

Lech Mankiewicz

Centre for Theoretical Physics, Polish Academy of Sciences, Warsaw,
Global Intelligent Robotic Telescopes Network GLORIA

<http://www.gloria-project.eu/>

Paweł Rudawy

Astronomical Institute, University of Wrocław

Handy Pinhole Camera (Latin Camera Obscura) to observe the transit of Venus, eclipses and other phenomena occurring on the Sun

The sun, our nearest star, occasionally allows us to observe spectacular astronomical phenomena: eclipses, appearances of large sunspots and solar flare fields, or passing of the inner planets (Venus and Mercury) between the Sun and Earth. In the morning of June 6, 2012 we will be able to observe the passage of Venus against the solar disk. Transits of Venus are quite rare (we will have to wait for the next one until 2117) so it is not surprising that the forthcoming event is of great interest. **Unfortunately, observations of the Sun are neither easy nor safe. The Sun must not be viewed with the naked eye, and under no circumstances can you look at it through binoculars or a telescope without a proper filter unless you want to go instantly and permanently blind!** Some shops offer special eclipse glasses, however, due to the minimal diameter of the visible Venus (less than 1") they are not very useful for observing planet transits. Therefore, for those who would like to observe the transit of Venus with their own observation instrument - we prepared a description of a simple pinhole camera (ie from Lat. Camera Obscura) for the observations of various phenomena occurring on the Sun. Have fun!

1. Materials required

To make Camera Obscura you will need:

- A mailing tube, the longer the better, one that you can easily hold in your hands. Available online and in stationery shops.
- 2 sheets of A4 black cardboard.
- A piece of tracing paper.
- A cardboard folder.
- A thin needle.
- A sharp paper knife, scissors, a pair of compasses, glue, black sticking tape.
- Nimble fingers and a little patience.



Pic. 1. Tools required to make Camera Obscura

2. Implementation



Pic. 2. Mailing tube

Remove both end caps from the mailing tube. Stick a black cardboard disc into one of them and secure its edges tightly with black sticking tape. Take a thin needle and make a small hole both in the end cup and in the cardboard. The pinhole diameter should be approximately 0.5 mm – 1 mm. It makes sense to experiment with the hole size – because of diffraction a hole diameter should not be smaller than 0.5 mm. Then place the cup back into the tube. After removing the needle it is worth to look through the tube from the other end - the light should fall into the tube only through the small hole. We insert the needle back into the hole every time we do not use our instrument, because otherwise the hole can deform by itself.

Now take the second cap and cut a circle window in it with a diameter equal to approximately 2/3 of the cap. Cut out a circle of tracing paper with a diameter equal to the cap and glue them together carefully, taking care not to stain the window with glue. This will be your focusing screen. Put it back into the other end of the tube.



Pic. 3. A small hole in the cap made with a thin needle



Pic. 4. A ready-to-install lid with a pinhole (note how carefully the edges of the cardboard are covered with black tape)



Pic. 5. Second cap circle window



Pic.6. Focusing screen from tracing paper.

Our Camera Obscura is basically ready. However, in order to carry out our observations of the Sun it must be equipped with a convenient aperture protecting the head of the observer from bright sunshine. For this purpose, cut circles in the middle of both "wings" of the cardboard file. The diameter of the circles should be slightly smaller than the outer diameter of the mailtube. Now mount the file on the tube about 20 cm from the focusing screen. To stiffen your aperture spread the wings of the file a little bit apart.

Using sticking tape roll the second black cardboard into a tube and push it onto the focusing screen. This additional cover will make the image of the Sun more visible.



Pic. 7. The cover - the first hole in the file



Pic. 8. A black cardboard tube ready to be put onto the focusing screen for additional cover from the sunlight.



Pic. 9. Camera Obscura ready for observations

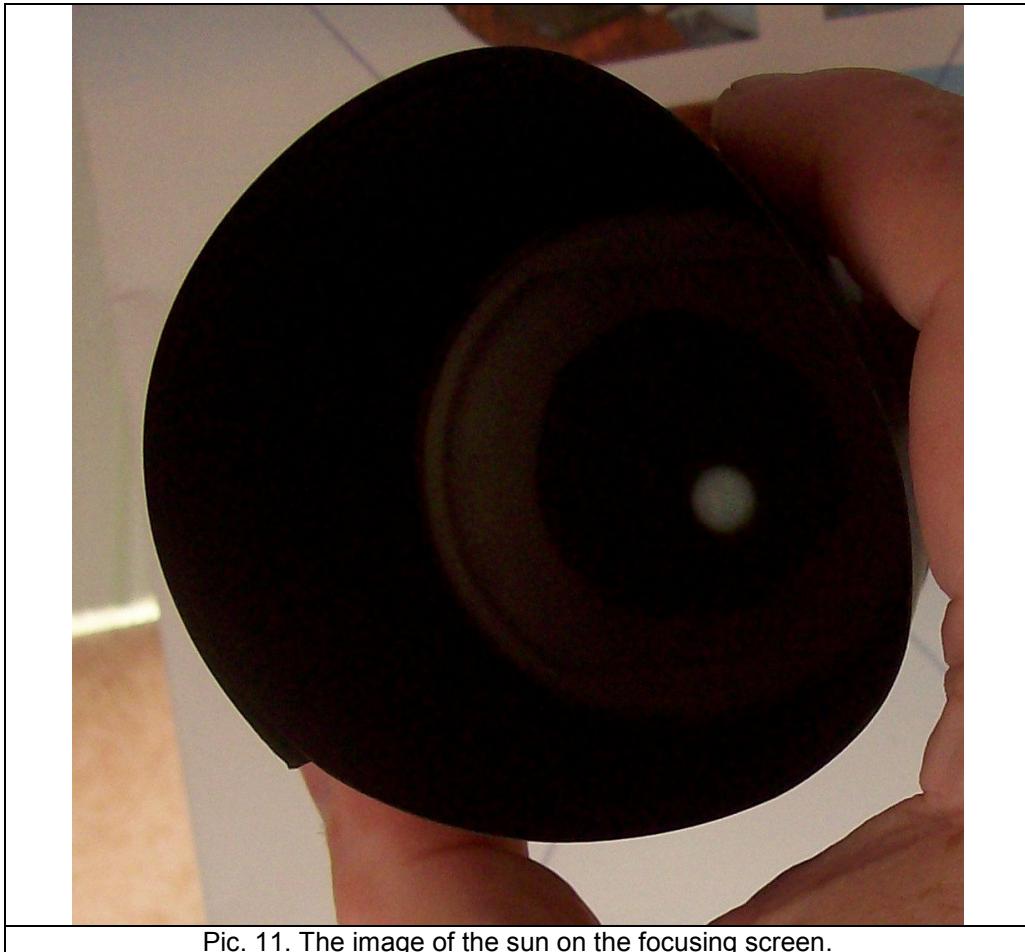
3. Observations

Our Camera Obscura for the observation of the Sun is ready. How to conduct observations? Simply aim the pinhole at the Sun and let it cast the image of our star on the focusing screen. The file cover will protect your eyes from direct sunlight and the black cardboard tube will provide additional protection against stray light which will make the image on your focusing screen more visible.

Despite appearances, finding the sun is not that easy, so we advise you to practice solar disk observations before the 6th of June in order to get some practice. Of course, your observations will be much more comfortable when you lean the front of your camera on a convenient wall, or mount it on a pole or tripod.



Pic. 10. Observations, aim the pinhole at the Sun and watch it on the focusing screen

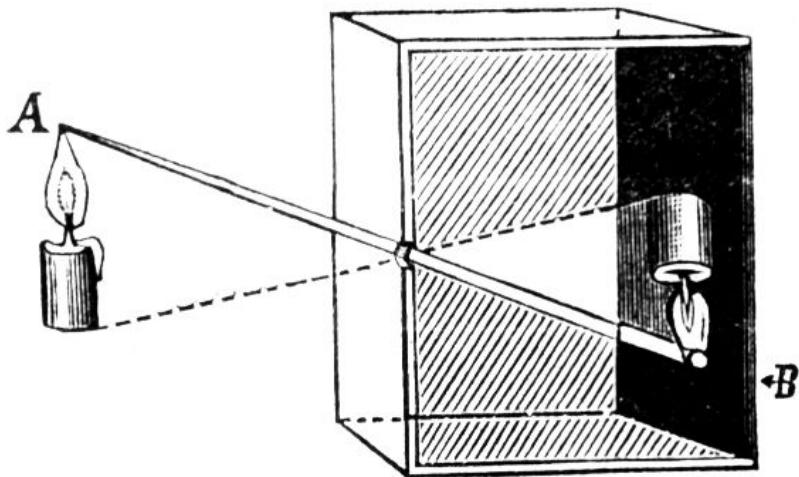


Pic. 11. The image of the sun on the focusing screen.

4. How does it work?

How does the pinhole camera work?

According to the principles of geometrical optics light rays go into all directions from every point of the observed object (the Sun, in this case). If there is not any media affecting the path of light rays (in particular, there is no refraction caused by the Earth's atmosphere), the light rays reaching the observer travel in straight lines. In the case of such a simple instrument as the camera obscura we can, despite the existence of the atmosphere, easily apply such an assumption about the straightness of light rays from the sun.



If we put an opaque diaphragm with a small hole on the way of the light rays, then different light rays from each single piece of the observed object (e.g. the solar disc) are cast on different parts of the screen that is placed behind the diaphragm. In this way we get a real, diminished, inverted, and relatively clear image of the observed object.

- Relatively clear, because each tiny bit of the image you get comes from a relatively small portion of the Sun (this is due to the small hole). It could be perfectly sharp, if the hole was infinitely small, and the light did not have the nature of the wave and did not result in the phenomenon of diffraction at the edges of the diaphragm.
- Real, because the image cast on the screen is made up by the actual light rays coming from the observed object.
- Inverted, because the ray of the upper part of the disc, passing through a small hole located on the axis of the object-hole-screen, falls to the bottom of the screen.
- Diminished, because the distance of the object-hole (that is practically the Sun-Earth) is much larger than the hole-screen distance of the camera obscura. The similarity of triangles shows that the diameter of the image is as many times smaller than the diameter of the Sun, as many times the distance from the screen-hole is smaller than the Earth-Sun distance.

Because each picture element is created by a separate light beam, the image created by the camera obscura has infinite depth of field (which is always sharp!) and shows a complete lack of distortion. If the observed object is the Sun with Venus passing in front of it, on the screen we get a clear picture of the solar disc with the black dot of the planet.

Therefore, finding the appropriate diameter of the hole is crucial for the quality of the resulting image. A large hole (about 1 mm or larger) gives a picture that is bright, but which at the same time is very (or completely) out of focus, because each tiny point of the screen will receive multiple rays of light coming from different parts of the observed object. In turn, with a very small hole (less than 0.1 mm) the wave nature of light becomes apparent causing strong diffraction effects. Therefore, the size of the hole is best chosen by trial and error.