Science & Technology

Lasers will maximize space communications

by Marsha Freeman

Since the dawn of the space age 25 years ago, man has been communicating with machines in space in largely the same way he communicates on Earth—by radio transmission. Scientists and communications specialists, however, have been excited by the possibility of using the higher frequency coherent light produced by lasers for space communications; this would increase the amount of data that satellites can send and improve the coverage of our craft in space, i.e., the amount of time that mission control can maintain contact.

Moving to higher frequencies along the electromagnetic spectrum increases the density of the energy contained in the wave. Increasing the frequency seven orders of magnitude, from radio frequency to coherent visible light, brings great advantages.

First, the coherent light is densely packed into a very narrow, focused beam. This increases the amount of information that can be carried along the light beam by two orders of magnitude over the radio frequency system. At the same distance—for instance, the half billion miles from Jupiter—one hundred times as much information could be sent by the spacecraft.

Conversely, by maintaining the same data rate for a laser system as with radio frequency, the distance can be extended by an order of magnitude, or to over 5 billion miles, with the same quality of data that the Voyager spacecraft sent from Jupiter.

Laser communications also provide a greater degree of security for military communications. Radio waves propagate through the atmosphere, or in space, in a circular pattern, like water waves on a pond. Anyone with a receiver can pick up the message. The laser beam is focused and very directly aimed, which makes it almost impossible for a receiver to pick up the message unless it is being sent specifically to that receiver. Laser messages would therefore be more resistant to jamming.

This small beam divergence also means that much smaller receiving antennae can be used. This is important, especially for the deep-space planetary program, whose spacecraft carry antennae; smaller antennae would leave a greater portion of weight capacity available for scientific instruments.

Because of the greater density of the energy contained in the laser beam, the amount of energy needed per unit of information transmitted, called a bit, is reduced. This, again, is key in the planetary program, where weight is at a premium. The energy needed to carry one bit of data to Earth from space with a radio frequency system is about one-ten millionth of a watt per second. For a laser system, the energy per bit per second could be *one billion times less*, in an optimized system.

The Jet Propulsion Laboratory and NASA's Goddard Space Flight Center are currently involved in design and technology studies for developing a laser space communications system. The JPL system would be used for deep space and interplanetary missions, the Goddard application for near-Earth transmissions.

One of the drawbacks to laser communications is the tendency of the beam to become attenuated in the atmosphere. For this reason, laser communications on Earth use underground fiber optic cables.

In space, there is no atmospheric interference. The problem is how to get the information back down through the atmosphere to Earth. Scientists have proposed a relay satellite, permanently stationed in geosynchronous Earth orbit for this purpose. The relay satellite would receive the data from the spacecraft, change the information into radio frequency waves, and then send the radio signals to an Earth receiving station. It would also be outfitted with its own laser transmitter, to send a beacon signal to the spacecraft so that its laser transmitter was properly directed. The relay satellite would receive data from the laser-equipped satellite at at least 100 times the rate it could send to Earth using radio waves. Therefore, the most efficient system design would have the relay satellite do some of the processing of the data on board, before the data is sent to Earth.

An Earth-orbiting relay satellite would also extend the coverage from space. At the present time, NASA is in contact with the Space Shuttle less than 50 percent of the time. Likewise, we can only receive data from planetary probes when their signal is within view of a ground station. The relay satellite, 22,300 miles above the Earth, would be in touch with a ground station almost all the time. It would provide 95 percent coverage for spacecraft no matter where they were.

Many different kinds of lasers have been under consideration for this space application. The problem with one of the most widely used, the carbon dioxide chemical laser, is that large tanks of gaseous laser fuel would have to be carried onboard the satellite.

Solid-state semiconductor systems, made of such materials as gallium arsenide and using electrical current to "pump" or power the laser, seem a better approach. The major problem to be solved is the requirement of an eight-or-more year lifetime for extended space missions.

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