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Nonlinear crystals: a unique platform for optical frequency synthesis and new quantum states of light generation

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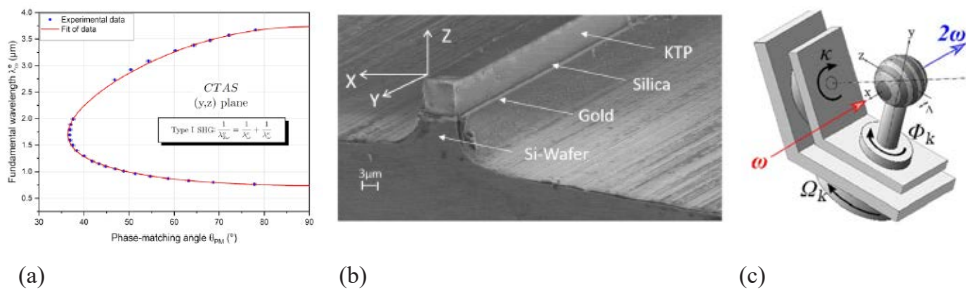
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Nonlinear optics relies on the coupling between photons and electrons, the last ones allowing the first ones to merge or split. The efficiency of this “photonic alchemy” is high when the intensity of light is large and when electrons of matter are relatively weakly linked. All the matter states, *i.e.* plasmas, gas, liquids and solids, can exhibit nonlinear optical properties. But among all these media, the organized solids, *i.e.* the crystals, lead to the biggest diversity of nonlinear optical interactions and applications due to their rich symmetries and chemistry, and to their purity and hardness. Associated with lasers, the crystals with nonlinear optical properties allow intense beams to be generated over a huge spectral range of the electromagnetic waves, from ultra-violet to far infra-red, leading to numerous devices and applications. Parametric light has also a strong interest in quantum physics since it enables the generation and manipulation of new quantum states of light. Among the various nonlinear processes, twin-photon and triple photons generations, which corresponds respectively to the birth of two and three correlated photons from the splitting of a single photon, allow to manipulate the quantum properties of light. These generations are driven by an optical pump field: it can occur spontaneously, which is called spontaneous parametric down conversion, or it can be forced by a seed field oscillating at one or both of the generated photons frequencies; this is the optical parametric amplification, or optical parametric oscillation if the process is enhanced by a resonant cavity.

This invited talk gives a quick overview of the 3-photons and 4-photons coupling showing the ability of both of these nonlinear interactions to convert laser frequency or generate new quantum states of light using bulk crystals and crystal waveguides based on birefringence phase-matching or quasi-phase-matching.



Second Harmonic Generation birefringence phase-matching tuning curve of a CTAS bulk crystal (a) [1]; KTP crystal ridge optical waveguide for phase-matched Third Harmonic Generation and Triple Photons Generation (b) [2]; scheme of a PPRKTP sphere used for the study of the angular distribution of quasi-phase-matched Second Harmonic Generation (c) [3].

References

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