

National Astronomical Observatory of Japan / National Institutes of Natural Sciences

# Solar Eclipse Viewing Guide

Planning: International Year of Astronomy 2009 Japan Committee

Production: "International Year of Astronomy 2009 Solar Eclipse Viewing Guide" Production team

# How to Enjoy a Solar Eclipse

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## Viewing the Sun through a Specially Designed Solar Filter

To view a solar eclipse, you need a specially designed solar filter, such as the one used in eclipse glasses. The following explains how to use a filter and gives examples of products.



Example of how to use specially designed solar filter

## Specially Designed Solar Filter



### Examples of specially designed solar filter

#### How to Use

1. In order to avoid direct sunlight entering your eyes, wear a brimmed hat when viewing a solar eclipse.
2. Hold the solar filter with one hand holding each side, wrapping your fingers around the edge of the device.
3. Bring the light shield of the solar filter as close to your eyes as possible.
4. Only view the Sun through the filter and only for a short period of time. Take several breaks during the observation.

#### Attention

1. Please read carefully and follow the instructions on how to use the solar filter.
2. Solar filters are created to protect your eyes, so please handle them with care. Before use, please make sure that the shield is not missing or has not been damaged in any way.
3. Do not stare for long periods at the Sun. Look through the filter briefly and then look away before resuming your viewing.
4. Please read "Things You Must Not Do When Using a Solar Filter (Observation Risks)."



### Baader Planetarium's AstroSolar™ Safety Film

Thin sheet-type shields, such as Baader Planetarium's AstroSolar™ Safety Film, are now available on the market. They can be cut to various sizes to be placed in filter rims or slide mounts. When hand-crafting a solar filter using this product, please assemble it carefully to prevent accidental exposure to direct sunlight.



Example of a handmade solar filter (shield placed in a paper slide mount)

Please make sure that there are no gaps, holes or damage to the filter that would expose your eye to direct sunlight.

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## Viewing a Projected Image of the Sun

There are several ways to observe solar eclipses other than using a solar filter. Here we will introduce three methods: pinhole crafting, sunbeams streaming through leaves, and mirrors.

### The Pinhole Projection Method

A “Pinhole” is a tiny hole made with a tool, such as a needle. By using a pinhole, you can project the shape of a solar eclipse onto the ground, in a box, and on other flat surfaces. Here we will introduce four types of handmade devices. The pinhole is a method you should only use to allow the viewing of a projected image of the Sun. As there is a risk of eyesight loss, do not look at the Sun directly through a pinhole.

**[Caution] Do not look at the Sun directly through a pinhole as there is a risk of eyesight loss.**



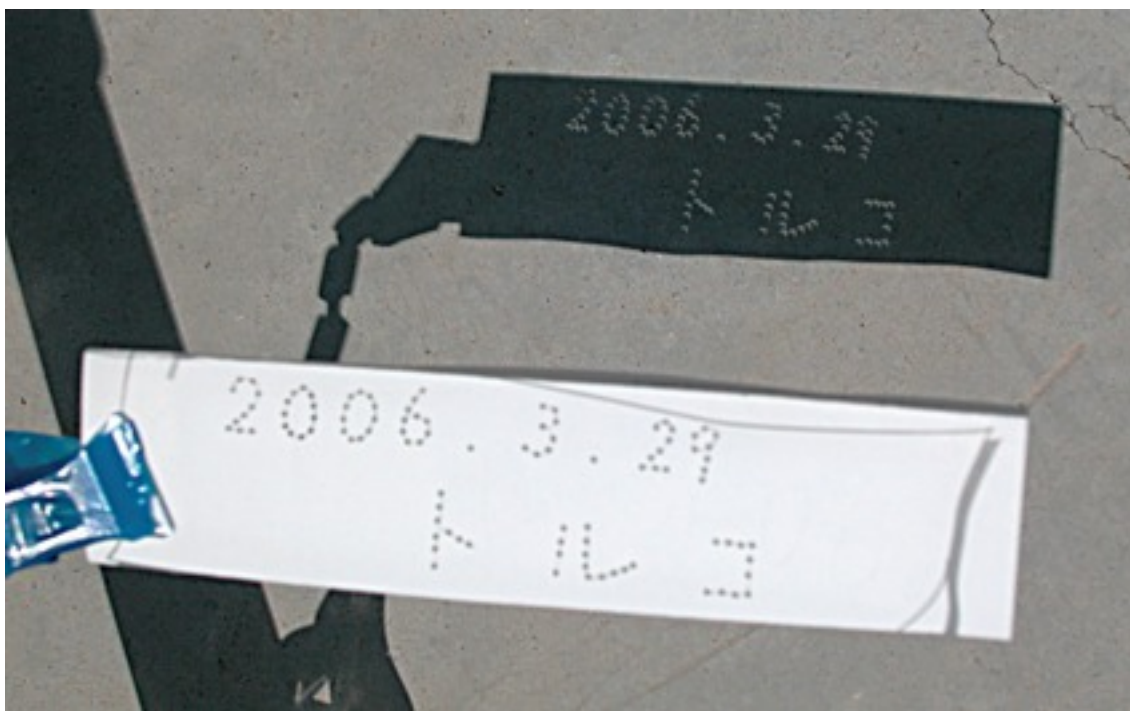
### Making a Hole on a Card

Pick a card and make a tiny hole in the middle with a tool, such as a pin, a needle, or a gimlet. Then project an image of the Sun onto a piece of white paper:

1. Make a tiny hole in the card.
2. View the shadow. It is easy to see the image if you project it onto white paper or a wall.
3. Observe different images of the Sun by changing the distance between the card and the white paper or changing the size of the hole.

### Create Letters through Pinholes

Takeshi Hirano, who traveled to Turkey to view a solar eclipse in 2006, used this method. It is a fun and different way to enjoy viewing a solar eclipse.



The letters are written by using many pinholes on a sheet of paper

The letters are written by using many pinholes on a sheet of paper. The holes are laid out evenly to achieve a neat finish. The shape of the solar eclipse is projected through the pinholes.

## Project an Image of the Sun in a Tube



### Project an Image of the Sun in a Tube

This is a way to project an image of the Sun in a handmade tube device, using the same principle used for pinholes. This device can be created by using a variety of tubular-shaped items, such as snack containers or the cardboard tubes used for cling film. Here is an example using a snack container. This is the method referred to and introduced in the “Eclipse Hunter’s Guide” (INFAS Publications), a book certified by the International Year of Astronomy 2009 Japan Committee.

1. Prepare two tubular containers. With care, remove the bottom of one container with a knife.
2. Connect one tube without a bottom securely with tape to another with a bottom to make a longer tube.
3. Prepare a sheet of aluminum foil, and make a small hole (approximately 1mm in diameter) in it with a pin. This hole is the point at which the sunlight will pass through, so it is very important to make one neat hole. You can use the lid from a cup noodle container as the aluminum sheet. Cut out a small window in the center of the tube lid and place the aluminum sheet with the pinhole in it.
4. Cut out an observation window on the side of the bottom part of the tube. Hold up the tube and aim the pinhole toward the Sun until you can see a round image of the

Sun at the bottom of the tube. The size of the image using this tube (two connected tubes) is approximately 5mm in diameter. Place the extra tube lid on the bottom of the tube so that it becomes thicker; this will improve the viewing of the image.

### **Advanced Version**

1. Here is an advanced version of the tube device. Connect several tubes to make a long device. When connecting, do not forget to remove the bottom of each tube to allow sunlight to pass through the device unhindered. (A card with a hole is attached to the top end of the tube in the photo.)

2. The longer the tube, the bigger the projected image of the Sun. If it is too dark to see, the hole at the top end of the tube can be slightly enlarged.

### **Project an Image of the Sun in a Big Box**

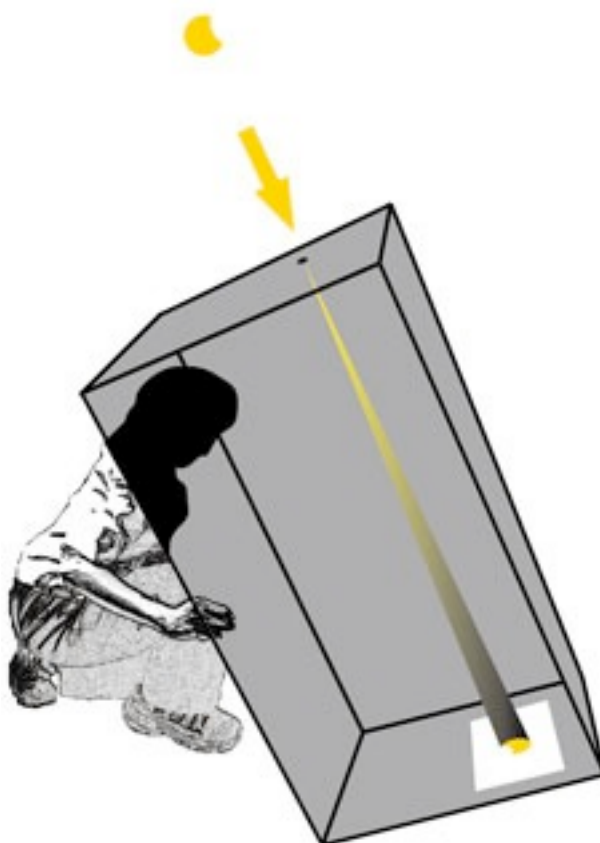
With a big box, you can make the projected image of the Sun a little larger. A box for a large astrometric telescope is a good example of an appropriate box to use.

The measurement of the diameter of the image of the Sun will be  $1/100$  of the distance from the hole to the projected point.

Make a 1-2mm hole in the top of the box and aim the hole at the Sun. When you see the image of the Sun projected in the box, you will see an approximately 1cm image of the Sun if the length of the box is 1m.

The image will be clearer if you darken the inside of the box and attach a piece of white paper to act as a screen. If it is too dark due to the small size of the hole, enlarge the hole little by little until you are satisfied.





**An example of a handmade box device made of a big box. Please do not conduct solar eclipse viewing in the middle of the road.**

Attach a piece of white paper inside the box to act as a screen and aim the hole toward the Sun.

If sunlight comes through a tiny hole in the wall of a dark room, the same thing will happen. It is the same method of viewing solar eclipses that has been employed since the 16th century.

### **The Method of Viewing Sunbeams Streaming through Leaves Projected on the Ground**

During a partial solar eclipse, you can observe the shadows of leaves and branches from a tree reflected on the ground or on walls. The sunlight that slips through the tiny gaps between leaves and branches becomes “sunbeams streaming through leaves” and is projected in the same way as that of pinhole. Although the shapes of the gaps vary, the sunbeams reflect the shape of the Sun, which is the source of the light. Aristoteles discovered and wrote about this phenomenon at the time of a solar eclipse in the 4th century B.C. Without any special tools or equipment, you can enjoy viewing solar eclipses directly using this method.

## The Mirror Projection Method

When projecting the reflection of sunlight onto a wall with a mirror, you can observe the shape of a solar eclipse regardless of the shape of the mirror. Use a small mirror to reflect the sunlight and project it onto a flat surface, such as the wall of a building, in the shade. This easy method works well when many people are viewing the eclipse together.

Move slowly away from the wall until a round shape of the Sun is projected on the wall.

Try using different sizes of mirrors or covering part of a mirror to see the difference in the projections. At the same distance from the mirror to the wall, larger mirrors project the Sun more brightly but the details are blurrier. On the contrary, smaller mirrors project a darker image but with more clarity.

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## Viewing with a Telescope

Some telescopes available on the market are not designed to be aimed toward the Sun. It is very dangerous to use them in the wrong way. Please read the product's instructions carefully before use.

With a telescope designed to allow solar viewing, you can see details on the surface of the Sun, such as sunspots. Sunspots indicate solar activity, and increase and decrease on an approximately 11-year cycle. When solar activity is low, it may be difficult to see sunspots on the day of a solar eclipse.

During a partial solar eclipse, pay close attention to the borderline between the Sun and the Moon. When observing the rim of the Moon closely with a telescope, you may be able to see craters on the Moon surface.

## Solar Projection Screen Method

### Preparing a Solar Projection Screen

This is also called the "projection method" and is a way of projecting an image of the Sun onto a Solar Projection Screen when viewing with a telescope. As this is a way to view the image on a board without looking directly into the path of light, it is possible for many to view at the same time. It is also a relatively safe way, as you do not look directly at the Sun.

First, check carefully in the catalog or instruction manual if the telescope you intend to use is designed to facilitate use of a Solar Projection Screen. If you are not sure, it is a

good idea to ask the manufacturer or specialist shop. If a Solar Projection Screen is included in the telescope set, there is no problem.

When using a Solar Projection Screen, fix an aperture cap onto the objective lens of the telescope. Neutral density filters are not required. Use an eyepiece that is designed for solar viewing. To view the entire solar photosphere, set the telescope at 40 to 50-fold magnification.

Most tubular framework telescopes have a viewfinder. A viewfinder is equipped with a lens, which can cause fire, burns, and damage. Therefore, it is safer to either use a viewfinder that does not focus light (spot finder of the same magnification) or simply remove the viewfinder.

A Solar Projection Screen must be installed near the eyepiece correctly with the weight balance of the telescope adjusted.



Example of a Solar Projection Screen in use (The model in the photo is Vixen's "Solar Observation Set 2009")

### Focusing on and observing the Sun

In order to focus on the Sun, pay attention to its shadow that the telescope projects onto the ground and look for the point where the shadow is the smallest. Do not look through

the telescope. Even if the viewfinder being used is not designed to focus light, do not focus on the Sun by looking through the viewfinder, but look at its shadow that the telescope projects onto the ground.

Once the Sun is focused on, adjust the focus in order to have a sharper image of the rim and the sunspots projected onto the board. It is difficult to have a good viewing if the telescope is fixed, as the Sun moves quite quickly and will quickly be out of its line of sight due to the Earth's movement. Check the direction (west) of the Sun's movement and follow it with fine focal adjustment.

Draw a circle on a sheet of white paper and place it on the projection board so that you can observe and record the location of sunspots and the shape of partial eclipses. Sunspots have been observed through the projection method since the age of Galileo nearly 400 years ago. It was considered important to collect this basic data to observe solar activity in the past.

Please read "Things You Must Not Do When Using a Solar Projection Screen" (Observation Risks: p21)

## Solar Filter Method

This is the method of fixing a specially designed solar filter over the objective lens of a telescope.

With a model that includes a special filter (e.g. "Skybird AT-MACS - 80L") in the package, and with the solar filter secured on the end of the telescope, it is possible to view the Sun directly through the eyepiece.

With other models, you can use the "Baader Planetarium's AstroSolar™ Safety Film (Visual ND5)" to cover the end of the telescope completely. As AstroSolar™ Safety Film is thin film, you need to hand-craft a sturdy cell to fix to the telescope.

Please make sure there are no gaps, breakages, or holes in the film. When fixing film to the end of the telescope, secure it tightly with tape so it will not be displaced by the wind or by a change in the telescope's position. As viewfinders equipped with lenses can be the cause of fire, burns, and damage to devices, it is safer to use a viewfinder that does not focus light (spot viewfinder of the same magnification) or remove it.

Make sure to fix a solar filter before focusing on the Sun. Focus on the Sun in the same way that you would focus on other celestial objects. However, it is quicker to focus on the Sun by looking at the shadow it projects on the ground.

Do not look at the Sun for long periods. Take several breaks during an observation.



Some models include a special filter in the package. (The model in the photo is Skybird AT-MACS - 80L)



If it is a little too bright when you look through the filter, tightly fix the aperture cap onto the frame of the filter.

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## Enjoying a Solar Eclipse through Images or Footage

There are some organizations that conduct live broadcasts of solar eclipses.

### Internet broadcasting

Internet broadcasting is very convenient if it is difficult to view a solar eclipse due to bad weather or for other reasons.

### Television broadcasting

There are special programs and real-time broadcasting on television.

### Satellite images

Images of the solar eclipse that was viewed in parts of Asia on July 22, 2009, were captured by Japanese Geostationary Meteorological Satellite “Himawari” and shown on the Meteorological Agency’s website.

### Footage viewing events

There are various places and events where live images are made available, such as science museums and other special locations.

\*Some event venues only allow admission by prior application and in limited numbers. Please inquire beforehand if you will be admitted without prior application.

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## Enjoying a Solar Eclipse Outside

### Participation in Observation Meetings or Solar Eclipse Related Events

Some solar eclipse viewing events are planned at various locations. For details, such as conditions for participation, please contact the organizers.

Many facilities associated with astronomy, such as science museums, observatories and planetariums, not only organize events on the solar eclipse day but also provide information about solar eclipses, including instructions, videos and displays on their viewing, which help viewers get the most out of the experience.



## To Avoid Risks

It is very important to understand the risks associated with solar (eclipse) viewing and pay special attention to safety. Please be aware that even the smallest mistake or lack of understanding can cause serious accidents or health problems.

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### Risks Associated with Solar Viewing: Basic Knowledge

#### **The Sun is an extremely bright celestial object.**

The Sun is approximately 120 billion times brighter than stars of the first magnitude and 460,000 times brighter than a full moon. We often feel that the light of a full moon at night is dazzling when we stare at it, so the brightness of the Sun is really beyond our imagination.

Therefore, please be aware that there is a real risk of causing serious damage to the eyes if you stare directly at the Sun with the naked eye even for the shortest time (less than one second). You need to know that retina problems (\*) or eyesight loss could occur through incorrect viewing.

\* The retina problem caused by solar eclipse viewing is called "solar eclipse retinopathy". Cases are reported after every solar eclipse.

#### **"Not bright = Safe" is completely wrong.**

The Sun may look dark through sunglasses or a black plastic board. However, this is only because the visible light (visible to the human eye) has been weakened and infrared radiation (also known as "heat radiation") that is harmful to the eyes is usually not shaded. Please be aware that the human eye does not feel the brightness of infrared radiation but could unknowingly be causing serious damage when you are not aware of the actual level of brightness.

This is the same for ultraviolet rays which are not detected by the human eye. UV rays can reach your eyes even when visible light has only been weakened.

To view the Sun or a solar eclipse safely, it is highly advisable to use a specially designed solar (eclipse) viewing device, such as solar eclipse glasses, that have been safety-approved.

### **It is dangerous to view the Sun for long periods.**

Avoid looking at the Sun for long periods even when using a specially designed solar (eclipse) viewing device (solar eclipse glasses).

Specially designed solar eclipse viewing devices weaken not only visible light but also harmful forms of radiation, such as UV radiation and infrared radiation. However, it is impossible for them to block 100% of these types of radiation. Take adequate breaks during an observation and make sure to limit continuous viewing to 2 to 3 minutes at a time.

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## **Things you Must Not Do (Viewing with Risks)**

### **Do not look at the Sun directly.**

Do not look directly at the Sun with the naked eye. It is very dangerous to look at the Sun directly, even with sunglasses. Make sure to use specially designed solar (eclipse) viewing devices, such as solar eclipse glasses.



It is very dangerous to look at the Sun directly even with sunglasses

Do not look at the Sun with standard telescopes or binoculars.

**[Warning]** You must not look at the Sun directly with standard telescopes or binoculars as there is a serious risk of blindness.



You must not look at the Sun directly with standard telescope or binoculars.

### Do not look at the Sun through the optical viewfinder of a camera.

If you try to take a photo of a solar eclipse and look through the viewfinder of a camera aimed at the Sun, you may be at risk of blindness.

### Risks of Darkening Methods

Even when you do not feel the Sun is too bright, there is the risk of serious problems to the eyes through infrared radiation. Some of the following may also pose safety problems.

Do not look at the Sun through:

- Black or colored plastic boards
- Acrylic boards and plastic boards
- CDs and DVDs
- Smoked glasses
- Black plastic bags, such as garbage bags and snack bags
- Neutral density (ND) filters for photography
- Glass plates with candle soot
- Black part of developed photo film



Do not look at the Sun through black or colored plastic boards.



Do not look at the Sun through neutral density (ND) filters for photography.

Use of some of the above may not involve risk if used properly with correct understanding. When using any of the above for solar viewing, please be sure to follow the instructions given by a person with full knowledge of solar viewing. It is very dangerous to conduct viewing without thorough knowledge of safe viewing methods.

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## Things You Must Not Do When Viewing with the Naked Eye through a Solar Filter (Viewing Risks)

### Do not combine with a telescope or binoculars

Solar filters used for viewing with the naked eye are not designed to be combined for use with optical instruments, such as telescopes, binoculars and cameras. If you view with such an instrument, the entry of light that has not been factored into the design could lead to serious eye problems. There is also the risk of damage or breakage to solar filters or optical instruments.





Do not combine solar filters designed to be used with the naked eye with binoculars, telescopes or cameras.

### **Do not look at the Sun for long periods.**

Even when viewing the Sun through a specially designed solar filter, do not look at the Sun for long periods and take adequate breaks during an observation. Please remember that 2 to 3 minutes is the limit for any stretch of continuous viewing.

In order to take adequate breaks during an observation, it is advisable to hold solar filters in your hands, not to wear them as you would wear eyeglasses.

### **Others**

- Do not walk or ride a bicycle while wearing a solar filter.
- Do not use damaged solar filters.
- Do not disassemble solar filters.

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## **Precautions for the Combined Use of a Telescope and a Solar Projection Screen (Viewing Risks)**

### **Do not use telescopes and their accessories that are not designed for solar viewing.**

Some models are not designed to allow a Solar Projection Screen to be installed or simply not suitable for solar viewing. Some eyepieces are also not suitable for solar viewing.

Please check if the telescope or its accessories, such as eyepiece, that you intend to use are suitable for solar viewing by reading the instruction manual carefully or by asking the manufacturer or retailer.

### **Viewing Precautions**

Remove viewfinders when not in use to avoid someone looking through them by mistake. When you focus on the Sun, make sure to do so by looking at its shadow projected onto the ground, never directly through the telescope.

Please make sure that observers do not place their hand or face in the path of the light to the Solar Projection Screen.

If a person in a position of responsibility has to leave for any reason, make sure to attach the cap on the lens of the telescope, or adjust the focus away from the Sun.

When using a Solar Projection Screen, do not place your hand or face in the path of light.





**It is very dangerous to insert body parts into or to look through the path of light.**

If you conduct solar viewing over a long period, the telescope or its accessories may become damaged due to heat. If you find any abnormalities to the telescope or its accessories, stop the viewing immediately.

## Other Cautions

### Be careful of heat stroke.

Please be very careful to avoid heat stroke when conducting a solar (eclipse) viewing in the scorching outdoor heat. Make sure to always wear a hat, drink plenty of fluids, and take occasional breaks in the shade.

### Precautions Regarding Solar Eclipse Viewing

It is only possible to view a solar eclipse directly with the naked eye during a total eclipse (when the Sun is hidden completely behind the Moon.) You will not see anything if you view it through a solar filter:

You can also view the “diamond ring” effect, which appears for a few seconds just before or just after a total eclipse, with the naked eye. **You can only look at the Sun with the naked eye up to this point.**

During a partial eclipse (when the Sun is not completely hidden behind the Moon), you need to use a solar filter, such as solar eclipse glasses. You also need a solar filter after viewing a total eclipse and the diamond ring effect, as the extremely strong light appears quickly as a flash. Do not continue viewing directly with the naked eye. Please use a solar filter:

**[Caution] Never look at the Sun directly with the naked eye during a partial solar eclipse. (A solar filter, such as solar eclipse glasses, is definitely necessary for your safety.)**

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When viewing, please be sure to follow the instructions given by a person with full knowledge of solar viewing to reduce risk. This Solar Eclipse Viewing Guide was designed to provide basic information for many people to enjoy viewing a solar eclipse, such as the one witnessed in parts of Japan on July 22, 2009.

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