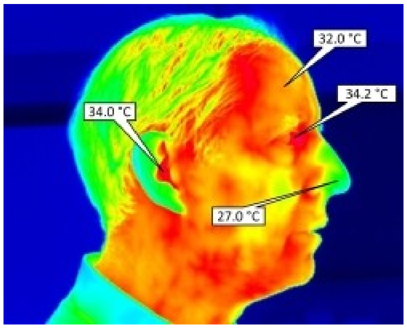


Fig. 2. Thermography of the head (left) and cold hands (right)) (Source: National Physical Laboratory, UK)

Herschel experiment: Infrared (IR) discovery

The proposal of NASE to celebrate globally the International Day of Light, which remembers the whole planet on the day when a laser beam created by human beings was first lit (https://www.lightday.org/), is to highlight those regions that are not detected with the eye, but are forms of electromagnetic energy and stop them, recreating the historic experiment of 1800, by which the famous astronomer William Herschel discovered a form of radiation other than visible light.

The experiment must be done outdoors, on a very sunny day. If there is a lot of wind, the experience can be done inside, near a window through which the Sun light enters directly.

Necessary elements:

- a prism of glass,
- four thermometers, of those used in the chemistry laboratory,
- permanent black ink marker,
- scissors,
- Scotch tape,
- a cardboard box,
- a white sheet.

Procedure:

1. Wrap the thermometer bulbs with tape and paint them with a black marker to absorb heat better.
2. Place a white sheet in the bottom of the cardboard box.
3. Install the prism carefully on the upper edge of the box, so that it is on the side of the Sun. The inside of the box should be all or almost all in shadow (figures 3 and 4).
4. Rotate the prism carefully until the widest possible spectrum appears on the sheet at the bottom of the box.

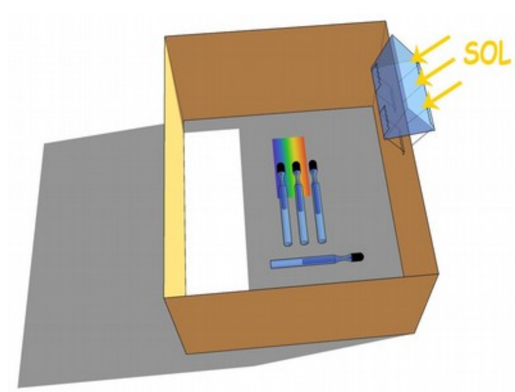


Fig. 3. Herschel device. The thermometers in the spectrum mark higher temperature than the temperature of the air.

5. Secure the prism in that position with adhesive tape.

Place the three thermometers in the light of the spectrum, so that each bulb is in one of the colors: one in the blue region, another in the yellow and the third a little beyond the visible red region (Figure 5) .

You must be able to see the graduated scale well. Not to move the thermometer when measurements are taken. The fourth thermometer must be installed and fixed in the shadow, not aligned with the previous ones (Figure 3).

7. Register the place where the experiment is performed.
8. Register the hour when the experiment starts.
9. Record each minute the temperatures in each of the three regions of the spectrum and in the environment, in Table 1.
10. Register the hour when the experiment finishes.

The temperatures take about five minutes to reach their final values. Do not move the thermometers from their position in the spectrum or block their light.

Fig.4: Placing the 3 thermometers, with the black bulb and the spectrum in the shadow.

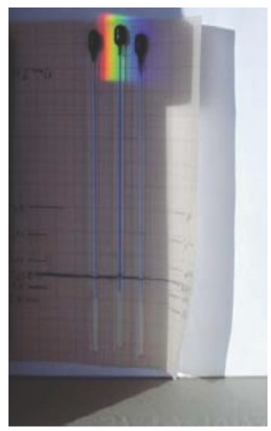


Fig.5: The thermometers in the blue, the yellow and just beyond the red.

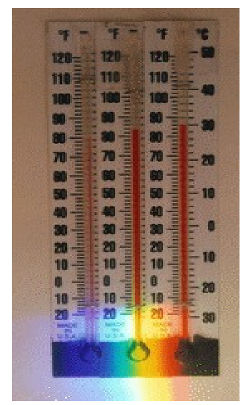


Fig. 6: Example of measurements after 3 minutes.

Table 1: Data Table

Start-time: **Ending-time:** **Site:** **Lat.:** **Long:**	Thermometer nº 1 in the blue	Thermometer nº 2 in the yellow	Thermometer nº 3 beyond the red	Thermometer nº 4 in the shadow
After 1 minute				
After 2 minute				
After 3 minute				
After 4 minute				
After 5 minute				

Results

The thermometer in the yellow (Figure 6) should mark a temperature somewhat higher than in the blue and in the environment, and the one that is close to the red should mark a still somewhat higher temperature: if so, it is possible to deduce that the thermometer next to the red one arrives to him some type of radiation of the Sun that is invisible to our sight.

The results will be shared globally among the participants in this proposal.

The tables must be sent in excel format to:

rosamariaros27@gmail.com
beatrizgarciautn@gmail.com

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- Chandra X-ray Observatory http://chandra.harvard.edu/about/
- The Fermi Gamma-ray Space Telescope http://fermi.gsfc.nasa.gov/
- IAU-100 Years Under One Sky, http://www.iau-100.org