Two-wave Mixing in a Quadratic Nonlinear Medium Containing a Saturable Absorber

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Quasi-phase matching has achieved wide recognition as a powerful and versatile tool for efficient second harmonic generation [1,2]. In such media, for imperfect phase matching, the process of frequency up-conversion evolves periodically with distance because the residual pump power is parametrically amplified in regions of high conversion efficiency, causing frequency down-conversion. Even when perfect phase-matching is met, any noise power at the pump frequency will be strongly amplified in regions of high second harmonic power, causing down conversion [3,4]. These effects limit the second harmonic efficiencies that can be achieved under stable conditions in practice.

We consider here the case of a nonlinear crystal that contains a saturable absorber, in the form of a dopant with a resonant transition whose frequency equals the pump frequency, and whose saturation intensity is relatively low. In this case, absorption does not play any essential role on the up-conversion process when the pump wave is strong enough to saturate the transition. It comes into the action, however, at the point where the pump is sufficiently depleted that the intensity becomes lower than the saturation threshold. This means that deleterious instabilities, caused by parametric down-conversion in regions of high second harmonic conversion efficiencies, are suppressed by elimination of the residual pump power.

In the paper, a comprehensive analysis of second harmonic generation in resonantly-doped nonlinear meda will be presented. An analytical study carried out in the phase plane allows estimation of the optimal values of the saturation intensity, phase mismatch, and crystal length. Further numerical simulations on a reduced set of Maxwell's equations allows practical recommendations on the arrangement of the experiment to be made.

References

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