# Research produces intense light beams with quantum correlations

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Potential applications of research conducted at the University of São Paulo include high-precision metrology and information encoding (pump laser for production of quantum-correlated light beams). Credit: Marcelo Martinelli / IF-USP

The properties of quantum states of light are already leveraged by such highly sophisticated leading-edge technologies as those of the latest sensitivity upgrades to LIGO, the Laser Interferometer Gravitational-Wave Observatory, deployed to detect gravitational waves since September 2015, or the encryption keys used for satellite on-board security.

Both solutions use crystals as noise-free optical amplifiers. However, the use of atomic vapors has been considered a more efficient alternative that enhances the accessibility of non-classical light states.

"We show that oscillators based on these atomic amplifiers can generate intense beams of light with quantum correlations," said Marcelo Martinelli, a researcher in the University of São Paulo's Physics Institute (IF-USP). Martinelli is a co-author of an article published in *Physical Review Letters* describing the main results to date of a Thematic Project for which he is the principal investigator and which is supported by São Paulo Research Foundation—FAPESP.

Both crystals and atomic vapors can be used to produce quantum correlated pairs of light beams. Investigating the behavior of these sources is a challenge. The behavior of light below a certain level of power resembles that of the light produced by a bulb. Above a certain threshold, its characteristics are similar to those of a laser. "It's as if the crystals or atomic vapor converted the light from a lamp into laser light. It's easier to investigate this transition in the atomic medium than the crystalline medium since more intense beams can be produced in an atomic medium," Martinelli said.

Optical cavities are used for this purpose. Controlling cavity geometry and atomic vapor temperature, Martinelli and collaborators were able to produce photon coupling in more open cavities.

"This offered two advantages in comparison with the old crystal-based cavities—more quantum efficiency so that the number of photons supplied by the output window easily surpassed the number of photons lost to the environment, and a chance to investigate more subtle details of the transition between light with heterogeneous frequencies and the production of intense laser-like beams. It was as if we had opened a window on to the quantum dynamics of the phase transition," Martinelli said.

Potential applications include high-precision metrology with manipulation of the quantum noise in light and information encoding via quantum entanglement.

**More information:** A. Montaña Guerrero et al, Quantum Noise Correlations of an Optical Parametric Oscillator Based on a Nondegenerate Four Wave Mixing Process in Hot Alkali Atoms, *Physical Review Letters* (2020). DOI: 10.1103/PhysRevLett.125.083601

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