

# Physics Colloquium

## Michigan Technological University

October 6 (Thursday) 2005, 4:00 to 5:00 pm  
Room 139, Fisher Hall

### Slow light and resonance phenomena in photonic crystals

Alex Figotin (the speaker) and Ilya Vitebskiy

University of California at Irvine

#### Abstract

The problem of slowing down electromagnetic waves has been extensively discussed in the literature. Such a possibility can be extremely useful in a variety of microwave and optical applications. Our objective here is to compare different ways to achieve this effect in linear dispersive media such as photonic crystals. A very low group velocity can be achieved in the vicinity of stationary points of the dispersion relation where it always vanishes. In periodic layered media, the dispersion relations can develop only three kinds of stationary points. In all three cases the group velocity  $\partial\omega/\partial k$  does vanish as  $\omega$  approaches  $\omega_s$ . But when the efficiency of conversion of the incident light into the slow mode is concerned, the three cases are fundamentally different from one other. In the vicinity of the band edge (case 1), the energy flux  $S$  vanishes along with the group velocity  $\partial\omega/\partial k$ . This implies that although the transmitted wave does slow down inside the semi-infinite slab, its amplitude, as well as the respective energy flux  $S$ , vanish as  $\omega \rightarrow \omega_s$ .

In the vicinity of stationary inflection point (case 2), the energy flux  $S$  remains finite even at  $\omega = \omega_s$ , contrary to the fact that the wave group velocity vanishes. The latter implies that the wave amplitude inside the slab increases dramatically. Case 2 provides ideal conditions for slowing down the light by a semi-infinite photonic slab.

Finally, in the vicinity of degenerate band edge (case 3), the energy flux  $S$  vanishes, similarly to what we had in the vicinity of a regular band edge (case 1). At the same time, the electromagnetic energy density inside the slab now becomes enormous, similarly to what takes place in the vicinity of stationary inflection point (case 2).

Finite periodic structures supporting the frozen mode regime, can also display a gigantic Fabry-Perot cavity resonance associated with the degenerate photonic band edge. In contrast to the regular transmission band edge resonance, in the case degenerate band edge the field intensity enhancement is proportional to the fourth degree of the number of layers in the stack. This allows one to drastically reduce the dimensions of the resonant cavity without compromising on performance.

#### Biography

Alexander Figotin, was born in 1954, Kharkov, USSR. He got his Ph.D. in Mathematics in 1980, Tashkent State University, USSR. Currently he is a professor at the University of California at Irvine. Area of expertise includes wave propagation in periodic and random media, theory of linear and nonlinear photonic crystals, spectral theory of dispersive and dissipative dielectric and other media, random number generation. He published more than 60 papers and one monograph.

