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Blinded by the Light!

This series of drawings shows how filtering out much of the light from the star can reveal planets that were "hiding" in the star's glare.

For at least a few hundred years people have understood that the stars they see at night are really suns like our own. Or, put another way, our sun is a star, like the ones we see at night. Our star looks so much brighter because it is so much closer to us than any of the other stars. Do these other suns also have planets around them like ours does? Or are planets uncommon and we just got lucky? Why do we care? As far as we know, planets are necessary for life. If there is any other life out there, and we want to find it, we'd best start by looking for planets.

In the past few years, astronomers have discovered a number of planets outside our solar system. The **extrasolar planets** that have been discovered are very large, about the size of Jupiter or larger. But even though they are so large, we can't see these planets with telescopes. We know only indirectly that they are there. Astronomers can measure the slightest wobble in the star's motion as the gravity of the orbiting planet tugs on the star.

Lost in Glare

Why can't we see them? Even though we have some very powerful telescopes that help us see almost to the edge of the known universe, finding a planet around a star is like looking for a mosquito a couple of inches away from a car headlight—at midnight! The light from the star is so bright that any planets get lost in the glare.

But astronomers and the space engineers who work with them do not give up easily! Using several clever technologies, they are certain that they will soon detect unmistakable signs of much smaller, more Earth-sized planets, and even be able to see them directly.

Although different from the techniques astronomers use to detect planets, **occulting** is a technique you have no doubt used yourself many times to block out the glare from the sun so you could see better. (To "occult" means to conceal or block from view.) You may have used your hand, the bill of a baseball cap, or the windshield visor of a car to occult the Sun's glare.

See for Yourself

Try this demonstration of occulting. You can do this activity in teams of three, or do it as a whole class. Make sure everyone has a chance to experience the demonstration.

Equipment needed:

- Flashlight
- Small objects, such as large paper clip, marble, spool of thread, golf ball, key, small stone, matchbook, etc.
- Small spoon (teaspoon)

Be careful! Use just an ordinary flash-light, not one that puts out a blinding beam of light! The light is too bright if it bothers people to look toward it (unless they are extremely sensitive to light).

Setup:

Make the room where you do this demonstration as dark as possible. It doesn't have to be totally dark, but turn off room lights and close any drapes or blinds.

Demonstration of occulting:

- One person (we'll call "Sunny") will hold the flashlight, which will represent the star.
- Another person (we'll call "Orbie") will hold one of the small objects near the flashlight. This small object will represent a planet orbiting the star.
- Another person (we'll call "Argus"*) will stand about 15 feet away and look toward the flashlight "star" and represent an astronomer on Earth looking for extrasolar planets. The astronomer will have the spoon close at hand to use as an **occulting disk** to block out the light source.

1. Sunny the Star shines the light beam toward Argus the Astronomer.
2. Orbie the Planet selects one of the collection of small objects and holds it beside the flashlight. Start out with the object about 2 or 3 inches away from the light source.
3. Argus looks toward the light (although it is not necessary to have the beam shining directly into the eyes) and tries to guess what object is being held up. If Argus can't see the object, Orbie can move the object farther away from the light source, and ask Argus to guess again. Keep moving the object away, bit by bit, to see if Argus can finally tell what the object is.

   Depending on how dark the room is, Argus may not have been able to see the object at all because of the glare of the flashlight.

4. Now try it again, with a different small object as the "planet." This time, however, Argus the Astronomer gets to use the occulting trick. Argus closes one eye and holds the occulting disk (bowl of the spoon) out in front of the other eye, adjusting the distance until the disk occults (blocks out) the light source. Now, what object is Orbie holding near the "star"? Is it easier to see the small "planet" near the "star" if the light from the star is occulted?

Tricks of the Astronomy Trade

Some spacecraft have used a similar occulting technique to block out the whole sphere of the sun so that the corona (outer atmosphere of the sun) could be better studied.

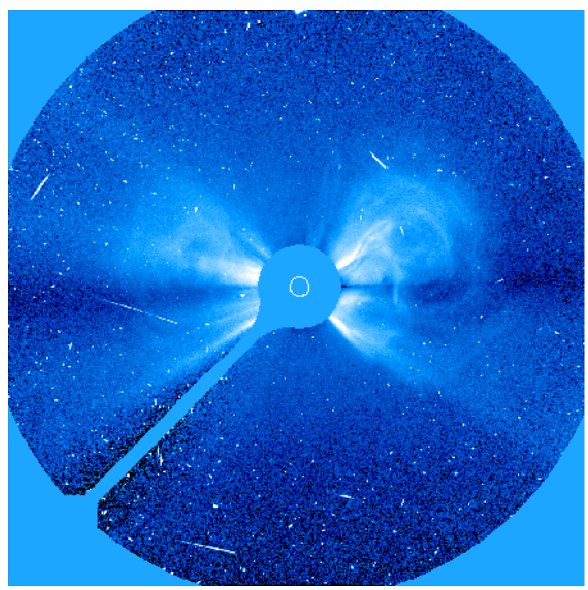


Image taken by one instrument on the SOHO (for Solar and Heliospheric Observatory) spacecraft. It shows a large coronal mass ejection (CME) from the Sun. A small occulting disk on the instrument blocks out the sun itself so that these huge events occurring in the sun's atmosphere can be studied. Learn more about CMEs at http://www-istp.gsfc.nasa.gov/istp/outreach/cmeposter/hurricane.html .

* In Greek mythology, Argus was a giant with one hundred eyes.

Although occulting is a good way to study our own star, other stars are too far away and appear too tiny in the sky for occultation to work. We can't block out the star without also blocking out the whole star system, should planets be present. We need techniques that are thousands of times better than occulting to get rid of the light from only the star and then sorting out the image of what is left. **Nulling** is just such a technology.

Telescopes such as those that make up the Keck Interferometer high on a mountain in Hawaii use nulling techniques. **Interferometry** (en-ter-fur-AH-muh-tree) combines the light beams from two or more telescopes that are focused on the same star at the same time. This combined image is far sharper than a single telescope could make. Thus, interferometers such as the Keck have extremely good **angular resolution**. That means they are very good at sorting out which light waves come from which part of the star system. An interferometer can be "tuned" so that the light coming from the exact center in the field of view (where the star is) will be blanked out or **nulled**, while the light from any other area will be viewed normally.

Lost in Dust

In addition to the glare from the star making the hunt for planets more difficult, stars are also often surrounded by a disk of dust. Even our own star has quite a lot of dust left over from the formation of the planets, moons, and asteroids. This dust, called **zodiacal** (zo-DI-a-kul) **dust**, glows in the light of the sun. It is so thin that we seldom see it. But it is visible as a faint glow across the sky in some very dark, clear, dry areas on Earth.

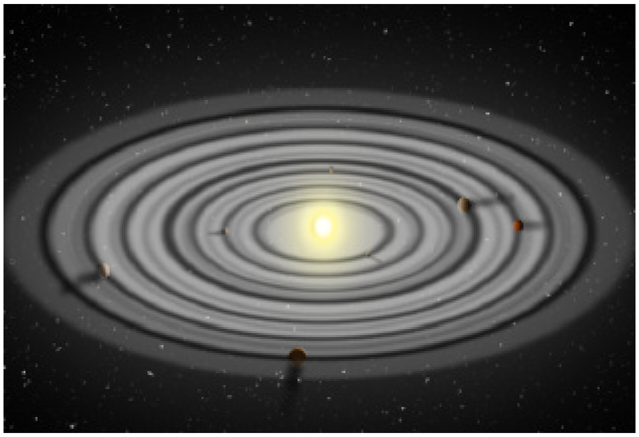
Stars that are most likely to have planets or be in the process of forming planets, will be surrounded by some or a lot of this dust. When the dust surrounds other stars, we call it **exozodiacal** (ex-o-zo-DI-a-kul) **dust**. This dust also makes it very hard to see any planets that might be swimming around in it.

One of two huge telescopes that make up the Keck Interferometer. Notice the tiny astronomer standing in the lower right corner of the opening in the dome.

If the Boat's too Small, Look for the Wake

But just as a boat leaves a wake behind it as it moves across the surface of a calm lake, a planet carves out a gap or lane as it plows through the exozodiacal dust of its star. Thus, another way to look for extrasolar planets may be to look for gaps in the dust.

How could we possibly see these gaps? Well, since the gaps would contain less dust to absorb energy from the star, they would appear colder than the surrounding dust. We could thus look for temperature differences within the cloud of exozodiacal dust. To find such small temperature differences, we would need to look in the infrared part of the spectrum. The waves of infrared light are just a little longer than waves of visible red light. We cannot see infrared waves with our eyes, but we feel them as heat. This is the best part of the spectrum to study in order to find small differences in the temperature of fairly cold matter.



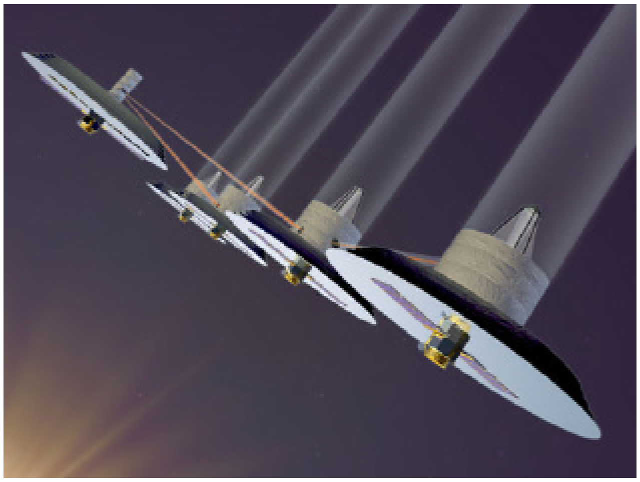
If a star is surrounded by a disk of exozodiacal dust, any orbiting planets might create a particular "signature" in the dust.

In the visible light part of the spectrum, a star shines thousands of times brighter than does its surrounding dust! Not much sense in even trying to find planets in that range of wavelengths. In the infrared part of the spectrum, the star is still much brighter than any planets, but the difference is not quite so great. So it would make sense to look only at the infrared part of the spectrum. The Keck Interferometer can do just that.

Now is when the excellent angular resolution of the interferometer comes in. We set the interferometer to null out the infrared waves coming from only--and precisely--the star itself. So what is left? Only the infrared waves coming from the surrounding dust disk. Now the dust and any tell-tale gaps carved out by planets are, at last, revealed!

But why would we be satisfied with just a hint that a star might have planets when we still couldn't actually see them? Well, we wouldn't! But this technique might point to some likely candidates for study using still more advanced technologies now being developed. Future missions, such as Terrestrial Planet Finder, will, indeed, be able to not only find Earth-sized planets, but will be able to detect the chemical signs of life!

For more information about the Keck Interferometer and the Terrestrial Planet Finder missions, see the web site of NASA's Origins Program (http://origins.jpl.nasa.gov/), which seeks answers to two questions: Where do we come from? and Are we alone? And for more fun space-related activities and amazing facts, go to The Space Place at http://spaceplace.jpl.nasa.gov.



The Terrestrial Planet Finder will be a space interferometer. One possible design would use four space telescopes flying in formation, beaming their images to a fifth combiner spacecraft.

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