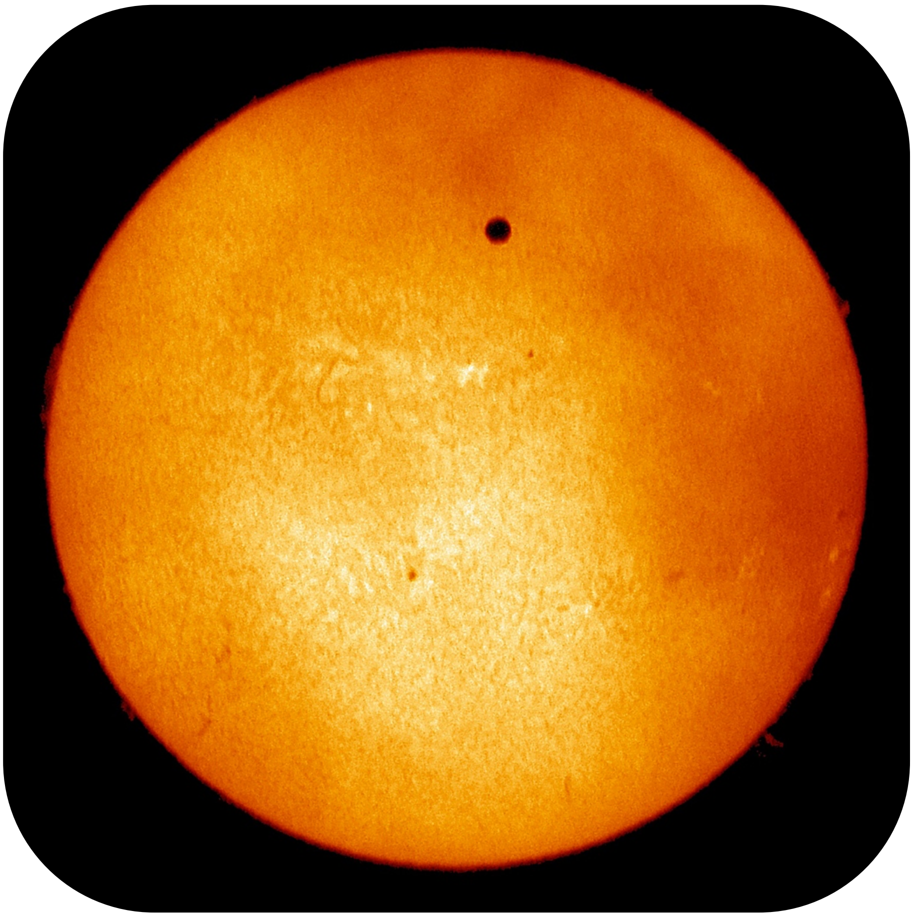
The Venus-Sun distance

Teacher's Guide – Basic Level

CESAR's Science Case



Introduction

This is the teacher's guide for "The Venus-Sun distance" CESAR's Science Case. Note that **this guide does not contain full instructions** to successfully develop the science case, those can be found at the student's guide. This guide includes information about the learning purposes of the activity as well as about the material and background needed for it, so that the teacher may decide **weather this laboratory is suitable** for his class or not. This guide is also meant to **help the teacher trough organising the activity**, providing tips and keys for each step, as well as the **solutions** to the case's calculations and the quiz.

In this science case the students are to **calculate the Venus-Sun distance** using images from a Venus transit. For this they will use parallax relations. By the end of this laboratory, students will be able to explain what a transit is and expose the main parallax concepts. By completing this science case, students will find out how astronomical pictures can be used to obtain valuable data, also they will find a real scientific use for proportionality (basic proportionality theorem / Thales' theorem / intercept theorem).

Material

What will they need?

- The Venus-Sun distance Student's Guide.
- Computer with Web Browser and Internet Connection.
- Google Earth or similar program to look for coordinates. (Optional)
- Access to CESAR web tools.

Background

The Basic Level Student's Guide requires no background, everything is explained in the guide and nothing is taken for granted. Also there's no math involved at all. If you want to consider a harder task, take a look at the intermediate level.

Even if no background nor math is needed, the concepts explained can be hard to understand, check the content before doing the Science Case, this particular one may not be suitable for kids under ten years old.

Laboratory Execution

All that students ought to do is read their guide and follow the steps. This task is suitable both for doing it alone or in small groups.

If they make no mistake, the final result for the **Venus-Sun distance should be around 108,000,000 km**. Usually the measurements are not done with absolute precision, and also the method described in this guide uses several approximations that slightly modify the result, so values between 93 and a 123 million km are good enough. In the final question, **the Earth is about 42,000,000 km further away from the Sun than Venus**; if the Venus-Sun distance value wasn't precise, we should expect a similar vagueness in this calculation.

Just in case they do commit some mistake, in the following paragraphs are every step's solutions along with common mistakes that may help you identify their error.

Step 1

Make sure not to align the images looking at Venus, just align the sunspots. After merging the images, if the two Venuses superpose a little, everything is probably right.

Common mistake is to measure the Sun diameter instead of the radius.

The distance measured in the image should be about 29,000 km.

Step 2

The coordinates for Canberra are 35º 18' S, 149º 9' E, and for Svalbard 78º 13' N, 15º 38' E. Similar values are alright as the specific position of the observatories is not specified.

Introducing this values into the CESAR web tool should approximately give 12,340 km as the value for the $\overline{AB}$ distance.

Step 3

Typing in the CESAR web tool the two values obtained before, students will obtain the final result. As this is the easiest level, the full math is not explained to the students, for further information you can take a look at the Intermediate Level Student's Guide where all the math is developed.

Conclusions

Earth-Sun distance is 150,000,000 km. If the Venus-Sun distance is about 108,000,00 km, then the Earth is 42,000,000 km further away from the Sun than Venus. Discuss with your class the fact that this distance is only true during the transit, and that at any other moment it's bigger. (The two first images in the Student's Guide's Background may help).

Even if the student's guide ends up here, the activity may continue with the quiz. Although this quiz can be used as a qualifiable exam, it is not only meant to be so. Even if the students have successfully obtained the Venus-Sun distance, if they don't fully understand the whole procedure, the quiz questions may make them doubt (some of them might be really tricky). Besides than examining them, it is a good idea to give them some time to do the test by their own, and then group them for discussing their answers. It is likely that they have different answers for some of the questions, and **by discussing them, they will achieve a much better comprehension of the whole process** they used. In the last pages of this guide, all the questions from the quiz are answered. For each question the correct answer is provided, and just in case it's not clear why, it's also indicated why the others are wrong. Finally, for each question there is a completely absurd possible answer, if one of this answers is given, you can be sure the student is randomly answering.

Quiz

The correct answers for the quiz are b b c d a d a b b d.

The absurd answers for each question are d c a b d c b d d b.

In case of doubt, the discussion of each question follows next:

1. In this laboratory you calculated

- ☐ the Earth-Sun distance.
- ☐ the Venus-Sun distance, using proportionality.
- ☐ the Venus-Sun distance, using an odometer.
- ☐ the Venus-Sun travel cost.

Nothing to ad in this one.

2. During a Venus transit

- ☐ Venus, the Earth and the Sun are aligned, with the Earth between Venus and the Sun.
- ☐ Venus, the Earth and the Sun are aligned, with Venus between the Earth and the Sun.
- ☐ Venus explodes in the Sun.
- ☐ Venus is hidden by the Sun.

If not clear, the second image in the Student's Guide's Background may help.

3. Parallax is

- ☐ a trick often used by magicians.
- ☐ the different positions of a tree placed near the road as seen from different cars.
- ☐ the difference in the apparent position of an object as seen from two different places.
- ☐ the different positions from where an object can be seen in different places.

The three last answers may seem correct, but answer b is an example of parallax, not a definition for parallax. Answer d does describe a parallax situation, nevertheless, parallax are not the positions from where you observe but the difference in the position of the object that is observed. So c is the only correct answer.

4. If we observe the transit from two different places,

- ☐ those places must be Svalbard and Canberra.
- ☐ the universe will collapse.
- ☐ we will see two Venus' shadows in the Sun.
- ☐ Venus would seem to be in two different positions, depending where you observe it from.

Svalbard and Canberra are the observatories in our example, but the experiment could have been done with different observatories. Answer c might also sound correct, but the reason we can see two Venuses in the same image is because we merged the images, not because we observed from two different places. And also note that the two images of Venus are not shadows, if you think about it you can not project a shadow in the sun, the Venuses look as shadows because we are looking at the half of the planet that is at night, so its completely dark. But they are not shadows, what is seen in each image is the actual Venus. So d is the only correct answer.

5. We measured the distances between A and B and between A' and B' because with those values

- ☐ and our knowledge about proportional triangles, we obtained the Venus-Sun distance.
- ☐ we used coordinates and measured distances in an image.
- ☐ we can find out the length of the red triangle's shorter edge.
- ☐ we can find out how to travel to Venus and to the Sun.

Using coordinates and measuring distances in images is how we did the measurements, not why, the reason is answer a. Note that the red triangle's shorter edge is the distance between A' and B' so it makes no sense to measure the distance between A' and B' because with it you can measure the distance between A' and B'. The only correct answer is a.

6. To measure the difference in the apparent position of Venus as seen by Alice and Brian we

- ☐ used proportionality and parallax, to obtain the needed quantities.
- ☐ used the coordinates from Canberra and Svalbard.
- ☐ travelled to Venus and make the measurements in Venus' surface.
- ☐ merged two images, one from each one, and measure the distance in the resultant image.

We used the coordinates from Canberra and Svalbard to measure the distance between Alice and Brian, not between the apparent position of Venus as seen by them. For that we used pictures of Venus and the Sun, one taken by each one of them, and after merging them we measured the distance in the resultant image.

7. To measure the distance between A and B we

- ☐ used the coordinates from Canberra and Svalbard.
- ☐ walked from A to B.
- ☐ used proportionality and parallax, to obtain the needed quantities.
- ☐ merged two images, one from each one, and measure the distance in the resultant image.

A and B were Alice and Brian, and for measuring the distance between them we used the coordinates from where they were. That is, Canberra and Svalbard.

8. To finally obtain the Venus-Sun distance, you had to introduce in the CESAR web tool

- ☐ the Venus-Sun distance and the distance between A' and B'.
- ☐ the distance between Alice and Brian and the distance between A' and B'.
- ☐ the distance between A and B and the Venus-Sun distance.
- ☐ the distance between Alice's and Brian's parking spots.

There is no point in introducing the Venus-Sun distance to obtain the Venus-Sun distance.

9. Parallax effect was useful because thanks to the fact that Venus is

- ☐ in two places at the same time, we can draw proportional triangles and use proportionality.
- ☐ seen in two different positions, we can draw proportional triangles and use proportionality.
- ☐ seen in two different positions from the same place, we can use proportionality.
- ☐ a green planet, we can draw proportional triangles and use proportionality.

First three answers may sound similar, but Venus is not actually in two different places at the same time, it is just seen in two different positions from two different places. Son only answer b is correct.

10. Proportionality was useful because it helped us find

- ☐ the distance between A and B.
- ☐ a shiny treasure.
- ☐ the distance between A' and B'.
- ☐ the unknown edge of a triangle after we obtained the length of two other edges.

The distance between A and B was obtained using coordinates and the distance between A' and B' was obtained measuring in an image. We only needed proportionality to use those two distances (known edges of the red and green triangle) to find the unknown edge, that is the Venus-Sun distance, which was an unknown edge from the red triangle.