Progress in Engineering Nonlinear Optical Phenomena by Arbitrarily Manipulating the Relevant Optical Phases

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Nonlinear optical process is stringently dominated by the phase relationships among the relevant electromagnetic fields including phase of the nonlinear polarization induced in it. This intrinsic physical nature implies that nonlinear optical phenomena may be manipulated to a variety of ways when we introduce a freedom of controlling such phase relationships to desired values at desired interaction lengths during evolution of the nonlinear optical process (Fig. 1). In fact, we have theoretically and experimentally investigated it so far how new possibilities may be opened by introducing the above concept in nonlinear optical processes, where we employed a Raman-resonant four-wave-mixing process as a typical nonlinear optical process demonstrating such concept [1-5]. In [1,2], we demonstrated it on the basis of the detailed numerical simulations that a single-frequency tunable vacuum-ultraviolet laser entirely covering a wavelength region of 120-200 nm can be realized as an attractive application of using such conceptual idea. Furthermore, in [3], we demonstrated it in the experiment that such physical concept can work in reality (proof-of-concept experiment).

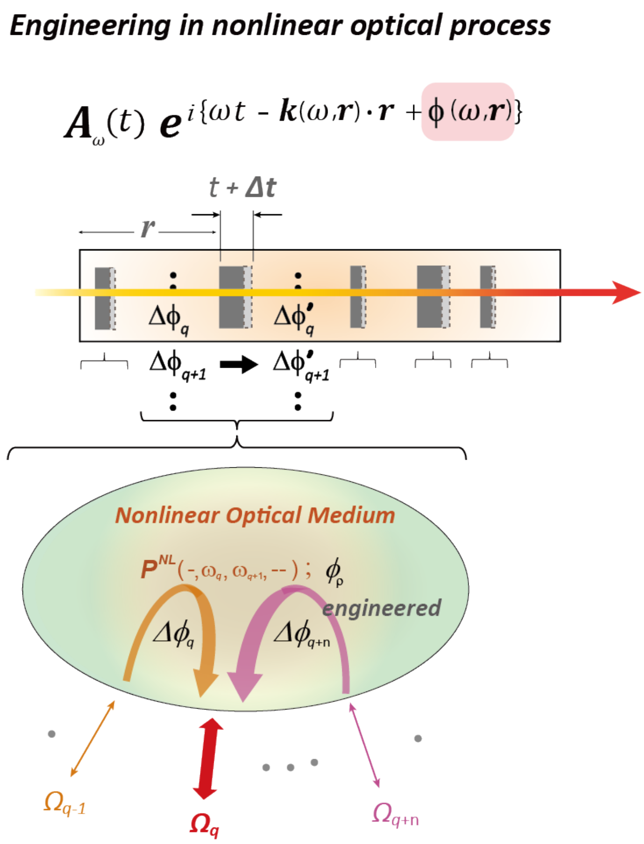

Figure 1: Conceptual illustration of engineered nonlinear optical process by artificially manipulating the relevant optical phases

Here, we report a recent progress in the experiment in addition to a brief review of the relevant studies achieved so far. In this experiment, we again focus on the Raman-resonant four-wave-mixing process as employed in [3] as a typical nonlinear optical process. The point here is that we implement the phase manipulation mechanisms in the nonlinear optical medium controlled at the liquid nitrogen temperature (77K, the optimal temperature). The experiment in [3] was executed in a room temperature. Consequently, the efficiencies of the nonlinear optical phenomena (generation of stimulated Raman scatterings) were on the order of 10^{-3}. Thereby, the manipulations of the nonlinear optical phenomena were also limited to the lowest processes, 1-st Stokes and anti-Stokes generations. In contrast, with the nonlinear optical medium (gaseous para-hydrogen) placed at the liquid nitrogen temperature, the efficiencies can achieve tens of percentages, thereby, the high order stimulated Raman scatterings can be generated with sufficient amplitudes. In this presentation, we show that the above concept in nonlinear optical processes (Fig. 1) can work in reality with efficiencies of tens of percentages including the high-order nonlinear optical processes [6,7]. We will also discuss a future plan of this research project.

References

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