UNIT 1:

INNER PLANETS – OUTER PLANETS

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ACTIVITY 1:

SIZE ESTIMATION OF VENUS AND PHASES CALCULATION

OBJECTIVES

In this activity we will use astronomical images obtained with the Liverpool Telescope. We will familiarise with typical astronomical images, we will learn to use the basic tools of the image analysis software, and obtain an estimation of the physical size of a planet. We will also observe the change in appearance of a planet, both on size and phase, over the months.

INSTRUMENTS AND MATERIALS

For this practice we are going to use selected images from Venus obtained in different dates with the Liverpool Telescope at the Roque de los Muchachos Observatory, in the island of La Palma (Canary Islands, Spain). The images are contained in the folder */Venus/* in the website **www.iac.es/peter**. For processing them we will use the "peter_soft" program, which can be downloaded on the same website and installed in your computer. The tool we will use the most is the one for measuring distances.

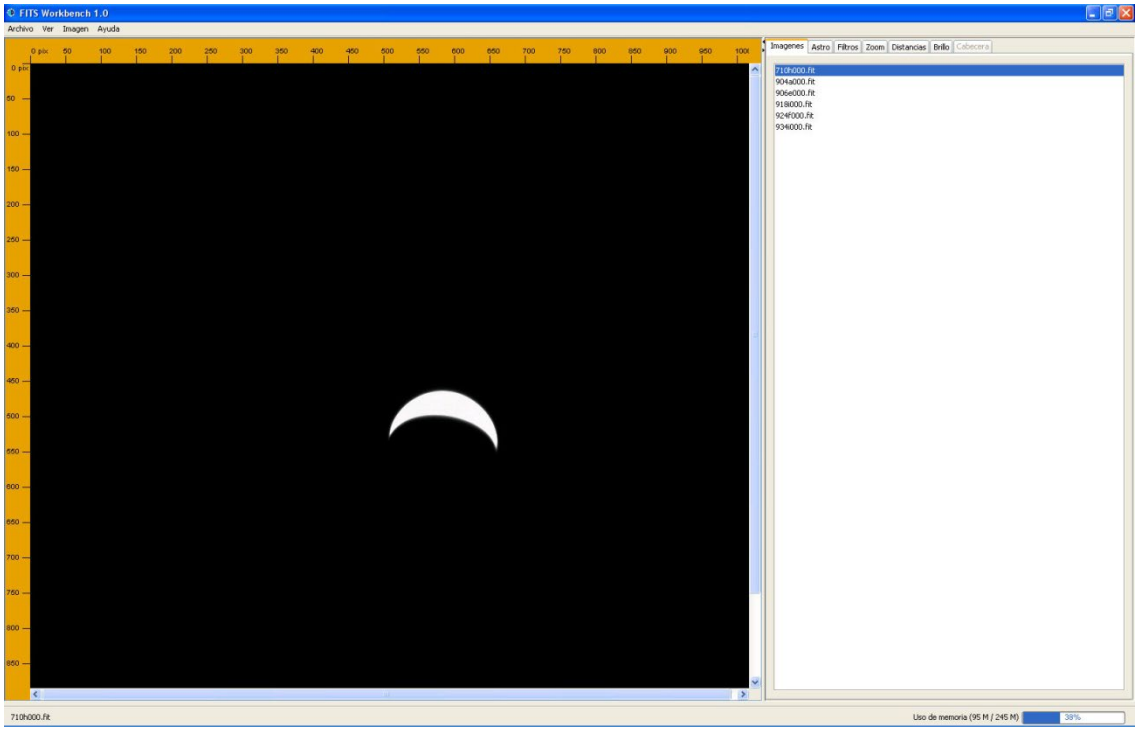
METHODOLOGY

We will examine each astronomical image and measure the planet size, as well as the part of the planet that is illuminated in order to calculate its phases. We will obtain a data table that will be represented on graph so it can be deduced the size variation of the planet depending on its distance to us, as well as the phase variation as it moves away from us.

PROCEDURE

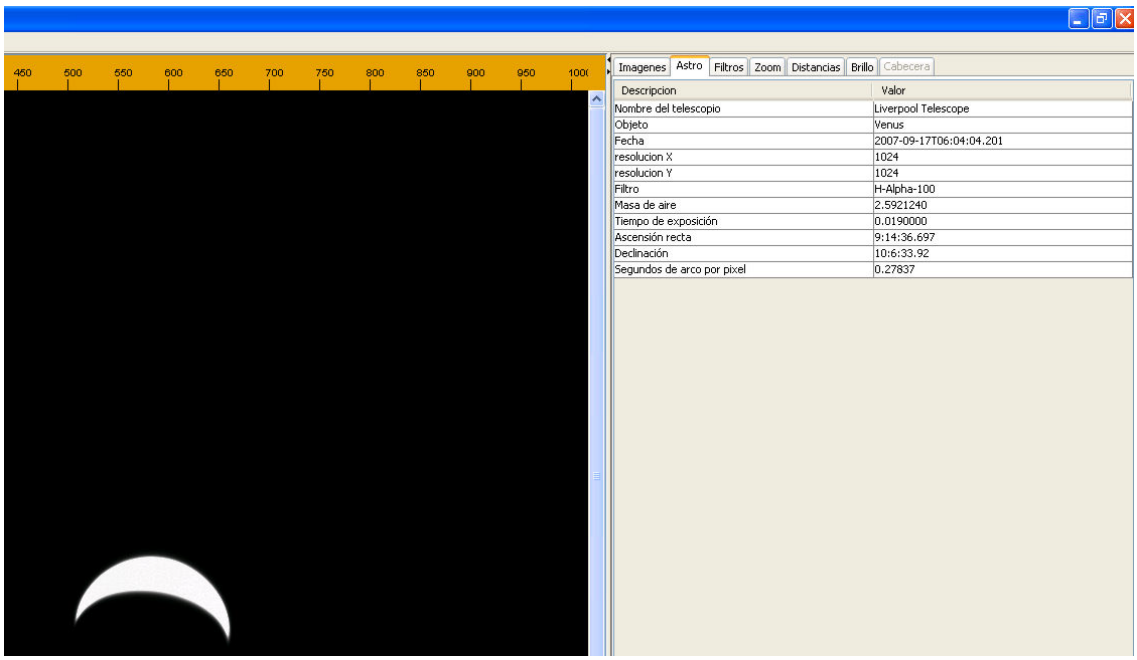
1st part. Diameter of Venus

The first thing to do is to download and unzip in our computer the file *U1_imagenes_Venus.zip,* which contains all images for this activity. Then we will run the "peter_soft" image analysis program and we will open the files with the images. To do this, we must click on the "Archive" tab and then "Open file". The maximum number of images we can open at the same time is around 15.

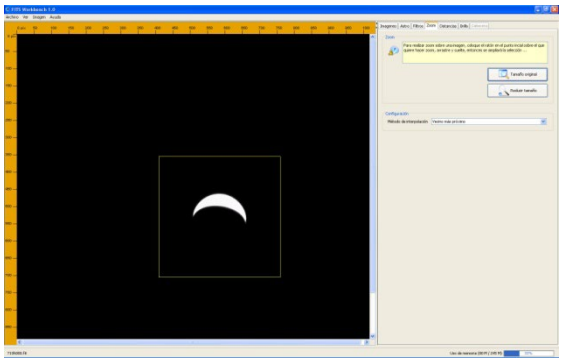


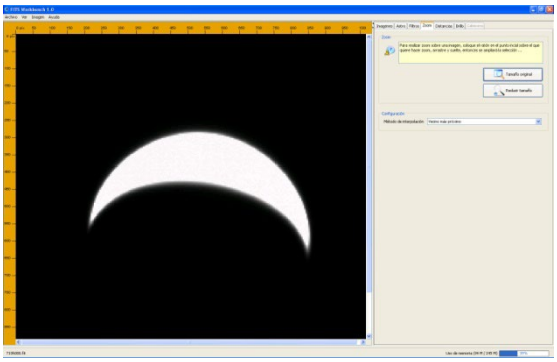
Once we have loaded all the images in the program, we can obtain information of each of them by clicking the “Astro” tab on the right: date and time at which the image was taken, as well as the used filter, exposure time in seconds, the arcsec/pixel scale, etc. This information, together with the measurements we are going to obtain, is very important as this will help us to get the necessary data for the purpose of this practice.

Have you opened one of the images and you see nothing? Please be aware that the object we want to study, Venus in this case, may not be in the centre of the image. In the “Zoom” tab you can increase the viewing window or reduce the image size to see it in full.

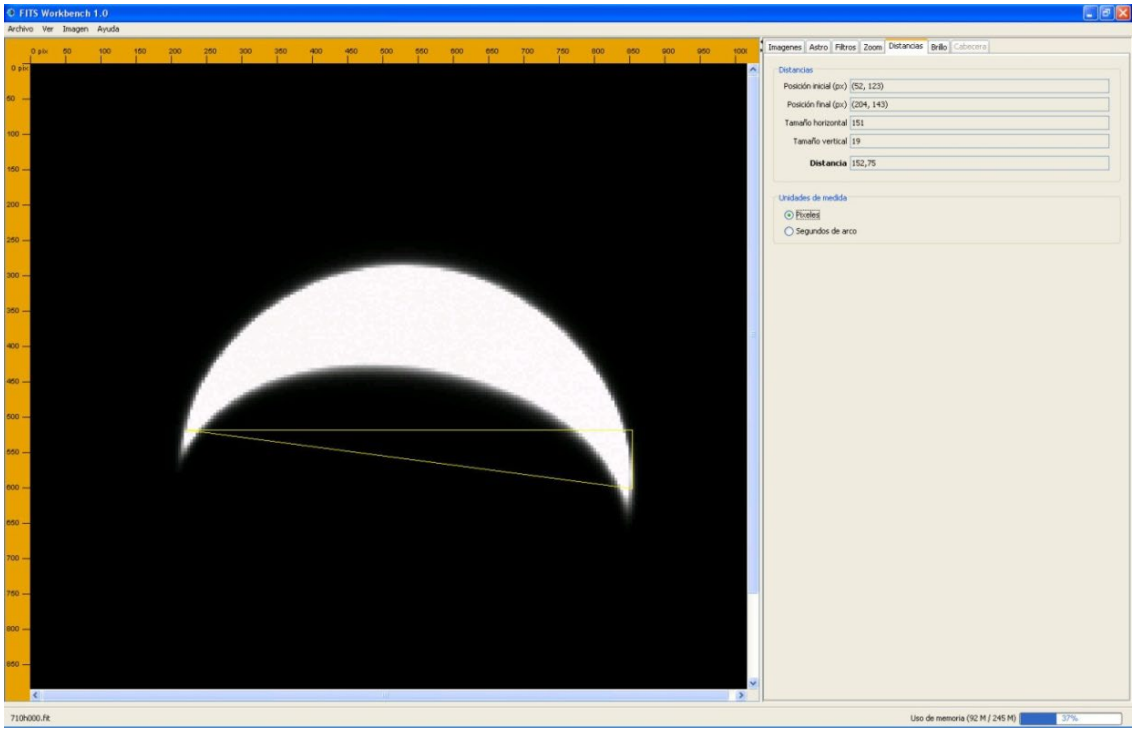


To increase the area we want to study (in our case, the planet) we must click on the “Zoom” tab and, with the left-hand mouse button pressed, we make a square around the planet in order to increase the specific area for our measurements.





By using the measurement tool, located in "*Distances"* tab, we measure the diameter of the planet from one end to the other. We have to measure the largest distance between the planet limbs. The result can be obtained in two units: pixels and arcseconds, which are equivalent. As we have seen in the image information (see the *Astro* tab), the image scale obtained with this telescope is 0,278 arcseconds per pixel, which allows us to convert between the two units. The software enables a direct conversion to arcsecs, but we will use pixels in this activity.



NOTE: One **pixel** is each light-sensitive cell composing the chip (CCD) of the astronomical camera, similar to the digital cameras that we normally use to take pictures. For example: a 7 megapixel camera has a chip containing 7 millions of very small

photosensitive cells with the size of few microns. The difference between our digital cameras and the astronomical cameras lies in the bigger sensitivity of these last ones. Moreover, astronomical cameras are in black and white and they are usually refrigerated to avoid the electronic noise in the image.

This measurement is going to be taken with each image, obtaining a table with the planet diameter in pixels for all of them. Given that we are able to know the image date and scale in km/pixel using the "*Astro*" tab, we can calculate the planet diameter, in kilometres, for any given date. We just have to multiply the measurement obtained by the scale and the result will be given in kilometres.

Image	**Date**	**Measurement** (pixel)	**Scale** (km/pix)	**Diameter** (km)
902a000				
906e000				
918i000				
924f000				
934i000				

You will probably see that the result obtained is not the same on each image. That doesn't mean that the planet is expanding or shrinking like a balloon, but that we haven't taken into account the error made when measuring.

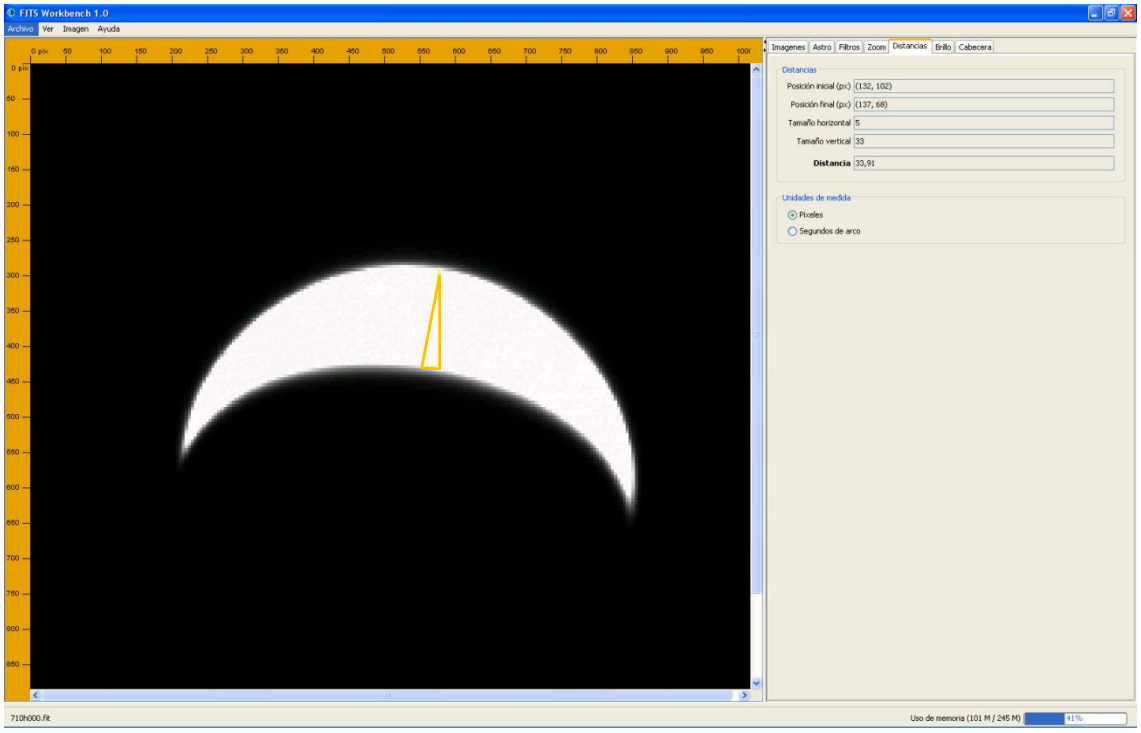
In sciences, when a measure of a given quantity, either a distance, time, temperature, etc., is obtained you must specify the error associated to that measure, which can be due to such its accuracy, the quality of instrumentation, etc. In this unit we are not taking errors into account, since the purpose is to have an initial contact with basic tools used by an astronomer.

You will probably obtain five different measures for the diameter of Venus. Then, what we need to do is to obtain a **mean value**, that is to say, we add up the five values and we divide the result by 5. This will be our value for the planet diameter. In a book or in the internet, look up the real value (understood as the most accurate measure so far), in order to know how close you are to that value. Think that you have only calculated pixels in a photograph of the planet and knowing the scale and the distance to it we can know its size, even if it is millions of kilometres far from us.

2nd part. Phases of Venus.

We had already discussed that as well as the Moon, Venus and Mercury present phases because of the different sunlight received as seen from Earth. When we see the planet surface fully illuminated, we say that its phase is 100% (concerning the Moon we call it Full Moon). When half of the Moon disc is illuminated, its phase is 50% (first quarter or last quarter in the case of the Moon). And finally if the side that we observe is not illuminated by the Sun, its phase is 0%. In this last case, it could only be observed when moving in front of the Sun. This phenomenon is called **transit** in the case of planets and **solar eclipse** in the case of the Moon (the Moon would be between the Sun and us. This may only happens on a New Moon).

Well, we are going to calculate the phase presented by Venus on each one of the five images. To do this, we shall only make an additional measure for each image. This measure is to count the pixels illuminated in a straight line going from the centre of the planet to the limb, as it's indicated in the image below.



In other words, we have to measure the illuminated wedge width. What we really want to determine is the illuminated planet portion, so we must divide this zone width by the size of the planet diameter, and the result will be represented as percentage.

$$PHASE = A / D \times 100$$

where:

A = Illuminated zone width measure
D = Planet diameter measure (obtained in the previous section)

Image	A (pixel) width measure	D (pixel) diameter measure	A / D x 100 (%)
902a000			
906e000			
918i000			
924f000			
934i000			

Once results are obtained, you will notice how the phase changes as the planet moves away from us. You can find information about the distance to Venus for each image in the *Astro* tab.

Para más información, visita nuestra página web: **www.iac.es/peter**

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