



PRESS RELEASE

Development of a chaotic light receiver for secure communication in hostile environments

A study by Télécom Paris and the Politecnico di Milano in *Light: Science & Applications*

Milan, 8 April 2025 - Development of a **new type of optical receiver**, able to **restore chaotic signals in free-space optical communication links** distorted by atmospheric turbulence. By use of a system of optical antennas integrated into a programmable photonic chip, the receiver can adapt in real time, maintaining the integrity of the signal even in harsh atmospheric conditions. The study by a team of researchers led by **Télécom Paris** and the **Politecnico di Milano**, has just been published in **Light: Science & Applications**, and paves the way for the use of **chaos-based encryption** for secure, high-speed communication in hostile environments.

The idea behind secure, chaos-based communication is to encode a secret message into a light signal, which appears so unpredictable and complex that it is almost impossible to decipher. However, when these chaotic signals travel in the real wireless world, they encounter a major obstacle: atmospheric turbulence. And what's the result? Transmissions are distorted and security is compromised.

The Study has found a solution to this problem. The secret lies in a new type of receiver, which uses a **system of optical micro-antennas integrated into a programmable photonic chip**. The micro-antennas act like many "smart eyes", capturing light from multiple points of view; the photonic chip **self-calibrates in real time to rebuild these fragments into a secure and reliable chaotic signal**.

The result is amazing: even in the presence of heavy rain, wind or pollutants, the signal can be fully retrieved.

Sara Zaminga, of LTCI Télécom Paris, Institut Polytechnique de Paris and author of the study, explained the thinking behind it: *"Chaos is a robust system, but can only be used in cryptosystems if its inherent nature is fully preserved. Atmospheric turbulence degrades the optical signal and apparently destroys the properties of chaos, making it hard to maintain secure and reliable communications. With our approach, we're not just mitigating the effects of turbulence, we're completely restoring the chaos of light in all its intrinsic complexity."*

Andrés Martínez of the Department of Electronics, Information and Bioengineering at the Politecnico di Milano and co-author of the study, also added this: *"What makes this solution really special is its ability to adapt in real time. Our receiver automatically adjusts to changes in the amount of turbulence, ensuring a stable and secure channel of communication without the need for manual interference."*



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Why is all this so important? Chaos-based systems have an inherent advantage: **their unpredictability makes them naturally secure**. However, atmospheric turbulence by its very nature has long constituted a main obstacle to optical wireless communications.

The impacts of this advance go far beyond its technological applications, providing new ways to send confidential messages even in extreme conditions. As **Francesco Morichetti, head of the Photonic Devices Lab at the Politecnico di Milano**, pointed out: *"In remote areas or emergency zones, places where traditional networks fail, a chaos-based, turbulence-resistant system could provide a secure connection when it's most needed."*

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The Study <https://www.nature.com/articles/s41377-025-01784-3>

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