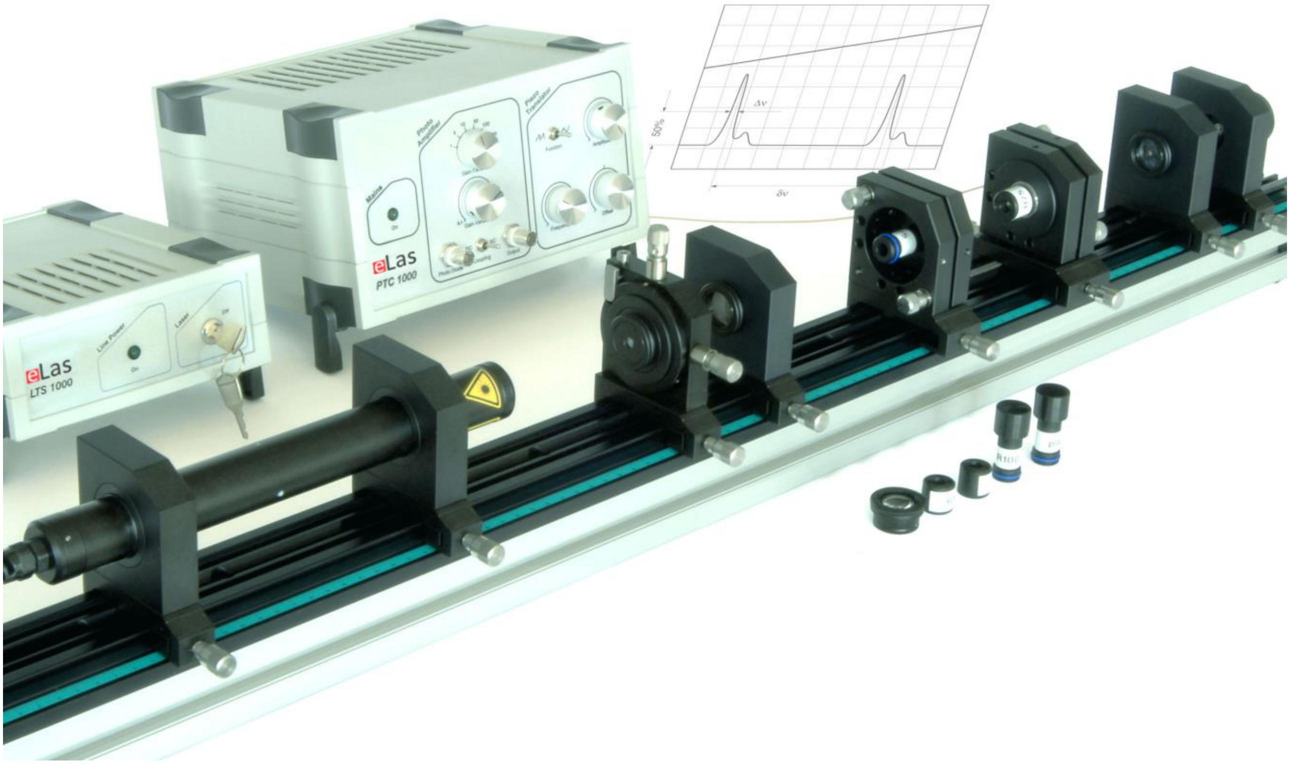
Fabry Perot Resonator (CA-1140)



The open frame Fabry Perot kit CA-1140 was designed for demonstration and investigation of characteristics like resonance, free spectral range and finesse of a resonator. Different resonator types can be built. By scanning the Fabry Perot the spectral pattern of the provided double-mode HeNe laser is analyzed. Unlike commercial scanning Fabry Perot analyzers, this system provides full insight to all components and is fully adjustable. A versatile controller allows setting all necessary functions of the piezo translator. For a basic start to the Fabry Perot topics a basic version (CA-1141) is available.

Educational Objectives of Investigation

- Interference of two and more laser beams
- Types of resonators
- Stability criterion of resonators
- External resonator in resonance
- Scanning Fabry Perot resonator with piezo translator
- Free Spectral Range of a Fabry Perot resonator
- Finesse of a Fabry Perot resonator
- Spectral Analysis of a HeNe Laser
- Perpendicular polarized laser modes

Modes of Operation

For demonstration and examination of optical resonators and their properties this fully functional open frame Fabry Perot resonator kit has been chosen because the Fabry Perot is the most important and most applied of all laser resonators.
Properties and characteristics like resonance, free spectral range and finesse of the resonator are presented. Criteria of different resonator types will be discussed and shown in measurements. The application of a scanning Fabry Perot interferometer as a spectrum analyzer for light is shown. With the help of the provided HeNe Laser, operated at two longitudinal modes, its mode spectra are demonstrated and measured.
The set-up includes a set of six interchangeable resonator mirrors in adjustment holders. One mirror is mounted on a piezo translator and controlled by a voltage controller to realize the scanning function. Variation of the resonator mirrors and the resonator length different types of optical resonators are evaluated. In case of a plane-parallel resonator a beam expander is used for enlarging the laser beam diameter. For distinction of the two laser modes a polarization filter in rotation mount is included in the kit. A versatile controller allows setting the piezo voltage, frequency, modulation mode and offset of the piezo translator.

The measured signals are detected by a PIN photo diode with amplifier electronics. The Fabry Perot transmission resonances are shown in synchronization to the piezo displacement on an oscilloscope (optionally available). For a basic start to the Fabry Perot topics a basic version (CA-1141) is available. Existing HeNe Laser kits can be upgraded by Fabry Perot extension kits (CA-1145 and CA-1146).

Ordering Information

This ordering information gives an overview of ordering numbers of the available Fabry Perot kits. All modules of the kits can be ordered separately, if required.

For ordering the Fabry Perot Resonator kit, Full Version (CA-1140)

use ordering number: 490091140

For ordering the Fabry Perot Resonator kit, Basic Version (CA-1141)

use ordering number: 490091141

For extending an existing HeNe laser kit (CA-1200, CA-1201, CA-1202) the following Fabry Perot upgrades are offered:

For ordering the Fabry Perot upgrade kit, Full Version (CA-1145)

use ordering number: 490091145

For ordering the Fabry Perot upgrade kit, Basic Version (CA-1146)

use ordering number: 490091146

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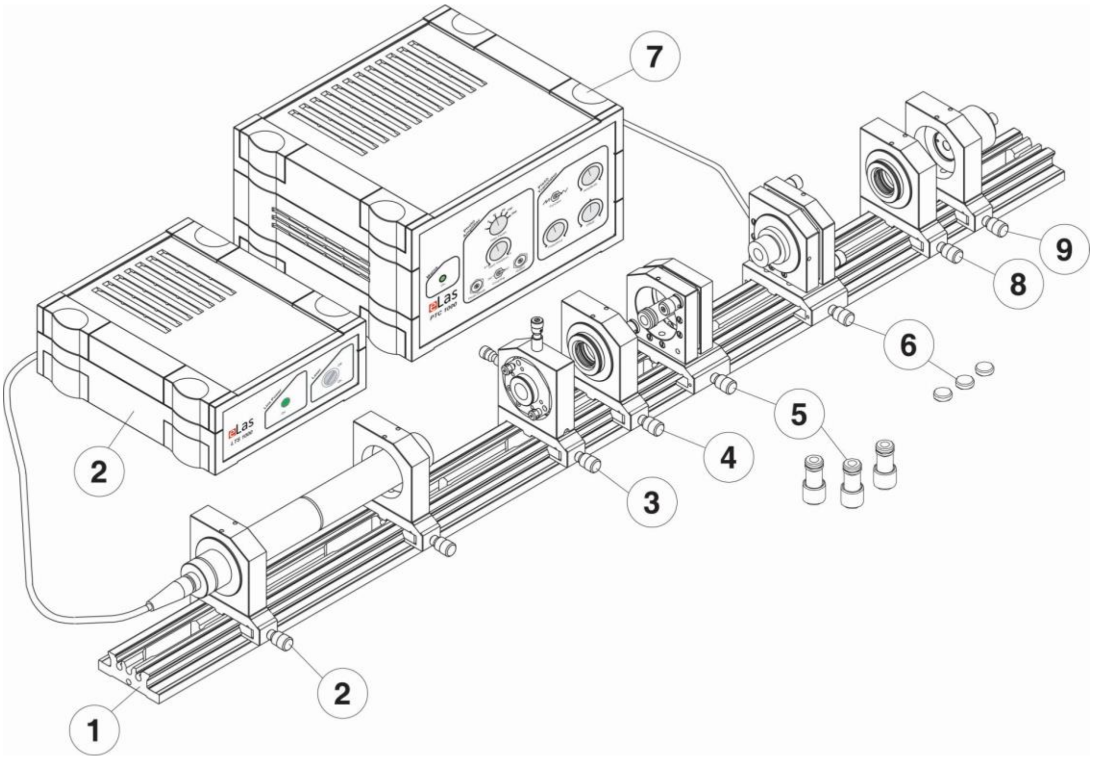
Setup and Components



1 Flat rail 1000 mm reinforced on stability profile, with integrated toothed rack, with scale
2 HeNe test laser in holder on carriers with power supply
3 Beam expander in XY adjustment holder on carrier
4 Beam expander in holder f=40/150 mm
5 Laser mirror adjustment holder on carrier with manual linear drive and set of mirrors (R75, R100, plane)
6 Laser mirror adjustment holder with piezo actuator on carrier and set of mirrors (R75, R100, plane)
7 Piezo Control Electronics PTC 1000
8 Beam shaping optics for laser beam in holder on carrier
9 Photo detector in holder on carrier
10 Polarizer in rotation mount on carrier (not shown)
11 3 BNC cables (not shown)
12 Set for optics cleaning (not shown)
13 User manual (not shown)

Please note:

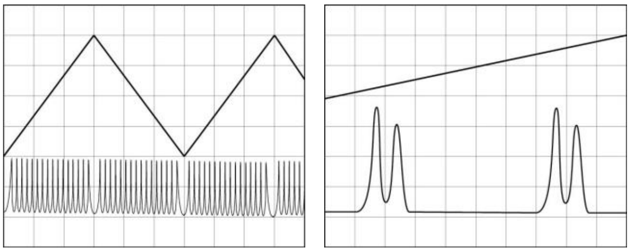
The Fabry Perot Resonator basic version (CA-1141) comprises item numbers
1, **2**, **5** with ROC=75mm mirror only, **6** with ROC=75mm mirror only, **7**, **9**, **11**, **12**, **13.**

The upgrade kits comprise the same components as their corresponding Fabry Perot kits, except of items **1, 2, 9, 12.**

Measurements and Handling

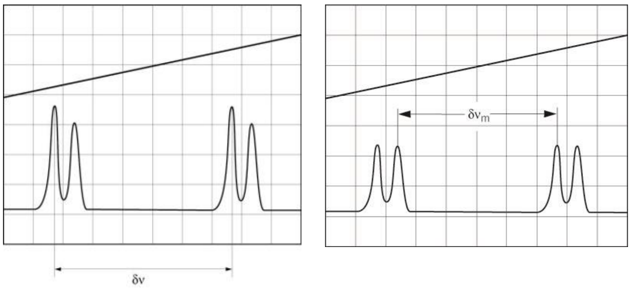
Some of the possible measurements are presented in the following list:

- **Resonator adjustment**



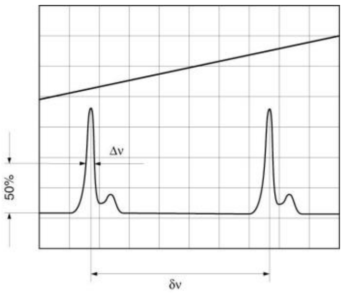
The alignment of the resonator mirrors and the adjustment of the cavity length are first tasks when setting up the Fabry Perot resonator. An iterative improvement of the resonator starting with a bunch of resonance peaks up to a clear pattern of resonances is the challenge of fine tuning of the system.

- **Free spectral range and mode distance**



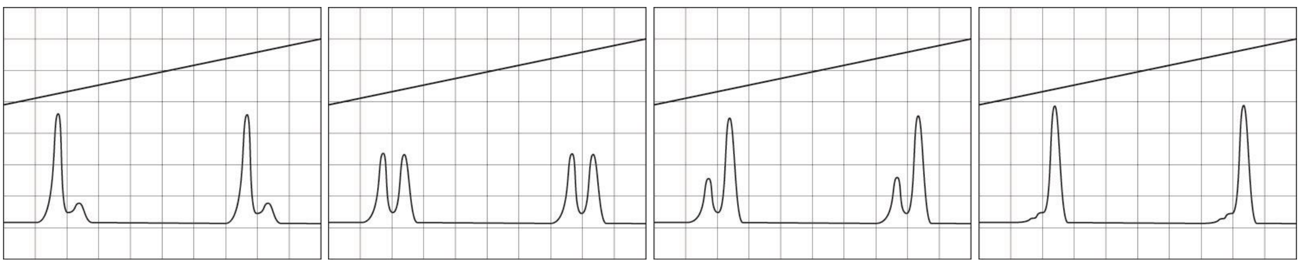
One characteristic value of a Fabry Perot is the free spectral range, FSR. The FSR is the frequency spacing of two successive axial modes of a resonator. The FSR of the resonator can be calculated using the resonator length. With this value the display of the oscilloscope can be calibrated relative in MHz.
With this relative calibration the mode distance of the Helium Neon Laser can be determined in measures of MHz.

- **Finesse**



Another important value for characterizing a Fabry Perot resonator is its finesse. The finesse characterizes the suppression of light throughput between the transmission maxima. For determination of the Finesse the Fabry Perot resonator has to be well adjusted. From the oscilloscope display the values for FSR and the peak width at half of the maximum height figured out as shown in the picture on the left hand side and the Finesse of the Fabry Perot resonator can be calculated.

- **Mode spectrum**



The system uses a two mode HeNe laser. The two modes are linearly polarized and stay perpendicular to each other. During the warm-up time of the laser the switching of the two modes is observed. Since the laser tube changes its dimensions when warming up the HeNe resonator length is in favour of one or the other mode as a function of the temperature. The mode pattern switches as depicted in the sequence of oscilloscope graphs shown above.

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- **Polarization behaviour (full version only)**

With a polarizer in rotation mount (item 9) one or the other mode of the laser emission can be suppressed when rotating the polariser. The sequence of oscilloscope graphs above also corresponds to the signal behaviour as a function of the polariser rotation angle.

- **Variation of resonator mirrors (full version only)**

Influence on FSR

Aim of the extended version of the experimental kit is the evaluation of the influence on the characteristics of a Fabry Perot resonator for different sets of resonator mirrors.

With the additional pair of concave mirrors (ROC = 100 mm) the change of the Fabry Perot response is determined. Using these mirrors and adjusting the resonator extensively another FSR is available. The differences of this resonator with respect to the resonator of 75 mm length are examined.

Different resonator types

With the concave mirrors other spherical resonators than the confocal resonator (d = ROC) can be tested by changing the mirror distance d (for example the concentric resonator with d = 2 ROC). How the Finesse changes in these cases is topic of evaluation.

- **Plane mirror resonator (full version only)**

First the Fabry Perot is set up with two plane mirrors and without an additional beam expansion. Again, the resonator has to be adjusted, but now the distance of the two mirrors is kept arbitrarily. The adjustment in this case is by far more critical than at a spherical resonator. The FSR as well as the Finesse are determined, also as a function of the resonator length.

In a next step the laser beam diameter has to be widened by a provided beam expander optics. The adjustment of the Fabry Perot resonator is less challenging now. The FSR as well as the Finesse is measured. Presuming the resonator is well adjusted the Finesse is larger than in the case without beam expansion.

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