Energy Exchange Properties during Second Harmonic Generation in Finite Photonic Band Gap Structures

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Summary

One of the principal goals in optics is to achieve the basic knowledge necessary to tailor the properties of light. A new class of materials, often referred to as photonic band gap (PBG) structures, offers this opportunity. These structures are characterized by the existence of allowed and forbidden frequency bands and gaps which either allow or forbid the propagation of light. One of the more intriguing uses of one-dimensional (1-D) PBG structures that have recently been suggested is their utilization in the realm of quadratic, nonlinear optical interactions as efficient nonlinear frequency converters[1-3]. However, in the case of second harmonic generation (SHG), for example, most if not all experimental and theoretical studies have been concerned with the undepleted pump regime . The introduction of strong feedback and pump-depletion makes the system almost intractable analytically, and to our knowledge it has never been investigated numerically either. And so we ask: What happens to field dynamics when the regime of pump depletion is approached, under conditions of strong feedback and global phase-matching in a finite structure? We provide surprising answers, and we report that while forward and backward propagating components start competing for the available energy initially carried forward by the pump, nonlinear pump reflections overwhelm all other processes, including SHG, leading to a new type of optical limiting behavior (see Figure). Excess pump reflections then lead to saturation of the SH signal as a function of increasing input pump intensity. This dynamics was unexpected, and it is bound to influence the way one goes about thinking and designing nonlinear frequency conversion devices in a practical way.

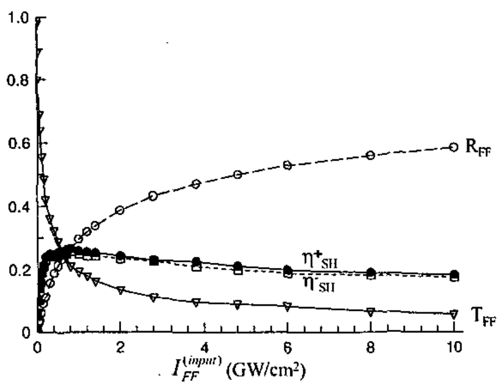

Figure: Forward SH conversion efficiency η_{SH}^{+} (filled circles-solid line); backward SH conversion efficiency η_{SH}^{-} (open squares-short, dashed line); reflected FF R_{FF} (open circles-long, dashed line); and transmitted FF T_{FF} (open triangles-solid line); vs. input FF intensity $I_{FF}^{(input)}$. The structure is composed of 59 alternating layers of air and a dielectric material. The nonlinear coefficient of the dielectric material is $d^{(2)} = 120 pm/V$.

References

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[2] G. D'Aguanno, *et al.*, *Phys. Rev. E* **64**, 16609-1-9 (2001).[3] G. D'Aguanno, et al. , *J. Opt. Soc. Am.* B **19**, 2111 (2002), and references therein.

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