Using Light for Data Transmission on a Terabit Scale

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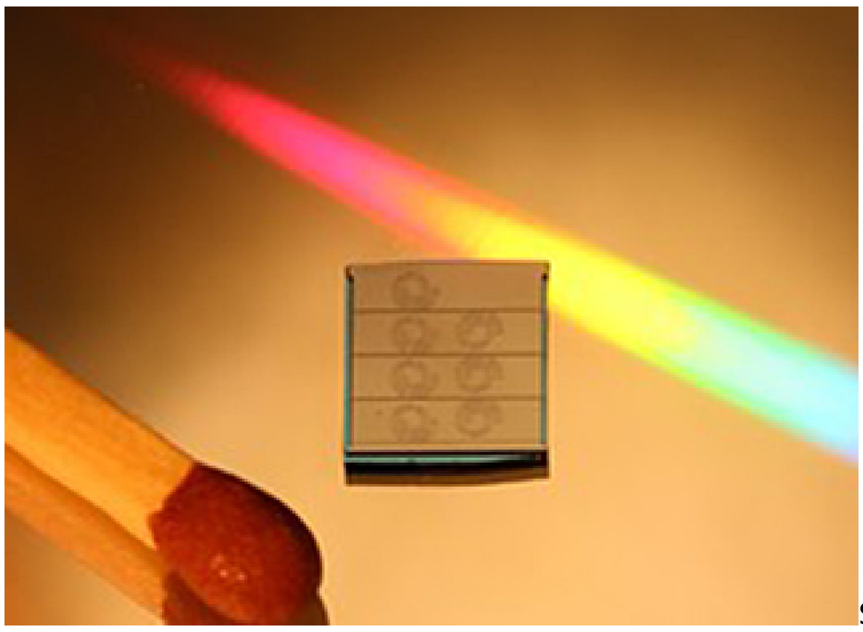

Scientists from EPFL and KIT have achieved data transmissions on a terabit scale with a single laser light frequency using miniaturized optical frequency combs. The findings open the way for using this system in future high-speed communication systems.

A continuous laser light is made of a single frequency, i.e. a single color. But that single frequency can be divided into separate lines of equal distance, which is referred to as an “optical frequency comb”. Practically speaking, that could allow the simultaneous flow of data in optical cables, which could dramatically increase today’s speed of data transmission. Optical frequency combs can transmit data on hundreds of separate wavelength channels, meaning that they can overcome transmission bottlenecks in data centers and communication networks. Publishing in *Nature Photonics*, scientists from EPFL and the Karlsruhe Institute of Technology (KIT) have shown that optical frequency combs can achieve a 1.44 Terabit/sec data transmission across a distance of up to 300 Km.

When one light frequency from a laser is fed into a device called an optical microresonator, it is possible to convert it into an “optical frequency comb”: a series of densely-spaced spectral lines whose in-between distances are identical and known. These frequencies represent the original light frequency fed into the microresonator, along with hundreds of new frequencies.

Optical frequency combs can be used as optical rulers for highly precise measurements and are currently exploited for numerous applications like optical atomic clocks and high-precision spectroscopy. However, they have not been used in data transmission because they are too large and expensive to scale up.

The team of Tobias Kippenberg at EPFL and the team of Christian Koos at the Karlsruhe Institute of Technology (KIT) have demonstrated for the first time that a miniaturized optical frequency comb can be used for high-capacity data transmission. The KIT scientists incorporated a data transmission system with an optical microresonator designed by Kippenberg’s team. Waveguides made of silicon nitride are used to couple the light and guide it in a circle where it is stored for an extended period of time.

The resulting high intensity of the stored laser produces a frequency comb called a Kerr comb, which has a large optical bandwidth. Unlike other optical frequency combs, Kerr comb lines (light frequencies) have large spaces between them that match the spacing of data channels required for communications. In this way, the “teeth” of the Kerr comb can be used as carriers for data channels. This property can be applied in wavelength multiplexing, a technique that combines multiple data signals together for transmission over a single optical fiber. However, it suffers from limited scalability because it requires one laser per signal. The data from this study show that a Kerr comb can be used to improve wavelength multiplexing, as it requires only a single laser for transmitting multiple data signals, which would make better use of available bandwidths.

The scientists were able to use a Kerr-comb system to transmit a data stream of 1.44 terabits per second over a distance of 300 Km. In addition, the method also fulfils the stringent criteria for the optical carrier’s amplitude and phase stability, which are required by the advanced modulation formats used in modern state-of-the-art communication systems.

The terabit transmission of data using an optical frequency comb system could mean a future increase of data rates, as the system could increase the number of data channels with a single microresonator frequency comb. The study demonstrates for the first time that miniaturized optical frequency combs can be used for coherent data transmission and can meet the highly demanding requirements of multi-terabit coherent communications. The scientists are now working to expand beyond the 20 Kerr-comb lines used as data channel carriers in this experiment.

This work represents a collaboration between the KIT Institute of Photonics and Quantum Electronics and Institute of Microstructure Technology and EPFL’s Laboratory of Photonics and Quantum Measurements. The microresonator chips were fabricated using the facilities of the CMi (Center of MicroNanotechnology at EPFL).

Reference

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