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Third harmonic generation in layered media in presence of optical bistability of the fundamental

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Abstract. We study third harmonic generation in layered configuration when the fundamental exhibits bistable response. We consider two geometries, namely, a Fabry–Perot cavity with reflection coatings and a distributed feedback structure with alternate nonlinear layers. In both the cases for suitable choice of frequency, the power response at the fundamental frequency is bistable. We show that bistability of the fundamental leads to a multivalued character of the generated third harmonic in both the forward and backward directions. Moreover, we study frequency response in the case of the Fabry–Perot cavity and show that additional structures arise in the generated third harmonic due to frequency bistability of the fundamental. Our calculations suggest the possibility of an all optical switch at third harmonic frequency controlled by the parameters (like intensity, frequency) of the fundamental.

Keywords. Layered media; third harmonic generation; optical bistability.

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1. Introduction

Harmonic generation in layered or periodically modulated media has been drawing considerable attention [1–3]. It has been well known that the nonlinear processes in various materials can be enhanced by using suitable geometries. Resonances and the associated local field enhancements have been utilized to lower the threshold for nonlinear processes and increase their efficiency. To this end high quality factor (high Q) modes of a Fabry–Perot cavity or a distributed feedback structure as well as surface and guided modes have been exploited [4–11]. Use of the reflection coatings in Fabry–Perot cavities leads to such high Q modes [10]. In finite distributed feedback structures such modes arise at the edge of the Bragg rejection bands [12, 13]. Optical bistability and multistability using such modes have been theoretically demonstrated [8]. Very recently there has been a lot of interest in harmonic generation using distributed feedback structures [2, 3]. Bethune has developed a matrix method to calculate the generated third harmonic in the forward and backward directions in a multilayered sample [2]. The method is restricted to the case in which the nonlinear process is weak in the sense that the specified pump waves are essentially unaffected by the nonlinear processes. Very recently, based on Bethune's analysis, it was shown that the local field enhancement aspect of the periodic structure can be exploited to enhance the