Does a theory of the laser linewidth exist?

Boris Spivak and Serge Luryi
University of Washington and *SUNY–Stony Brook, U.S.A.*

Contemporary theory of laser linewidth was pioneered by Schawlow and Townes. The theory is essentially based on the assumption that in the mean-field approximation, for the intensity of injection I larger than a critical injection level I_C, one has singular frequency generation.

The finite linewidth then results from the account of fluctuations associated with the random spontaneous emission processes. In the framework of this theory, one finds the laser linewidth to be inversely proportional to the injection intensity I.

We discuss both the experimental and the theoretical status of the basic assumption in the instance of semiconductor lasers.

It is unclear whether the available experimental data on semiconductor lasers really support the theory of Schawlow and Townes. On the other hand, the solution of the kinetic equations for the electron and photon energy distributions shows that even on the mean field level (before the fluctuations related to spontaneous photon emission are taken into account), the generation of light occurs in a finite interval of energies and, as a consequence, the linewidth increases with the injection intensity.

We will discuss the relevance of this picture to the experimental situation and the theoretical scenarios, which provide narrow laser line width in the framework of the mean field approximation.