Amplitude squeezing with a Fabry Perot laser in presence of gain supression: Existence of optimum biasing conditions.

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For a few years, amplitude squeezing with semiconductor lasers has attracted the attention of the scientific community. Several models have been developed based on a quantum mechanical approach [1] or semiclassical one [2]. A new model based on a semiclassical analysis using a Green's function analysis [3,4] has been developed. This model enables to take into account structural dependences like spatial hole burning and other phenomena as non-linear gain. This model [3] permits to predict the internal amplitude and phase noise of a D.F.B structure and also the external amplitude and phase noise of such a structure, taking into account the influence of the vacuum fluctuations at the laser facets.

In the case of a Fabry Perot laser, many simplifications occur which leads to a complete set of analytical formula. With a linear gain approximation, similar results as Yamamoto et al. have been found [1].

Gain supression has a great effect on the laser characteristics when it is pumped far above threshold, as needed for an amplitude squeezing experiment using a quiet source. It seems then important to study the effect of this phenomenon on the squeezing characteristics of a Fabry Perot laser. A gain supression assumption has been take, of the form:

\[ g(N,P) = g_d \frac{(N - N_0)}{1 + \varepsilon P} \]

where N is the carrier density, P is the internal photon density and ε is the non linear gain coefficient.

The variation of the internal and external amplitude noise depends on the use or not of quiet source. All the simulations presented have been made under assumption of no internal loss.

**Figure 1:** Internal amplitude noise normalized by the shot noise level for ε=1e-18 cm³ at various biasing level R= I/Ith - 1 ranging from 1 (1), 10 (2) to 400(5).

**Figure 2:** External amplitude noise at the zero frequency for ε=1e-18 cm³ without a quiet pump.
With or without a quiet source, the internal amplitude noise tends to zero for a very high pumping rate as shown in figure 1. Only a slight difference exist between pumping with a quiet source or not. Concerning the external amplitude noise, the effects of non linear gain are important. Without a quiet source, amplitude squeezing is possible, with a decrease of a maximum 25% under the shot noise value as presented in figure 2. This fact has been already pointed out by J. Arnaud [2].

Under a linear gain assumption, the use of a quiet source enables a substantial noise compression. In fact, the introduction of a gain supression leads to an optimum biasing point, for which a maximum of amplitude squeezing may be obtained (figure 3). For low pump rates, no significant differences exist between a linear or a non linear gain assumption. The external amplitude noise decreases and may get under the shot noise value. At high pump rates, a major difference appears. As the internal amplitude noise decrease and tend to zero because of non linearity, the vacuum fluctuations reflected at the facets becomes the major contribution to the external noise. In such conditions, the external amplitude noise increases and tends to the shot noise level but not to zero as in the linear gain one. Consequently, an optimum biasing point for squeezing exist. This optimum performance depends strongly on the non linear gain coefficient. Such results may be found for a laser with internal loss.

![Figure 3](image1.png) ![Figure 4](image2.png)

**Figure 3:** External amplitude noise at zero frequency normalized by the shot noise level with a quiet source pumping for various non linear gain coefficient ranging from 1e-19 cm^3 (1) to 1e-17 cm^3 (5).

**Figure 4:** Minimum external noise value obtainable as a function of the non linear gain coefficient \( \varepsilon \).

As small non linear gain coefficient appears desirable, the use of quantum well lasers may not be optimum for amplitude squeezing.

**Bibliography:**


