National Aeronautics and
Space Administration

ACTIVITY SHEET

NASA Space Communications and Navigation

Irradiance

GRADES 10–12

NASA's Laser Communications Relay Demonstration (LCRD) will demonstrate the advantages of optical communications, which uses infrared lasers to provide missions with higher data rates. While this infrared light is invisible to the human eye, it is similar to light from other sources like the Sun.

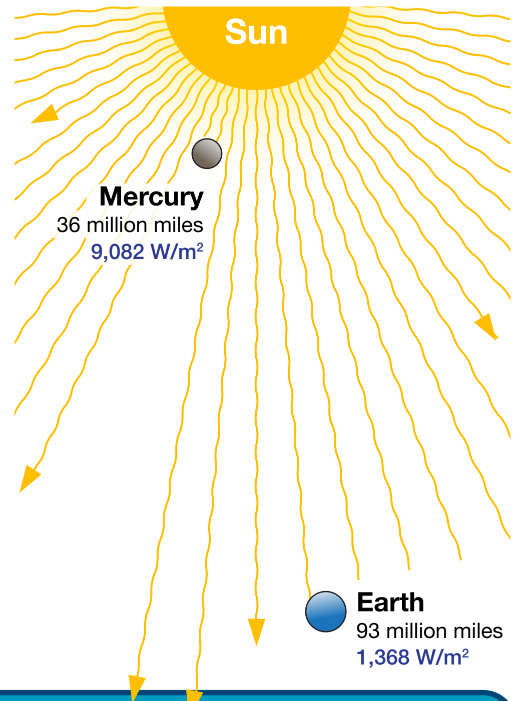
How does LCRD's laser light compare to the Sun's light as we experience it on Earth's surface?

Just like a light bulb, electromagnetic energy—light—disperses in all directions as it moves away from its source. The further away from the source, the weaker the light will be. Consider two planets, Mercury and Earth: Mercury's orbit averages 36 million miles from the Sun, while Earth's orbit is around 93 million miles.

To compare the light received by the planets, let's discuss units of **irradiance**. Irradiance is a specific term for the amount of radiant energy flowing through a two-dimensional area. It is usually expressed in units of power (Watts) over area in square meters (m^2).

The closer to the source, the more energy per square meter is received and the higher the **irradiance**. The irradiance on Mercury is a scorching 9,082 W/m^2. Combined with its lack of atmosphere and magnetosphere, this contributes to its incredibly volatile temperature, which swings from 800 °F to –290 °F. On Earth, we only receive 1,368 W/m^2 at the top of our atmosphere, which results in our more temperate climate.

The concept of irradiance doesn't just apply to the Sun; we can also measure the irradiance of other energy sources, like the ones we use for space communications.

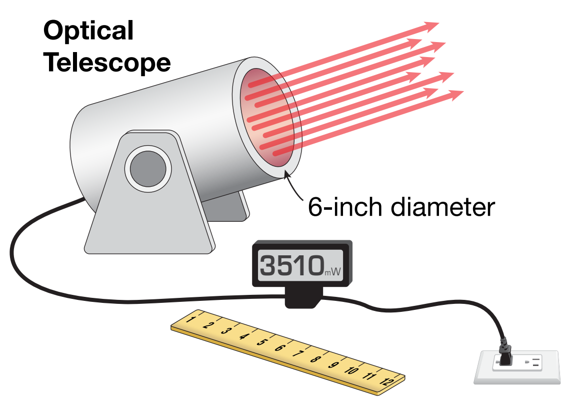


Currently, NASA uses radio frequency (RF) transmitters, but it is also developing optical communications technologies that use infrared lasers to send more data than traditional RF. Optical terminals are also smaller and lighter than comparable RF dishes, which can leave more room on the spacecraft for science instruments.

PROBLEMS

We use about 3,510 milliwatts (mW) of power to send information from an LCRD ground station to the LCRD spacecraft in orbit. **Let's compare the irradiance of the LCRD ground terminal to the irradiance of the Sun.**

1. The LCRD ground terminal uses an optical telescope to focus the infrared light it generates. This telescope has a circular aperture (opening) 6 inches in diameter. What is the **area** of this aperture in square inches (in^2)? Recall that $\text{Area}_{circle} = \pi r^2$, where r is the radius.



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PROBLEMS *(continued)*

2. Convert the LCRD telescope aperture area above into square centimeters (cm^2) and then to square meters (m^2). Recall that 2.54 cm = 1 in and 100 cm = 1 m.

3. Given that we are putting 3,510 mW of power into the telescope and we now know the area of the aperture in m^2, what is the irradiance of the LCRD ground station at the aperture in W/m^2? Recall that 1,000 mW equals 1 W.

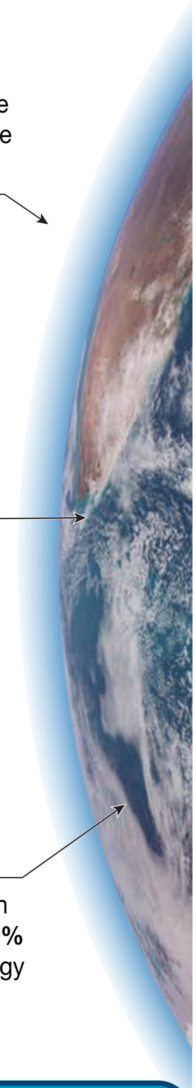
4. A few important factors alter how much energy from space reaches the surface of Earth. Our atmosphere plays a critical role in protecting us from too much energy! Let's apply two of those factors to get a more realistic sense of the energy felt on the surface compared to the energy felt at the top of the atmosphere:

Approximately **56%** of the Sun's energy (in all wavelengths) reaches the surface. 26% is reflected by the upper atmosphere, and ozone absorbs another 18%.

Of the light that does reach the surface, approximately **50%** of that is infrared energy—the kind emitted by the LCRD ground station.

Apply these atmospheric factors to Earth's irradiance value provided above. What is the total solar irradiance at Earth's surface? What is the infrared solar irradiance at Earth's surface?

5. How does the infrared solar irradiance at Earth's surface compare to the infrared LCRD ground station irradiance at the telescope aperture? Which one is larger? By how much?



NASA's Laser Communications Relay Demonstration (LCRD) is the next step in optical communications.

Hosted on a U.S. Space Force spacecraft, LCRD will demonstrate optical technology in geosynchronous orbit 22,300 miles above Earth's surface. LCRD is built and managed by NASA's ***Goddard Space Flight Center*** in Greenbelt, Maryland.

LCRD is a technology demonstration that will pave the way for future optical communications missions. When NASA has developed a new way to solve a problem and wants to show how it works, they create a technology demonstration. LCRD's first orbiting experimental user will be the International Space Station's Integrated LCRD Low-Earth Orbit User Modem and Amplifier Terminal (***ILLUMA-T***). The terminal will receive science data from experiments and instruments aboard the space station and then transfer the data to LCRD, which will then transmit them to a ground station. After the data arrive on Earth, they will be delivered to operation centers and scientists to help make decisions about the mission.

LEARN MORE

Learn more about LCRD's predecessor, the Lunar Laser Communications Demonstration (LLCD), at ***http://go.nasa.gov/LLCD_history***.

Learn more about LCRD at ***http://go.nasa.gov/LCRD_overview***.