Phase-Matching Schemes for Back-Conversion Suppression in Nonlinear Wave Mixing: Towards Ultra-High Efficiency and Ultra-Broad Bandwidth

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***Abstract*—By suppressing the conversion-back-conversion cycles typical of optical parametric processes through novel phase-matching schemes, octave-spanning frequency conversion and highly efficient parametric amplification can be achieved. Several recent developments will be reviewed.**

Keywords—Frequency upconversion and downconversion; Optical parametric amplification; Adiabatic frequency conversion; Coupled parametric processes.

I. Introduction

Frequency up-conversion and down-conversion applications are limited in conversion bandwidth and suffer from an efficiency-bandwidth product limitation because of the dependence of the conversion back-conversion cycle on frequency. Over the past decade, the related concepts of adiabatic frequency conversion and autoresonance have been proposed for the suppression of back-conversion in wave mixing processes [1-4]. Recently, adiabatic frequency down-conversion has enabled octave-spanning mid-infrared generation and pulse shaping. Such devices proposed and demonstrated in both quadratic nonlinear media by quasi-phase matching [5-7] and cubic nonlinear media by waveguide tapering and pressure gradients [8,9] will be reviewed.

The efficiency of optical parametric amplification also suffers greatly due to the asynchronicity of conversion-back-conversion cycles across the spatiotemporal extent of the mixing waves, which contributes heavily to the roughly order-of-magnitude drop in power incurred during conversion from pump to signal or idler in typical devices. Rather than employing spatiotemporal pulse shaping [10,11], or idler absorption [12,13], a recently proposed solution to the problem will be reviewed that uses simultaneously phase-matched optical parametric amplification and idler second harmonic generation in order to produce nonlinear evolution dynamics identical to optical parametric amplification but with damped back-conversion, making it possible to achieve highly efficient parametric amplification as well as efficient fractional harmonic up-conversion [14,15].

In summary, back-conversion suppression in three-wave mixing processes enabled by novel phase-matching schemes has expanded to a wide variety of applications and device platforms, and is a promising route to solving longstanding nonlinear optical frequency conversion device limitations.

II. References

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