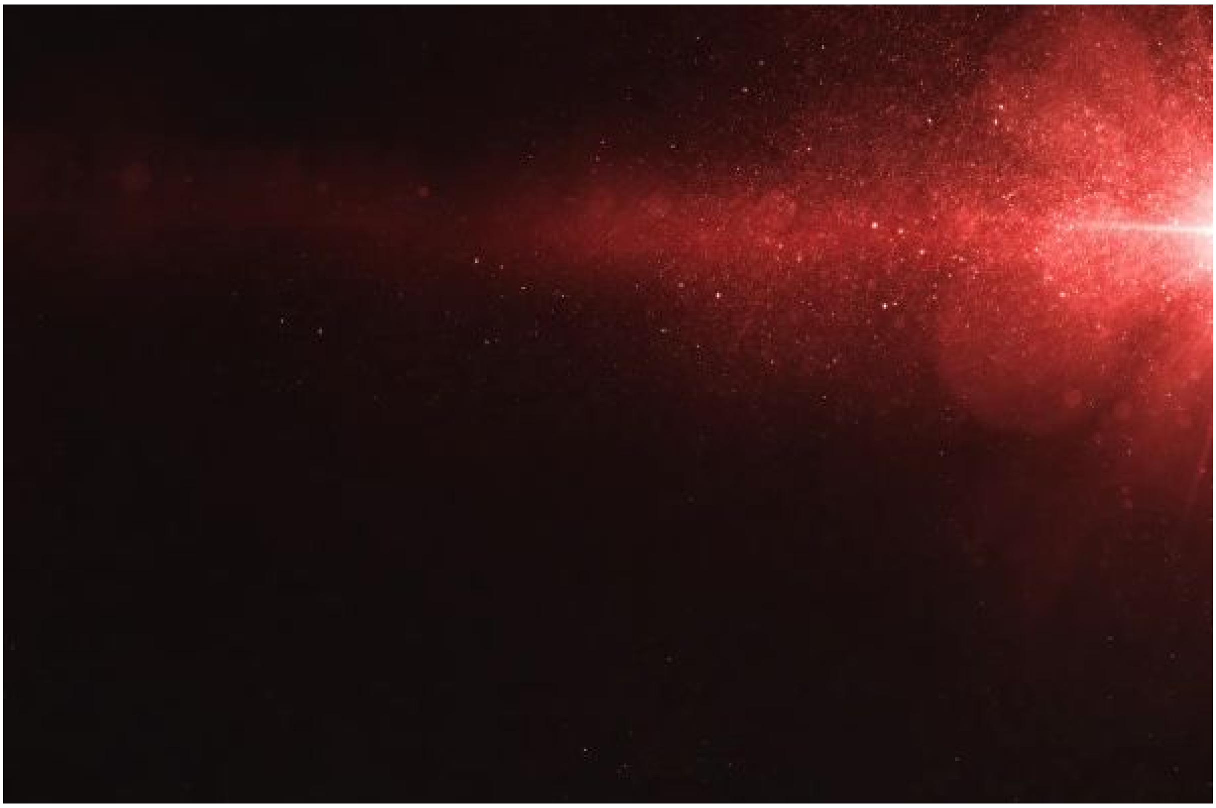

How to generate high harmonics with quantum light despite decoherence

Bright squeezed vacuum (BSV) light can achieve strong light-matter interactions, including the generation of high-order harmonics with quantum properties. Previous investigations, however, had only considered its interaction with a single atom. Now, ICFO researchers and collaborators have studied BSV's propagation through a medium full of argon atoms, the resulting decoherence effects, and how to minimize them. The results are published in Nature Communications.

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The shortest light pulses to date are just a few attoseconds long. They are so much shorter than the blink of an eye that our brains have a difficult time trying to imagine them. But that is precisely what allows them to investigate extremely fast electronic processes ubiquitous to life on Earth; processes that occur when chemical reactions unfold or when biological molecules transfer energy from one to another.

High-harmonic generation (HHG) -the generation of high-order harmonics of a given light pulse when it is absorbed by an atom- is the physical precursor of the shortest light pulses to date. While HHG has been extensively studied when driven by a classical light source, quantum light has recently been shown to have this capacity as well. But does the quantumness remain after harmonic generation? That is one of the most important questions currently under investigation.?

There are many different types of quantum light, however, each with distinct properties Bright squeezed vacuum (BSV) is an especially interesting one because, as the nam suggests, it exhibits squeezing - a purely quantum feature that reduces noise in on observable (for instance, position) at the expense of increasing noise in its conjugat (momentum) - and, at the same time, carries a high number of photons. BSV is therefor suitable for inducing strong light-matter interactions, like those needed to produc high-harmonic generation

So far, theoretical investigations of BSV-driven HHG have only considered the interactio with a single atom. But for assessing the real-world applicability of BSV light sources, th much more realistic situation of a medium full of atoms must be considered. This is precisel the scenario that ICFO researchers,**Dr. Javier Rivera-Dean** and **Dr. Philipp Stammer**, led by **Prof. Dr. Maciej Lewenstein**, have theoretically investigated, in collaboration with the Institute of Electronic Structure & Laser in Crete, the Technische Universitat Wien, the Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie, ELI ALPS, and the Cente for Quantum Science and Technologies (FORTH-QuTech)

Published inNature Communications, the study reveals that high-harmonic generation driven by BSV may be obscured by atomic ionization and photon losses -collateral effects of BSV propagation through the medium. This degrades the quantum features of the radiation, limits its maximum propagation length, and decreases the number of emitted harmonics. Fortunately, these decoherence effects are not an insurmountable obstacle. ï¿½ e demonstrate tha**under the appropriate conditions, BSV can preserve its quantumness and efficiently generate harmonics with quantum properties**,ï¿½ says Prof. at ICFO Maci j Lewenstein, long-time expert in HHG who was involved in the study. The conditions inclu e significantly reducing photon losses from atomic ionization and carefully controlling B V intensity, so that decoherence is minimized while preserving BSV's ability to generate hi h harmonic

. The researchers are now planning to determine the precise conditions for experiment l realization. Implementing the proposed theoretical framework would further deepen o r understanding of BSV propagation through media, which in turn would bring the fields f ultrafast and quantum physics closer togethe

Reference:

Rivera-Dean, J., Kanti, D., Stammer, P., Carlstrom, S., Tsatrafyllis, N., Ivanov, M. Yu Lewenstein, M., & Tzallas P., Propagation effects in high harmonic generation media drive

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