Transmitting Information Securely

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INFORMATION

The assurance of confidentiality is required in all aspects of transmitting information, from the exchange of banking information and health records to military tactics and trade secrets. The problem is there is no foolproof method to ensure that confidentiality. No matter how encrypted the information is that is transmitted, as long as there is a key to decrypt it, there is a weak security link in the chain of communication.

The solution may lie in quantum photonics, the sending and receiving of data in the form of photons – the tiniest particles that make up light. By sending data encoded in photons, the data stream becomes a single-use, self-destructing key. If the message is intercepted, the stream would change, immediately alerting the receivers to the breach. In addition, by intercepting the stream, the disturbance would automatically scramble the message, making it indecipherable.

Quantum photonic networks could decrypt classically-encoded messages in a matter of minutes – rather than months or years as per today's networks. And such networks would allow for absolute security; even another quantum computer would not be able to secretly crack a coded message sent via a quantum network.

Working in the quantum world, addressing present day problems, requires an in-bred curiosity about the nature and behavior of matter and energy on the atomic and subatomic level, and a desire to develop revolutionary applications. Those are the talents of Dirk Englund, assistant professor of electrical engineering and of applied physics, who leads the Quantum Photonics Group at Columbia Engineering. He concentrates on quantum optics in photonic nanostructures, with primary applications in communications, computation, sensing, and energy. His research focuses on implementations consisting of quantum bits (qubits) that are encoded in photons and in spins of electrons and nuclei in semiconductors.

Englund's work includes chip-based quantum networks that promise exponential speedups in computational algorithms and unconditionally secure cryptography as well as highly sensitive quantum-limited sensors. Recent works include time-resolved lasing action from single and coupled photonic crystal nanocavity array lasers, and optical modulation based on a single strongly-coupled quantum dot.

His group is also developing spin-off applications that rely on phenomena from cavity quantum electrodynamcis (QED) to substantially lower the power consumption of optoelectronic systems for high-speed, low-power devices. These applications have potential for adaptation in high-performance computing. Related projects include radiation-hard electronics and radiation detectors and thin-film solar cells.

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