MAR12-2011-000363

Abstract for an Invited Paper
for the MAR12 Meeting of
the American Physical Society

Photoacoustic and Photothermal Effects in Periodic Structures and Acoustic Resonators

GERALD DIEBOLD, Brown University

Laser excited photoacoustic and photothermal waves can be generated in one-dimensional structures whose acoustic or thermal properties vary sinusoidally in space. The wave equations describing the pressure or the temperature in such structures can be shown to reduce to inhomogeneous Mathieu equations. Solutions of the Mathieu equation are obtained based on both the method of variation of parameters and expansion of the pressure or temperature in a summation over eigenfunctions. The solutions for the photoacoustic effect show the space equivalent of subharmonic generation where resonances occur at one half of the period of the structure. The positions of the band gaps and the dispersion relations for any modulation depth of the acoustic properties of the structure can be found directly from the Mathieu characteristic exponent. Since the photoacoustic effect is governed by an inhomogeneous differential equation, excitation within forbidden gaps is possible. For excitation within a finite region of the structure, the Mathieu equation equivalent of Hankel functions are defined. From these functions the properties of the photoacoustic waves excited within or outside of the band gaps are found. For thermal waves, the character of the waves and the dispersion relation can be found as well, however no band gaps result from the periodicity of the thermal properties of the structure. The generation of sound by continuous, unmodulated irradiation of an absorbing gas in a resonant cavity is discussed. A longitudinal resonance of the cavity is predicted to be excited since any pressure increase from optical absorption is accompanied by a density increase, the latter resulting in additional energy deposition by the laser beam. Thus, on each return of the pressure pulse to the window of the resonator where laser beam enters the acoustic signal is amplified. Calculations show that for a strongly absorbing gas, the acoustic modes of the resonator become mode locked.