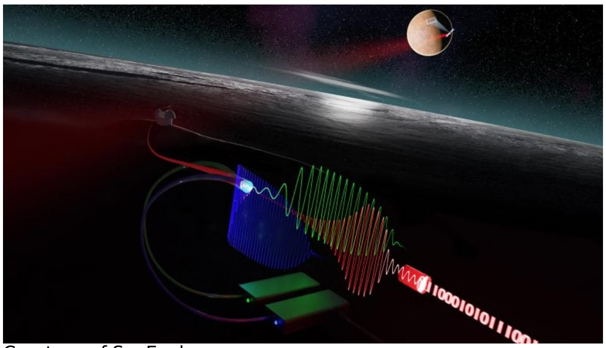
Silent Signals: The Innovative Technology Enabling Quicker Space Data Transmission

Posted by Okachinepa 10/04/2024



Courtesy of SynEvol
Credit: Chalmers University of Technology

Since light loses signal strength over long distances, space communication systems are increasingly using optical laser beams rather than conventional radio waves. Even light-based transmissions, however, lose strength with distance, thus optical systems require extremely sensitive receivers to pick up these weak signals before they reach Earth. Researchers at Chalmers have developed an innovative approach to optical space communication that could unlock new opportunities—and discoveries—in space.

Peter Andrekson, a professor of photonics at Chalmers and one of the study's primary authors, says, "We can demonstrate a new system for optical communication with a receiver that is more sensitive than has been demonstrated previously at high data rates." The work was just published in Optica. "This implies that information can be transferred over very long distances more quickly and accurately, for instance, when sending high-resolution photos or videos from the Moon or Mars to Earth."

In order to recycle its information, the researchers' communication system uses an optical amplifier in the receiver to amplify the signal with the least amount of noise. The transmitter's light expands and diminishes with distance, much like a flashlight's glow. After the space voyage, the signal is so feeble without amplification that the receiver's electrical noise drowns it out. A few years ago, the Chalmers research team finally demonstrated a noise-free optical amplifier after twenty years of battling with distracting noise that distorted the signals. But because it has created whole new and much more complicated requirements for both the transmitter and the receiver, the silent amplifier has not yet been able to be employed practically in optical communication lines.

A space probe's transmitter must be as simple as feasible because of its limited resources and little space. The Chalmers researchers successfully implemented the noise-free amplifier in an optical communication system for the first time by permitting the transmitter to generate only one of the three light frequencies required for noise-free amplification while permitting the receiver on Earth to generate two of those frequencies. The results demonstrate exceptional sensitivity, despite a low level of transmitter complexity.

In theory, this phase-sensitive optical amplifier doesn't produce any additional noise, which makes the receiver more sensitive and allows for error-free data transfer even at lower signal power levels. Rasmus Larsson, a postdoctoral researcher in photonics at Chalmers and one of the study's lead authors, says, "A traditional laser transmitter with one wave can now be used to implement the amplifier by generating two extra waves of different frequencies in the receiver, rather than as previously done in the transmitter."

Larsson notes, "Our transmitter simplification means that the noise-free amplifier in a receiver on Earth could be used in conjunction with already existing optical transmitters on board satellites and probes."

The development implies that the researchers' silent amplifiers may one day be put into use in space-to-Earth communication links. As a result, the technology is well-positioned to help address a well-known bottleneck issue that currently plagues space organizations.

The speed at which scientific data is collected from space to Earth is one of the factors that creates a bottleneck in the chain that NASA refers to as "the science return bottleneck." According to Peter Andrekson, "We think that our system is a significant step forward towards a workable solution that can resolve this bottleneck."

The researchers' next task is to evaluate the optical communication system using the constructed amplifier in field tests on Earth and, subsequently, in satellite-to-Earth communication lines.