Teacher's guide

CESAR Science Case – The Venus transit and the Earth-Sun distance

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There are different methods to use in this laboratory. Here, three methods are going to be presented.

- **Material that is necessary during the laboratory**

- CESAR Astronomical word list
- CESAR Booklet
- CESAR Formula sheet
- CESAR Student's guide
- ESA Venus transit photos
- The software for this Science Case
- Calculator, paper, ruler, eraser
- Projector (optional)

The ESA Venus transit photos can be downloadable on the website for this Science Case as well as the astronomical word list, the booklet, the formula sheet and the student's guide. The software can be found on the same website.

All the images taken from the observation of the Venus transit can be found at the website: http://www.sciops.esa.int/sun_monitor/archive/venus_transit_2012/. If you decide to use images from this site, note that there is a gap of two hours between Canberra and Svalbard i.e. you need to choose an image from Canberra with two hours added to match with an image from Svalbard. Furthermore, all of these images have to be horizontally flipped. All the images are named as:

place_filter_year_month_day_hour_minute_second_number.jpg

Introduction

The task that the students need to complete is to calculate the astronomical unit (AU), which is the Earth-Sun distance. Trigonometry is the key method during this laboratory. Without trigonometry, it is impossible to get the value that we are searching for. It is essential for the students to understand the parallax effect, since it is the most important theory. Without knowing that Venus is in different positions on the Sun depending on the location of the observers, trigonometry cannot be used. Explain the parallax effect to the students, if they did not find it descriptive enough in the Student's guide. The students have to decide which of the three methods presented gives the best result. As a science case, their criteria are essential too.

First of all, the students need to examine the images and edit them so that the sunspots are at the same point on the disk as they were during the June 2012 transit. They can use whatever method they want, preferably by editing with the software available on the CESAR website for this Science Case or similar software. Another option is to project the images on a screen and measure everything on it, but it's not recommended. The three methods combines distance measurements, trigonometry, timing and image processing which is a good point since they will learn a bit of it that could be useful in their future.

At the website you have all the software that is needed for the laboratory, however, the free software named GIMP is another good choice (downloadable at http://gimp.com). It might be a good idea to get familiar with the chosen software for image processing. A class dedicated to the software, where the teacher goes through all the important tools is a plus.

METHOD 1

Calculating the AU using alignments between sunspots and Venus's disk

Below there are two pictures taken from the CESAR website for this science case, one of them was taken from Canberra and the other one from Svalbard at almost the same time. Either using the software at the CESAR website or using the software GIMP, the first step consists in rotate both of them and then merge/superpose them together to see the difference of the position of Venus inside the solar disk and get a single image.

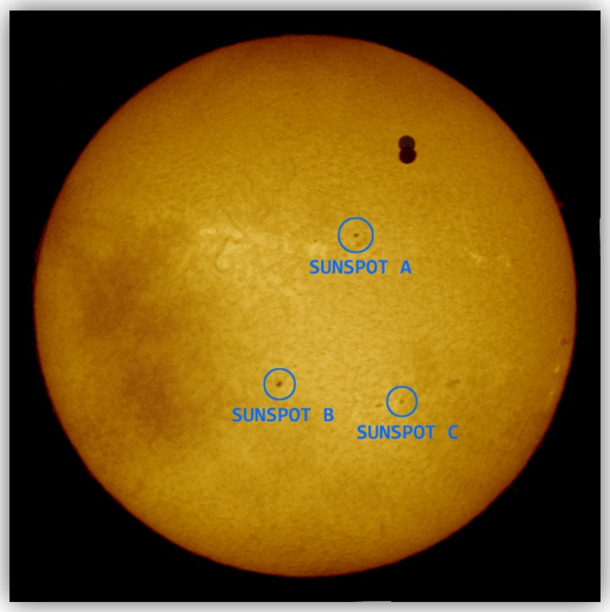
It is noticeable that the sunspots are at different locations on both images so we need a reference image. One good tip for this that introduce students into database searching is to visit the SOHO website and their data archive in order to compare its images with the images taken by the ESA team. The link to the SOHO page is http://sohodata.nascom.nasa.gov/cgi-bin/data_query. There, you need to select the image type "HMI Continuum", the "1024" resolution and finally choose the appropriate start and end date (2012-06-06 to 2012-06-07). The images from SOHO are named as:

YYYYMMDD_hour_filter_resolution.jpg

Chose the date of the transit and save an image at almost the same time as your images. Then compare the sunspots on their photos with previous combined image using the software. You need to make a horizontal flip of the ESA team images if you downloaded them from the database. Rotate the image in order to see the sunspots at the same places as the SOHO image. It can be easily done by adjusting the transparency of the images. After comparing the ESA image with those from SOHO you can delete the SOHO image and save the final image. You may get a picture similar to the one below:

The gap that was mentioned earlier is really noticeable on the picture. This is essential since the students need to measure that gap to calculate the AU.

Below is the same processed picture, where a set of sunspots are named, A, B and C. One method is to use these sunspots as reference points. There are more sunspots but they are the most noticeable.



The strategy that we are going to follow will give them the value of the AU. Here there are the steps:

- Until now, we have a combined image from Svalbard and Canberra at almost the same time and we have edited both images as showed before. The linear distances from the middle of the centre of Venus to the sunspots A, B and C should be measured. These measurements are transformed into parts of the solar diameter (which is also measured from the photos).

- For each time step (i.e. for each pair of images edited), the dissimilarity between the distance measurements from Canberra and Svalbard is calculated, separately for spot A, B and C.

- The moment when Venus, the sunspot and the positions of the two observers go through the same level or plane in space, the variance should come close to a minimum: such a constellation should be expected given the central position of the sunspots and the long chord that Venus cut through the Sun. In conclusion, the students have to choose the minimum value of the differences.

- This value of the minimum distance expressed in kilometres or mm is then supposed to be converted into an angular distance in the sky. This can be achieved by multiplying that value (given in parts of the solar diameter) with the diameter of the Sun of 31,5 arc-minutes on that day.

- Lastly, the AU can be calculated using this angle, the distance of both observers in a plane perpendicular to the Earth-Venus vector and the Sun-Venus distance as explained at the end of this method.

It is important to mention that if we measure more than one pair of images we have more possibilities to find a global minimum. For this reason, try to measure at least images of two times (i.e. two pairs).

The unit of arc-minutes or arc-seconds represents an angle, not a distance or lengths, and is often used by astronomers. It is obvious that a circle has 360 degrees, each of which can be divided into 60 minutes of arc. Then, each minute can be divided into 60 seconds of arc, or an arc-second.

To start with, measure the images. The students need to use the cursor tool to handle this task. The diameter of the Sun should be measured, in pixels that is. Correspondingly, the sunspot's positions should also be known. This if you chose to get the measurements with software.

Instead of using the software, another method is to project the picture on a screen, with the distance between the screen and projector known. By using a ruler, the distances from Venus to spots A, B and C can be taken off the screen with a ruler. The precision of it can be about 1 mm, as an example. Thus in both cases the measurements should give values to about x arc-minutes (*for example 5 arc-minutes*). With a table, like the one below, the values of the measurements can be written down just to keep them on track. Remind the students to pick a unit of their choice that is the one they think is the right unit.

Time	SVA: V-A	CAN: V-A	A: CAN-SVA	SVA: V-B	CAN: V-B	B: CAN-SVA
…	…	…	…	…	…	…
…	…	…	…	…	…	…
…	…	…	…	…	…	…

This table (note: more timescales are needed depending on the number of pair of images used), has SVA as a shortening for Svalbard and CAN for Canberra. The projected distances between Venus and the spots A and B is called V-A and V-B. The instant of true parallax, is when the measured value of Canberra distance minus the Svalbard distance is equal to the true Venus parallax relative to the Sun. This should be included in the covered time interval.

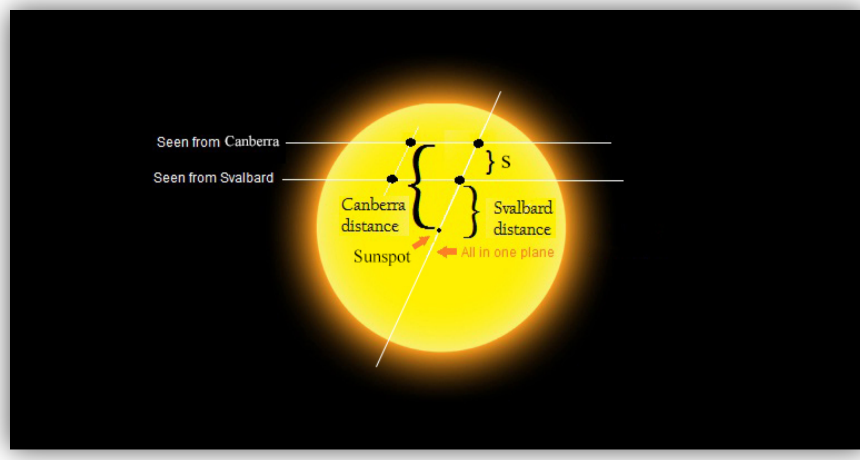


Figure 1: A visualization of the reference spot and the position of Venus. This is not related to the ESA images because Venus was not at these points during the transit. ***Credit:*** *CESAR*

Now, it should be possible to decide the true parallax (S), i.e. the real angle by which Venus changes relative to the disk of the Sun when one switches the location of observation between Canberra and Svalbard. As we have seen on the steps, the students have to look if there is a clear global minimum of the value $(V-(A,B))_{CAN} - (V-(A,B))_{SVA}$ in the columns of CAN-SVA at the data table. This can be easily done using the software provided due to the students just measure distances and the software provides them the value of the global minimum expressed in arc-minutes.

Canberra and Svalbard are far from each other and one need to know the distance between both places. To calculate the distance $\overline{\text{AB}}$ between the two places (A and B) we can choose different trigonometric formulas. The complexity of these formulas depends on the precision that we want to obtain.

The easiest way is to consider that the Earth is a two dimensional body, so you can for instance use the ruler and measure the distance on the screen (using an image of the Earth that contains both sites). However, since the Earth is not a two dimensional body, it is better to use another method (see Figure 3) but if you want to simplify the mathematical background you could use that.

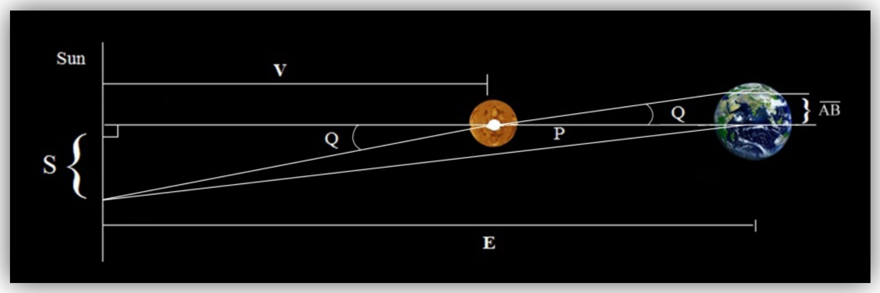


Figure 2: How the parallax is related to the AU. **The figure is not in scale.** ***Credit:*** *CESAR*

The Earth is obviously a rotating sphere. That means that if the student wants to be more precise, they cannot just draw a line between the two points, they need to find the value $\overline{AB}$ by trigonometry. Here is one method that they can use:

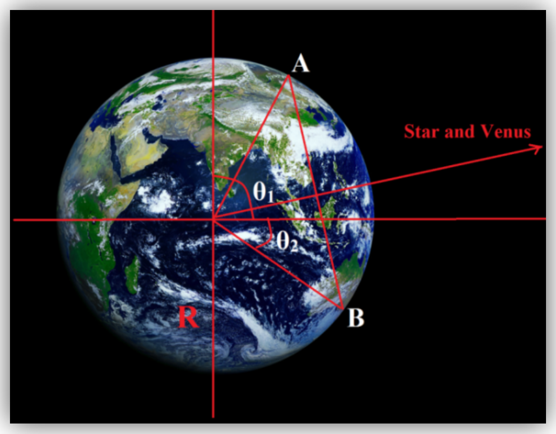


Figure 3: Here, the two observers are named as A and B. The distance $\overline{AB}$ can be deduced from the latitudes of the two observer's places. In the figure, θ_1 and θ_2 are the latitudes of A and B, and R is the Earth's radius. ***Credit:*** *CESAR*

Using trigonometric rules, we see that in the right triangle that divides the isosceles triangle RAB is:

$$sin\left(\frac{\theta 1+\theta 2}{2}\right)=\frac{\left(\frac{\overline{AB}}{2}\right)}{R} \quad (1)$$

Where the distance is:

$$\overline{AB}=2Rsin\left(\frac{\theta 1+\theta 2}{2}\right) \quad (2)$$

Let the students know that if the both locations are in the same hemisphere, the angles and also the geometrical situation changes if the cities are on different longitudes. Allow the student look up the latitudes and altitudes for each location, which is Canberra and Svalbard. The values can be found by using a search engine of your choice and must be introduced in the formula in absolute value. With that, they should get an equation that gives the angle β, using θ_1 and θ_2 in the equation. Note that β is the new angle that is between the two locations. After calculating that value, the equation for $\overline{AB}$ (that gives a value in km) should be:

$$\overline{AB} = 2R\sin\left(\frac{\beta}{2}\right) \quad (3)$$

This method already involves trigonometry, but it could be performed. In fact, having the coordinates for both sites i.e. their longitudes and latitudes, we could use the next formula to calculate the angular distance between both sites, and then calculate the linear distance $\overline{AB}$ that is approximately 11700 km.

$$\cos\beta' = \sin\alpha 1 \sin\alpha 2 + \cos\alpha 1 \cos\alpha 2 \cos(\delta 2 - \delta 1) \quad (4)$$ *where α is the latitude and δ the longitude*

The coordinates for both sites could be obtained using some free software as *Google Earth*. It could be an extra for the students to obtain that value. However here they are:

Svalbard: $\alpha_1 = 78{,}22°\ N$ *and* $\delta_1 = 15{,}55\ E$ *Canberra:* $\alpha_2 = 35{,}4°\ S$ *and* $\delta_2 = 149{,}02\ E$

Note that the value of: $\alpha = 35{,}4°\ S$ must be introduced as a negative number in (4).

Lastly, the student need to use all the data and calculate the AU *(see figure 2)*. With S and $\overline{AB}$ already determined, and with the value of the Sun-Venus distance given, the AU can be determined. It is rather straightforward when one considers three triangles, which can be seen on the figure above. The math is the following:

$$\frac{S}{V} = tan(Q) = \frac{\overline{AB}}{(E-V)} \quad (5)$$

Where E is the astronomical unit AU; $V = 106411476\ km$ and the value of E is then:

$$E = \frac{\overline{AB}}{S} + V \quad (6)$$

To sum everything up, the students should review their values and the laboratory. A discussion is good to have among the students, since some of them may not fully understand the concept. They should understand that the result is very sensitive to both S and $\overline{AB}$. For example, if S were just x arc-minutes larger and $\overline{AB}$ x km smaller, our AU would shrink by x million km. Finally, the value of the Earth-Sun distance for the day of the observations was 151800000km instead of the 149597870km of an AU.

METHOD 2

Calculate the AU measuring strings

Here is another example of how the distance between the Earth and the Sun can be calculated. The idea is the same but with a small difference. As in the previous method, the simultaneous (*or almost*) images from two different locations are going to be used, but now we are necessary going to use all of them. The observable that is measured is the distance between the centers of the shadow of Venus of the disk of the Sun as seen from two sites using strings.

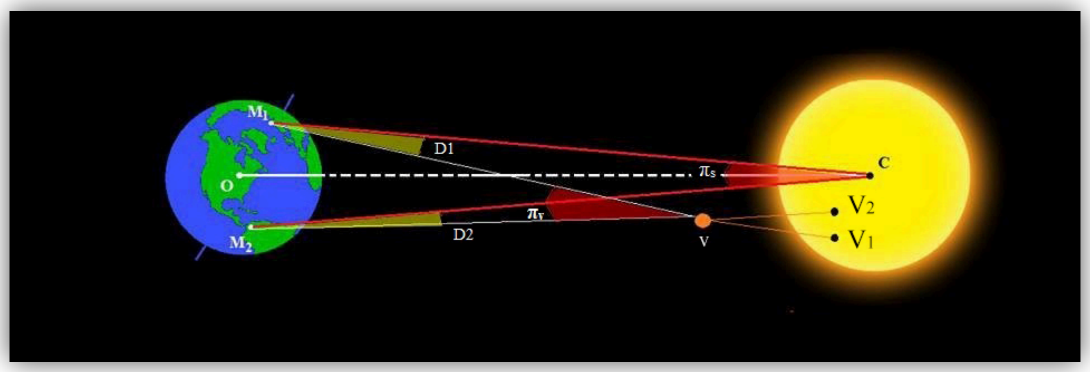


Figure 1: Synchronized observation of the transit of Venus in front of the disk of the Sun from two different locations M_1 and M_2 at the same time. **The image is not in scale and it does not represent the June 2012 transit. This should only be used as a visualization of the geometry.** **Credit:** CESAR

Let us say that the geometry of the transit looks like the one in Figure 1. Point O is the centre of the Earth, C is the centre of the Sun and V_1 and V_2 the observed centers of the projection of Venus from the locations M_1 and M_2. The angles D_1 and D_2 are the separation between the centres of the Sun and Venus observed from M_1 and M_2 separately. That is, these are the angles of parallax CM_1V_1 and CM_2V_2. With the similar method, we can explain the angles π_v and π_s as the angular separations between M_1 and M_2 viewed from Venus and the Sun, correspondingly. These are the angles M_1CM_2 and V_1VV_2. By definition we have:

$$\sin(\pi_v) \cong \frac{d}{R_{EV}} \text{ and } \sin(\pi_s) \cong \frac{d}{R_{ES}} \qquad (1)$$

Here, R_{ES} is the distance between the Earth and the Sun, R_{EV} is the distance between the Earth and Venus, and d is the straight line distance between M_1 and M_2.

The student can make a list of assumptions that can work as a guideline. The examples given below are not the ones they need to come up with. Anything helpful is just as good.

- The Sun, Venus and Earth are all aligned, so $R_{ES} = R_{VS} + R_{EV}$, where as we mentioned, R_{VS} is the Venus-Sun distance.
- The two points of observation, M_1 and M_2 are along the same meridian, so that C, V, M_1 and M_2 are in the same plane. This is also called that they are coplanar.

- Since the distance between the celestial bodies are big, and the parallax effect is relative small, we can estimate the sinus of the parallax to the parallax itself, that is : $\sin \pi_i \approx \pi_i$.

We can define the difference in degrees as $\Delta\pi = \pi_v - \pi_s$. We also have:

$$\pi_v \cong \frac{d}{R_{EV}} \text{ and } \pi_s \cong \frac{d}{R_{ES}} \qquad (2)$$

If we use substitutions (by using (2)) we get:

$$\pi_v = \frac{\pi_s * R_{ES}}{R_{ES} - R_{VS}} \qquad (3)$$

Because of the difference: $\Delta\pi = \pi_v - \pi_s$, a substitution of π_v gives:

$$\Delta\pi = \pi_s \left[\frac{R_{ES}}{(R_{ES} - R_{VS})} - 1\right] = \pi_s \left[\frac{R_{VS}}{R_{ES} - R_{VS}}\right] \qquad (4)$$

This can also be simplified as:

$$\pi_s = \Delta\pi \left[\frac{R_{ES}}{R_{VS}} - 1\right] = \frac{d}{R_{ES}} \qquad (5)$$

We can now rearrange the equations and get the Earth-Sun distance, R_{ES} at the time of observations to be:

$$R_{ES} = \left[\frac{d}{\Delta\,\pi \cdot (R_{ES}/R_{VS} - 1)}\right] \qquad (6)$$

We find that $\Delta\pi$ is the distance between the centres of Venus's shadow on the surface of the Sun (has the units of radians).

The ratio R_{ES}/R_{VS} of the Sun-Earth and Earth-Venus distances that can be obtained using the Kepler's third law as follows:

If we consider an Earth year as a unit of time, and one AU as a unit of distance, we could define the Kepler's third law as:

$$\frac{T^2}{R^3} = 1 \qquad (7)$$

So if we apply this to any other planet (Venus in this case), then we have:

$$R_{Venus} = T^{2/3} \qquad (8)$$

In Venus, a year takes 224,7 days, or in terms of Earth years 0,615. The substitution of that value gives:

$$R_{Venus} = T^{2/3} = 0{,}615^{2/3} = 0{,}723\ AU$$

However instead of that value we could use a more precise one for that day is, that is $R_{ES}/R_{VS} = 1{,}4265$.

Finally, d can be determined from the two known locations as shown in the previous method and expressed in km.

Let us now take the next step, which is to determine $\Delta\pi$, but first one thing to point out. Over the course of the transit, the Earth-Sun distance changes only slightly. This change is about 7,500 km compared to the average distance of approximately 150 million km. With this in mind, we can assume that the two "strings" are parallel and now the observable to be measured is not the distance between Venus' shadows but the distance between the two "strings". Below is an illustration of it.

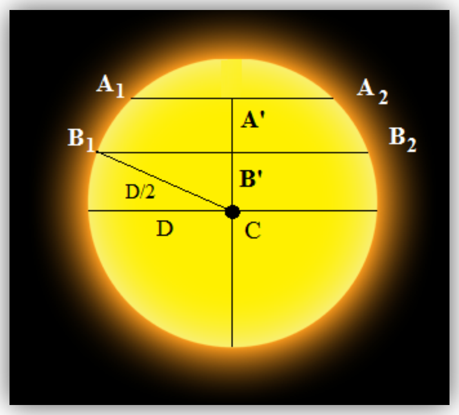


Figure 2: Here are the "strings" that have been mentioned. A_1A_2 and B_1B_2 is Venus seen by observers at the locations M_1 and M_2 on Earth. ***Credit:*** *CESAR*

By using Pythagoras's theorem we can write the following expressions:

$$A'C = \sqrt{\left(\frac{D}{2}\right)^2 - \left(\frac{A_1A_2}{2}\right)^2} \quad (9) \quad \text{and} \quad B'C = \sqrt{\left(\frac{D}{2}\right)^2 - \left(\frac{B_1B_2}{2}\right)^2} \quad (10)$$

This means that we can express A'B' as:

$$A'B' = A'C - B'C = \sqrt{\left(\frac{D}{2}\right)^2 - \left(\frac{A_1A_2}{2}\right)^2} - \sqrt{\left(\frac{D}{2}\right)^2 - \left(\frac{B_1B_2}{2}\right)^2} \quad (11)$$

By measuring the length of the "strings" (A1A2, B1B2) along with the Sun's diameter (D), we can then obtain the parallax with the following formula:

$$A'B' = \frac{1}{2}\left[\sqrt{D^2 - (A_1A_2)^2} - \sqrt{D^2 - (B_1B_2)^2}\right] \quad (12)$$

As mentioned, we are going to use the "string method". It is an easy method since we only need to determine the lengths of "strings" or lines that create the noticeable path of Venus on the surface of the Sun.

As in the Method1, this can be achieved either measuring a projected image or with the software provided for this Science Case but the second option is the one that we are going to follow.

It is good to know that this method can only be applied if we have more than one pair of images. But this can on the other hand be applied even if the weather was bad during the event. The day of the transit in June 2012, the weather in Svalbard was cloudy and the ingress was not easy to see. With this method, we only have to extrapolate the rest of the trajectory which is good.

Keep in mind that the images for each time must be aligned all together throughout the transit. Due to the rotation of the Sun the sunspots will be at a different position each time. This is not a huge movement, but the students will probably notice it when they try to align the images. Another point to mention is that the length of both "strings" might be very similar, and we have to point out that the value of the diameter of the Sun (D), and the length of the lines M_1 and M_2 should all be measured in the same units.

As in the Method1, we need to align every image with the SOHO image for that date and time. For both paths, try to use as many pictures as possible to draw the string correctly. The final image should be similar to the one below.

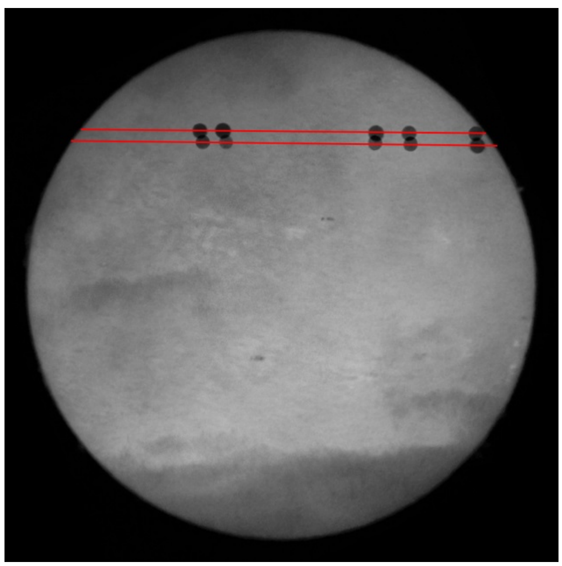


Figure 3: An image made with astronomical software, with a simulated representation of the "strings".

Credit: *CESAR*

The strings join A_1 to A_2 and B_1 to B_2 correspondingly as seen in Figure 2. It can be measured both in mm or in pixels, depending on if the students decide to measure with a ruler after printing the transit image (not recommended), or using the software on the website. Principally, any software that permits one to calculate proportions of objects inside an image is helpful.

Either if you chose to measure the strings in mm or pixels, you must be clear with the units as mentioned earlier. This means that you might need measure the Sun's diameter in mm or pixels once the students get the value of the parallax to convert the value into an angular distance. The solar diameter for that day was 31,5 arc-minutes.

Now, we need to calculate the ratio A'B', where A'B' is the space between the two strings, a distance which is going to be used as the parallax: $\Delta\pi$. Therefore, the expression that we need to use is:

$$A'B' = \frac{1}{2}\left[\sqrt{D^2 - (A_1A_2)^2} - \sqrt{D^2 - (B_1B_2)^2}\right] \qquad (13)$$

Numerically, equation (13) will give **x pixels or mm** as an answer. That value has to be converted into an angular distance as mentioned and finally turned into radians. Lastly, substituting into equation (6) we get:

$$R_{ES} = \left[\frac{d}{A'B' \cdot (R_{ES}/R_{VS} - 1)}\right] \qquad (14)$$

By using the numerical values for each parameter, we will get the value for the AU. Remember to point out that they do not need to get the exact value of the Earth-Sun distance. A value close to it is good enough. In fact, it may not be possible to get the exact value since the student may not do the exact measurements. The point of this science case is to understand the parallax effect and the calculation and science between these methods. As a closure, have a discussion time, maybe for 10 minutes, where the students (in groups or together) come to conclusions etc. This may clear up any misunderstandings during the lab.

METHOD 3

Calculate the AU timing the Venus transit

Now we are going to describe another method for measure the AU. This method is usually called "The Halley's method" as it was a great idea of the astronomer Edmund Halley.

As there is not a huge difference of the Venus position in the Sun viewed from two different places on Earth, Halley developed another method to measure the distance between the Earth and the Sun. Instead of measure the separation between the centres of Venus from two places on Earth, each observer would time the duration of the transit. This avoids the problem caused by the proximity of the paths too. They are very close together, so it is difficult to measure the separation between them.

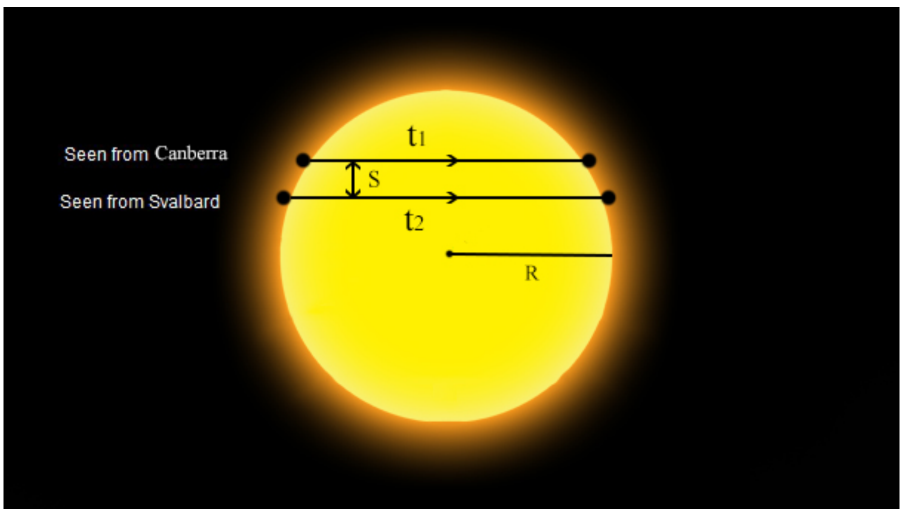


Figure 1: A representation of the paths viewed from Canberra and Svalbard, and the separation S between them. **Remember that the figure is not in scale.** ***Credit:*** *CESAR*

Have to be noticed that the path is longer if we see it from Svalbard. Venus will be on the disk longer there, with a difference of minutes out of the several hour duration of the transit. We have to point out that we can obtain a very good precision using this method if we consider that we are counting seconds.

The Venus' drift across the Sun's disk have to be calculated in order to obtain the distances. For this we have to make some considerations. The first one is that both Venus and Earth are orbiting the Sun at different velocities (that we call r_V and r_E respectively) due to they are at different distances from the Sun. The second one is that we have to calculate the rate of Venus referred to the Earth i.e. not just the difference of angular velocities. We are going to call d at that rate. This could be visualized with the next figure.

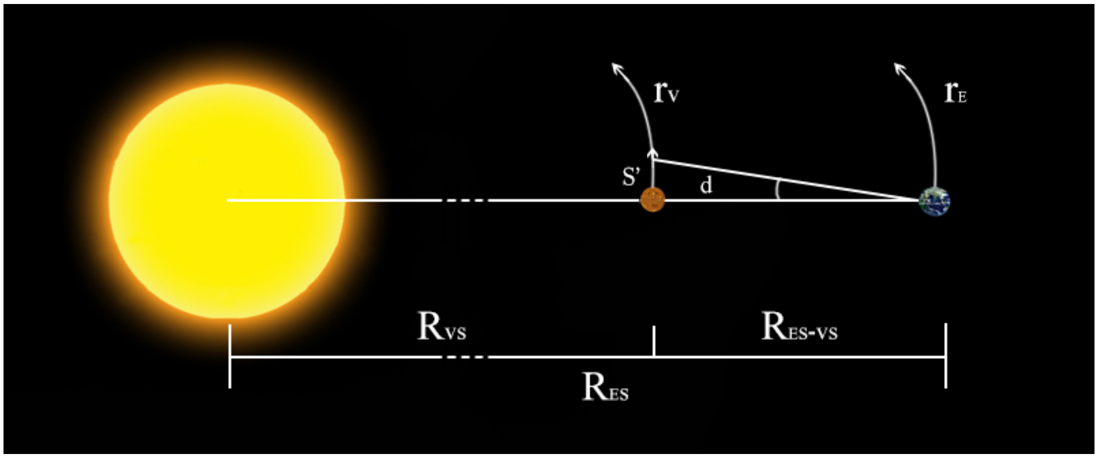


Figure 2: A representation of the distances between planets, their angular velocities and the Venus rate viewed from Earth (d). **Remember that the figure is not in scale.** ***Credit:*** *CESAR*

For the first consideration, we need to calculate the orbital velocity of both planets. For this, we could easily divide the angle of a circle by the period of each planet:

$$r_V = {}^{360°}\!/_{224,7 days} = 0{,}0668\ arcseg/sec \qquad r_E = {}^{360°}\!/_{365,25\ days} = 0{,}0411\ arcseg/sec$$

It is very important to notice that $r_E - r_V$ is not the right rate viewed from Earth. To calculate this we are going to use the Pythagoras's theorem once again and we need to obtain the value of *S'* by multiplying the difference of rates by the Venus-Sun distance (R_{VS}). Then, the formula that we need to use is:

$$d = \frac{R_{VS}(r_E - r_V)}{R_{ES} - R_{VS}} = \frac{(r_E - r_V)}{{}^{R_{ES}}\!/_{R_{VS}} - 1} \qquad (1)$$

We have already seen how to obtain the value of ${}^{R_{ES}}\!/_{R_{VS}}$ using the Kepler's third law and we determined an approximate value of 1,4265. Finally, the value of *d* is:

$$d = {}^{0,0257}\!/_{0,4265} \cong 0{,}0602\ ''/sec$$

Now, we are going to use a procedure similar to the previous method. In fact the formulas are almost the same except for in the "Method 2" we measure the string in pixels, and now we are going to time the transit, but in fact we are doing the same thing because using the value of *d* multiplied by the time Venus uses to cross the Sun disk we could obtain a distance value. For this reason, we just need to replace some distance values in the formulas for time and velocity.

We can then obtain the parallax with the following formula:

$$S = \sqrt{\left(\frac{D}{2}\right)^2 - \left(\frac{t_1 d}{2}\right)^2} - \sqrt{\left(\frac{D}{2}\right)^2 - \left(\frac{t_2 d}{2}\right)^2} \qquad (2)$$

The As the Figure 1 shows, we are going to call S to the distance between the paths. The radius of the Sun is going to be D/2. Finally, the Earth-Sun distance is:

$$R_{ES} = \left[\frac{d}{S \cdot R_{ES}/R_{VS} - 1)}\right] \qquad (3)$$

Now, we are going to see how to determinate the time t_1 and t_2 from the images. Either for t_1 or t_2, we need to consider that the first useful image is the one in which the centre of Venus crosses the Sun's disk going inside the Sun, and the last image that we need is the one that has the centre of Venus crossing the Sun's disk going outside. Getting the difference of time between both images we obtain the values of t_1 and t_2.

This is not the best way to get an appropriate value of t because we can't see the precise moment the center of Venus crosses the Sun's disk. If we want to be more precise, we need a total of four images for t_1 and another four images for t_2 i.e. an image taken the moment when Venus starts entering the Sun's disk, an image taken the moment when Venus totally enter into the Sun's disk (first pair), and on the other side, an image taken when Venus starts going outside the Sun's disk, an a final image taken when Venus finally leaves the Sun's disk (second pair).

Once we have these four images for each path, we need to determinate the precise time that Venus crosses the solar disk. For this, we just need to calculate the mean time of both pairs and see the difference between them.

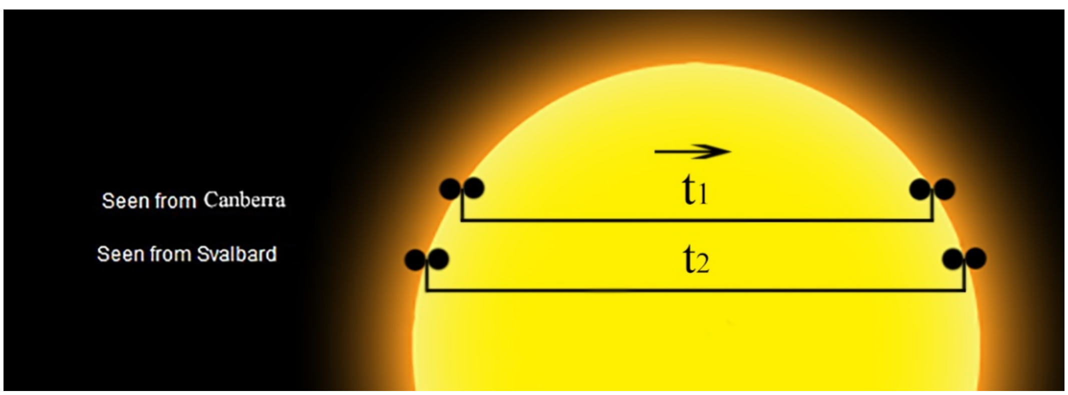


Figure 3: A representation of the paths considering that both start exactly when the center of Venus crosses the Sun's disk and end when that center goes outside. **Remember that the figure is not in scale.**

Credit: *CESAR*

To use this method, you could take the four images for each path from the archive of images located at: http://www.sciops.esa.int/sun_monitor/archive/venus_transit_2012/. It is a good practice because students have to search and decide which images they should use. You could also use the software available at the CESAR website for this case where the students decide the four images for each path of a set of selected images. It is preferable because the archive has too many images and we have chosen a set of useful images at the website. Each image has attached it's time and using the software you could obtain the difference of time just selecting two of them.