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The Nearest Stars: A Guided Tour

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A tour through our stellar neighborhood

As evening twilight fades during April and early May, a brilliant, blue-white star can be seen low in the sky toward the southwest. That star is called Sirius, and it is the brightest star in Earth's nighttime sky.

Sirius looks so bright in part because it is a relatively powerful light producer; if our Sun were suddenly replaced by Sirius, our daylight on Earth would be more than 20 times as bright as it is now!

But the other reason Sirius is so brilliant in our nighttime sky is that it is so close; Sirius is the nearest neighbor star to the Sun that can be seen with the unaided eye from the Northern Hemisphere.

"Close'' in the interstellar realm, though, is a very relative term. If you were to model the Sun as a basketball, then our planet Earth would be about the size of an apple seed 30 yards away from it — and even the nearest other star (alpha Centauri, visible from the Southern Hemisphere) would be 6,000 miles away.

Distances among the stars are so large that it is helpful to express them using the light-year — the distance light travels in one year — as a measuring unit. In this way of expressing distances, alpha Centauri is about four light-years away, and Sirius is about eight and a half light- years distant. (Thus if your students look at Sirius this evening, then they will be seeing light that left the star in 1977!)

The table shows the distances and brightnesses of the dozen stars (distributed among eight star systems) that are known to be within 10 light-years of us. But let's first get to know each of these stars a little better. (An explanation of some of the unusual names follows the table.)

By the way, don't reproach yourself if many of our stellar neighbors are not familiar to you. Only Sirius and two others are bright enough to be seen without a telescope. Our Sun isn't really a very "average, garden-variety'' star at all! Of the 12 nearest stars, only two are brighter, and most of the others are *much* dimmer. This preponderance of dim stars isn't restricted to our immediate neighborhood. It seems that dim stars in the universe at large are like rabbits and bureaucrats: They may not be very bright, but there are a lot of them.

Alpha Centauri

Through telescopes, we find that the Sun's nearest neighbor is really a system of three stars, slowly orbiting around one another. Alpha Centauri A (the brightest of the three) is very similar to our yellow Sun. Alpha Centauri B is a bit smaller, and its dimmer light has an orange hue because the temperature of its outer layers is cooler — about 4800 degrees Celsius compared to the 5800 degrees of the Sun and alpha Centauri A. (Stars' colors are dictated by their temperatures, just as an electric stove-top heating element changes color as it heats up. The coolest visible stars are red, and hotter ones are orange, yellow, and bluish-white.)

The two central stars take 80 years to orbit around each other, and they are about 20 times as far from each other as Earth is from the Sun. (This is about the same as the distance from the Sun to the planet Uranus.)

The third star, alpha Centauri C, is sometimes called Proxima Centauri because it is the closest to us of the three. It is a dim, red (cool), small star, and is very far from the central pair; at least 300 times as far as the most distant planet in our solar system is from the Sun! This is still a very small fraction of the average distance between star systems, though, and Proxima is certainly caught in a long and slow orbit around its brighter two siblings. If our Sun had a companion just like alpha Centauri C that far away, it would look like a very ordinary starlike point of light in the night sky, visible to the unaided eye, but dimmer than hundreds of other stars.

Barnard's Star

This very modest little star, located just six light-years away in the direction of the constellation Ophiuchus, is the closest star that can be studied from the Northern Hemisphere — but only with the aid of telescopes, since it is much too dim to be seen with the unaided eye. It's a dim red dwarf star like Proxima Centauri (and most of the other stars on our list of neighbors) which first caught astronomers' attention in 1916. In that year, Edward Emerson Barnard of California's Lick Observatory found that this star's motion across the sky is the fastest known.

While the constellations appear fixed and unchanging over a human lifetime or two, the stars do slowly change their positions over the centuries as the Sun and the other stars move through space at various speeds and in different directions. For most stars, this change in position on the sky is very slow, indeed — the constellations of 10,000 years ago were only slightly different from what they look like now. But stars that are quite nearby can change their positions relatively rapidly, just as an automobile on a street right next to you zips past you quickly, but cars on a distant highway seem to crawl along.

Barnard's Star moves across the sky at a rate of about half a degree (the size of the Moon's diameter) every 175 years. As it moves across the sky, it also is getting closer to us. Calculations indicate that it will pass by us at a distance of 3 3/4 light-years (closer than alpha Centauri) — in about A.D. 11,800!

As the star moves, it doesn't seem to follow a perfectly straight line. Careful observations over several decades by Peter van de Kamp and his colleagues at Sproul Observatory in Pennsylvania indicate that it may be "wobbling'' slightly around a straight-line path. It is possible that this wobble comes from the star's being tugged this way and that by the gravity of one or more large planets orbiting around it. (Currently, planets around other stars can't be seen through telescopes from Earth if those planets are like the ones in our solar system. Not producing light by themselves, they would be very dim and so close to their stars that their feeble, reflected light would be swamped in glare.) Astronomers have found very faint companion stars using the "wobble'' method, but no planets have been confirmed as yet. The work is continuing at several observatories.

Wolf 359

This red dwarf star in the constellation Leo is the weakest light producer among our neighbors and it is one of the dimmest stars known. If the Sun were to be replaced by Wolf 359, then you'd need a telescope to see its ball shape clearly. Daylight would be dim: Wolf 359 would be only 10 times as bright as full moonlight is now.

BD +36 degrees 2147

Yet another red dwarf — it's a little bigger, warmer, and brighter than any of the others we've seen in this list, but it's still quite feeble compared to the Sun and alpha Centauri's brighter two stars. About three times too faint to be seen with the unaided eye and in the same constellation as the Big Dipper, this star (like Barnard's Star) is suspected to have at least one companion planet. (In some tables of nearby stars, this star is referred to as "Lalande 21185.'')

Luyten 726-8

One member of this pair of red dwarfs — sometimes called "UV Ceti'' — is the prototype of a whole class of stars called "flare stars.'' These are red dwarfs that seem to have explosive personalities: Sometimes they suddenly become much brighter than usual — occasionally several times brighter — and then fade back to nominal within a few minutes or hours. Astronomers suspect that these outbursts are due to localized, intense eruptions on their surfaces similar to explosions on the Sun called "solar flares.'' Such flares — which increase our luminous star's total brightness only minimally — would stand out brilliantly on the much dimmer red dwarfs. (Other red dwarfs on our list are flare stars, too: Proxima Centauri, Wolf 359, and Ross 154.)

Luyten 726-8 A and B are about six times as far apart as Earth is from the Sun, and they take about 25 years to orbit around one another. Each of these little stars is among the lightest weight known: Together their total mass, which they probably share about equally, is only about 30 percent of the Sun's. (Luyten 726-8 is in the constellation of Cetus, the whale.)

Sirius

The bright jewel of our stellar neighborhood — the "Dog Star'' in the constellation Canis Major — is really a double star, and each member is remarkable among local stars.

Sirius A, electric blue-white and roughly twice as wide in diameter as our Sun. is by far the brightest. hottest (nearly 10,000 degrees Celsius at the surface), and heaviest (about 2.2 times the Sun's mass) star close to the Sun. (The closest star which is even hotter and more luminous than Sirius is Vega, about 25 light-years away from us.)

Sirius B is our nearest example of a *white dwarf* star: an ultra dense, collapsed core of a star which long ago ran out of fuel to keep its energy-producing nuclear reactions going. While it is only about the size of the Earth — about a million times smaller than the volume the Sun takes up — it weighs fully 94 percent as much as our star! Its material is so compressed that a quart bottle full of its material would have about as much mass as a jumbo-jet airliner. The force exerted by its gravity would literally be crushing; if we could somehow stand on its surface, a 100-pound student would weigh something like 10,000 tons. (The next-nearest white dwarf star orbits around the bright star Procyon, about 11 1/2 light-years away from us.)

The two stars are both blue-white, but radically different in all other respects. They orbit around one another in about 50 years with an average distance between them of roughly 20 times the Earth-Sun distance.

Ross 154

The last of the stars we know to be closer than 10 light-years, Ross 154 is another of those ubiquitous red dwarfs. Much too dim to be seen with the unaided eye, it is a thoroughly unremarkable-looking point of light in the crowded constellation Sagittarius as seen through a telescope.

Table: Stars Within 10 Light- Years

Name	**Distance (light-years)**	**Apparent Brightness[1]**	**Luminosity[2]**
Sun	—-	(120 billion)	1.00
Alpha Centauri A	4.3	0.26	1.56
Alpha Centauri B	4.3	0.077	0.45
Alpha Centauri C	4.2	0.00001	0.00006
Barnard's Star	6.0	0.00004	0.0005
Wolf 359	7.7	0.000001	0.00002
BD +36 degrees 2147	8.2	0.0003	0.006
Luyten 726-8 A	8.4	0.000003	0.00006

Luyten 726-8 B	8.4	0.000002	0.00004
Sirius A	8.6	1.00	23.6
Sirius B	8.6	0.001	0.003
Ross 154	9.4	0.00002	0.0005

Table adapted from one compiled by Alan H. Batten in The Observer's Handbook 1986, edited by Roy L. Bishop, Royal Astronomical Society of Canada.)

Notes

1. The apparent brightness is how bright the stars look in our sky, compared to the brightness of Sirius A.
2. Luminosity, or the true brightness, is how bright the stars would look if all were at the same distance (compared to the Sun).

Names

Most of the "names'' of the stars are really numbers from various star catalogs and surveys, or designations according to their brightnesses or positions on the sky. The exceptions in this table are the Sun, Sirius (a name which comes from a Greek word which means "sparkling''), and Barnard's Star. The reason for this generally anonymous state of affairs is that — despite their proximity — most of these stars do not shine very brightly (noticeably) in our nighttime sky.

A designation which starts with a Greek letter or a number is based on the star's brightness rank within its constellation. For example, alpha Centauri is the brightest star in the constellation Centaurus. (Alpha is the first letter in the Greek alphabet.) "BD'' stands for "Bonner Durchmusterung,'' a 19th-century star catalog. The other names refer to stars found in individual surveys of the sky.

If a star is found to be a multiple star — that is, two or more stars orbiting around one another — then 'A', 'B', and so on are added to its name to identify its individual members. It's interesting to note that multiple stars are not at all rare; in fact, more than half of the individual stars in our table are members of three multiple-star systems!

Distances

As you might imagine, measuring distances as vast as these is a very difficult thing to do. The numbers given in the table's distance column represent a "progress report'' of sorts; the data here are all subject to some experimental uncertainty, and astronomers continue to refine their distance measurements. This means that the order of the stars shown here — especially for those which have similar distances — is subject to change.

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Additional information on viewing solar eclipses (pdf)

Activity: Observing the Sun — Safely

by John R. Percy, University of Toronto

[Editor's note: Since other stars are so far away, much of the progress we are making in understanding stars in general comes from studying our own "hometown'' star, the Sun. Although most of us associate the study of astronomy with the night, in this month's activity our newsletter's newest contributing editor shows that the Sun can lend itself to useful daytime astronomy activities. (Dr. Percy is professor of astronomy at the University of Toronto in Canada and one of the world's leaders in the field of astronomy education.)]

We must begin with an important warning: Never look directly at the Sun, especially when using binoculars or a telescope. Direct sunlight can cause *permanent eye damage* in seconds, without the victim being aware of it until it is too late.

For safe direct viewing of the Sun, #14 welder's glass can be used, or a proprietary material known as Solar Skreen (Roger W. Tuthill, Inc., 11 Tanglewood Lane, Mountainside, NJ 07092). Although some telescopes are equipped with Sun filters, many of these are not reliable, and should not be used unless you are *absolutely* sure of what you are doing. The only reliable filters are some (but not all) which fit over the front of the telescope, and reflect away most of the light.

The best way to view the Sun with binoculars or a telescope is by *projection* — looking at an image of the Sun rather than at the Sun itself. Instructions for doing this are given below.

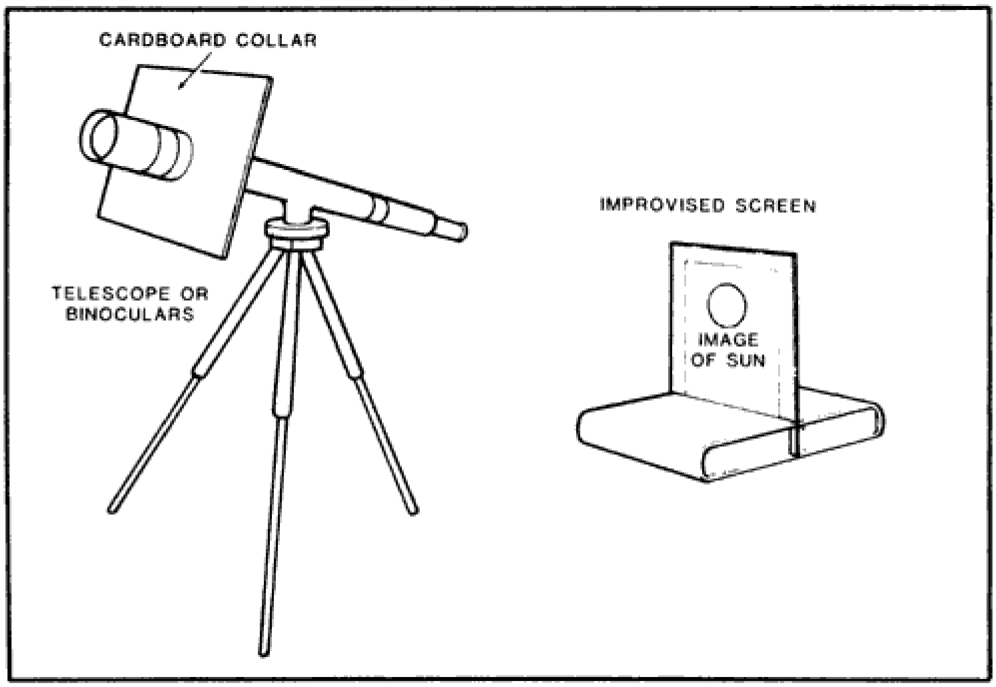
We should note that some school officials feel that all viewing of the Sun should be forbidden. Even though there are safe ways to view the Sun, there is always a chance that some student will not take the necessary precautions, or will disobey instructions, and an accident will occur. The projection methods described below are quite safe, however — and the number of astronomy-related school accidents is far less than the number encountered in other science subjects!

Viewing the Sun by Projection

This method is relatively safe and, with it, many people can view the Sun at once. You will need a pair of binoculars or a small telescope, a piece of plain cardboard about 30 centimeters square for the "collar,'' and a second piece of white cardboard (or paper) at least 10 centimeters square for the screen. If you use a telescope, you should mount it on a tripod. If you use binoculars, you can hold them in your hand, but it is much more convenient (and you will have a steadier image) if you improvise some sort of stand or tripod to hold them.

This demonstration can be done at any time of the day when it is clear and when your class has access to direct sunlight.

Note: Do not use binoculars whose front lenses are 50 millimeters across or wider. (Binoculars usually are described by a pair of numbers separated by an 'x', such as "7 x 3'' or "7 x 50''; the number to the right of the 'x' is the diameter of the front lenses in millimeters.) Big lenses gather a lot of light, and the heat generated by direct sunlight in side large binoculars can damage their complex optics.



Method

1. Make a cardboard collar to fit around the front end of the binocular or telescope, as shown in the figure. This shades the area where the image will be from sunlight. and (in the case of binoculars) will cover the lens which you are not using.
2. Focus the binocular or telescope on infinity by looking at a distant object (not the Sun!) in the normal way. (If you are using a telescope. use a low-magnification eyepiece.)
3. Point the binoculars or telescope at the Sun (do *not* look through the instrument to do this!), as shown in the figure, and adjust the direction of pointing until the image of the Sun appears on the screen. (This may take a minute or two. One useful trick is to watch the shadow of the binoculars or telescope tube: if pointed directly toward the Sun, then the sides of the tube will cast no shadows, and the instrument's shadow will be as small as it can be.)
4. Move the screen toward or away from the eyepiece until the image of the Sun fits neatly in the middle. and adjust its tilt until the Sun's image is circular.
5. Jiggle the binoculars or telescope very slightly. Any specks on the image of the Sun which do not jiggle along with the image when you do this are specks in the binoculars or telescope (or smudges on the screen), and not spots on the Sun itself.

Observations

When you and your students examine an image of the Sun, you will notice the following properties:

1. The image is brighter in the middle of the disc than at the edges. This effect is called *limb-darkening.* It occurs because, when we look at the middle of the Sun's disc, we are looking straight down into the hotter part of the Sun. At the edges of the disc, we look more obliquely, and see only the cooler, less bright gases, higher in the Sun's atmosphere.
2. The image moves slowly across the screen. This is due to the east-to-west motion of the Sun in the sky, caused by the rotation of the Earth. The direction of motion of the image therefore tells you which direction on the screen (and on the Sun's image) is west.
3. There may be small darks spots on the image. These are called *sunspots* and are regions in the outer layers of the Sun which are cooler and therefore not as bright as their surroundings. In sunspots, the

Sun's magnetic field is exceptionally strong, and astronomers suspect that this is connected to their being darker than the material around them. Sunspots, when examined closely with a telescope, are seen to be very complex. They can form within a few days, and may endure and evolve for weeks or months.

An Alternate Way to Project An Image of the Sun

This method produces an image which is a bit fuzzy, but good enough to show large sunspots, and it is particularly suitable for observing a partial eclipse of the Sun. It is very safe, and can be used to show an image of the Sun to an entire class. You will need a small pocket mirror or hand mirror. a piece of plain cardboard to fit over the mirror (or some tape to cover it), and a piece of white cardboard or paper to use as a screen.

Method

1. Cut the plain cardboard or paper so it fits over the mirror.
2. Cut or punch a very small hole, about 5 millimeters in size. in the middle of the plain cardboard. You could also use tape to cover all but a small portion of the surface of the mirror.
3. Put the mirror on a window sill in the sunlight such that it catches the rays from the Sun. Turn the room lights off and draw the window blinds so that as little as possible of the room other than the mirror is in sunlight.
4. Reflect the sunlight onto a wall of the darkened room.
5. Put the white cardboard or paper on the wall at this point, so you can use it as a screen to display the image of the Sun.

Observations

1. You will notice that the image of the Sun is round (unless an eclipse is in progress), even if the hole which you cut or punched in the plain cardboard or paper was square!
2. You can also demonstrate that the size of the image of the Sun is proportional to the distance of the screen from the mirror. The larger the distance. the larger (and fainter) the image. In a more advanced class, you might want to develop an explanation for these two observations.

If you do not have a classroom in which there is a sunlit window, you can do the activity outdoors. Find a place where you can catch the sunlight with your mirror, and reflect it onto a shaded wall. (Better still, reflect it into a darkened classroom.) Again, you can use a sheet of white paper or cardboard as a screen. It takes a few minutes to discover the best arrangement for the mirror and the screen, but once you have done so, it is easy to set up the demonstration again on any following day.

Further Reading About The Sun

Robert Burnham: "Observing the Sun,'' *Astronomy,* August 1984, p. 51.

B. Ralph Chou: "Safe Solar Filters,'' *Sky & Telescope,* August 1981, p. 119.

Alan MacRobert: "Close-Up of a Star'', *Sky & Telescope,* May 1985, p.3 97.

Simon Mitton: *Daytime Star* (1981, Scribner's)