Problem Set 06, Introduction to Laser Physics, WS 10/11 01/02/11

Topic: optical resonators

Please answer the following questions until 01/02/2011

Problem 6

The linewidth of optical systems is a relevant factor in many optical experiments.

Problem 6.1

High resolution spectroscopy experiments demand single mode laser emission. But real lasers do not provide exact single mode emission. The fundamental linewidth of lasers is not zero. In general: Describe the factors influencing the linewidth of lasers. To what extent do e.g. semiconductor lasers differ from gas or solid state lasers? Please work through C. H. Henry *"Theory of the Linewidth of Semiconductor Lasers"*, IEEE J. of Q.E., Vol. QE-18, No. 2 (1982), 259-264. Please answer the following questions:

- What is the reason for the so-called Henry-Factor to appear in the description of the linewidth of semiconductor lasers?
- What is the influence of pumping noise on the linewidth of semiconductor lasers?
- Assume the laser is a gas laser. The optical transition frequency is detuned by means of an external frequency selective element by half the linewidth of the resonance frequency of the cavity. Explain occurring changes in the linewidth.

The appendix is for further reading only.

Problem 6.3

You have a laser that emits at 780 nm. Assume the mirrors of the Fabry-Perot interferometer to have a reflectivity of 99.99%. Its air filled cavity is 1m long. Please calculate the corresponding free spectral range Δf_{FSR}, the finesse F and the cavity linewidth δf_{FWHM}.

Assume the cavity length changes by 1 µm. How far do you have to tune the emission frequency of your laser to be again in resonance with the Fabry-Perot interferometer?

How small a length change can be detected with the setup assuming that the laser is sufficiently frequency stable and narrow linewidth?

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