acta phys. slov. 43 (1993), No. 1, 30–33

SPHERICAL MIRRORS LASER SPECTRUM ANALYZER: DESIGN AND PERFORMANCE

H. El-Kashef
Physics Department, Faculty of Science, Tanta University, Tanta, Egypt

We have described the design and performance of a quartz glass passive optical spectrum analyzer in the wavelength range between 560 nm – 650 nm. It consists of two spherical mirrors with curvature radius $R = 35$ mm. The mirrors are separated by a distance equal 35 mm which gives free spectral range of 2.14 GHz and finesse equal 174.

I. INTRODUCTION

In many applications of laser spectroscopy, high spectral resolution, low frequency drift and precise frequency scanning are required. Many papers [1–4] discussed the stabilization of laser frequency by locking it to a suitable eigen-frequency of a stable external optical resonator. Most of these resonators were made from materials of high thermal expansion coefficient such as invar. This leads to frequency drift of 600 MHz/K.

For designing an optical resonator for high precision measurements many parameters must be considered, include mechanical stability regarding both vibrational stability and mechanical creep, thermal stability, linearity of mirror tuning, mirror mounting without distortion and, of course, cost. Simply the optical resonator consists of two mirrors and spacer tube limit the distance between the mirrors. It is very important that the resonator components made from the same material, which must have a very low thermal expansion coefficient.

This letter is interested in the design of a 2.14 GHz optical resonator, all of its components made of quartz glass, which is used efficiently as a wavelength filter, frequency monitor and scanning.

II. DESIGN AND PERFORMANCE

The present optical resonator as shown in Fig. 1 is constructed from two quartz glass mirrors. The mirrors have a curvature radius of 35 mm, a reflectivity of 99%, dielectric coating in the wavelength range between 560 nm – 650 nm, diameter of 12 mm and thickness of 6 mm. The spacer tube is made from a quartz glass with

Fig.1. Photograph of the 2.14 GHz spectrum analyzer.

the length of 50 mm, an internal diameter of 12.3 mm an external diameter of 18 mm. The mirrors are adjusted and fixed by a system described in details in [5]. The optical resonator is aligned relative to a collimated monochromatic beam from a He-Ne laser at a wavelength 632.8 nm within the spectral range of the mirrors. The incoming laser beam (is computer mode matched to the resonator [6]) will be normal to the input. The degree of angular alignment required is not great. Reflecting the laser beam which is coincident with the optical axis, back on itself as well as can be determined visually, will normally be adequate. The input radiation should be centered on the resonator aperture, where the mounting bases allow angular and vertical adjustment. The traversing beam across the resonator is collected with a lens to be incident on a photodiode, where the effective fringe pattern and mirror alignment can be determined. By changing the alignment and repeating the process, the resonator alignment can be improved until the transmission is symmetrical and the intensity is maximum as shown in Fig. 2 on the oscilloscope. The resonator length control is obtained with a PZT triangle tube on one end, where one of the two mirrors is mounted with epoxy on the PZT tube. The mirrors are cement into the spacer tube at three points. Both mirrors and PZT tube are mounted with epoxy to give an airtight cavity. Continuous tuning is possible over a range of about 15 GHz for an applied voltage of 1000 volt. The construction of the PZT translator is identical to that described in [7]. The measured finesse of the resonator is 174, which agrees with the calculated one.

This fixed resonator is ultimate in terms of simplicity and mechanical stability. This is insured by maintaining a high degree of design symmetry. The coefficient of expansion, thermal inertia and configuration are the controlling parameters for thermal stability. The construction of the resonator from quartz glass insures low thermal drift. On the other hand PZT material has a low expansion coefficient and is used for alignment by adjusting the voltage applied to it.

The developed optical resonator can be efficiently used in many laser applications such as laser frequency stabilization, scanning and tuning. High precision measurements can be obtained by studying the Rayleigh scattering from gases,

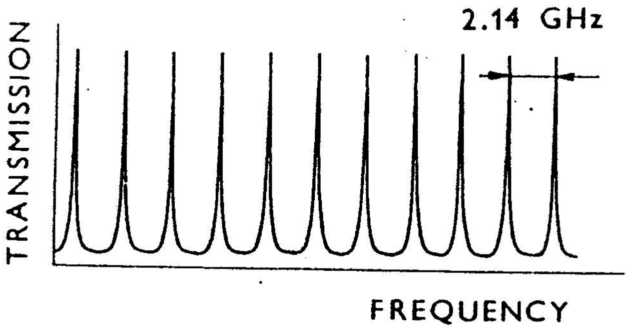

Fig. 2. Fringe pattern of the spectrum analyzer.

liquids and solids. On the other hand the resonator is used in high resolution applications, where low light levels are not a problem. This includes laser mode analysis, wavelength filtering and monitoring. Fig. 3 shows a He-Ne laser scan over the fixed spectrum analyzer resonances.

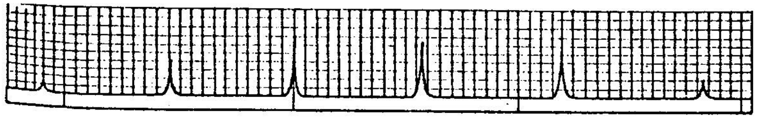

Fig.3. He-Ne laser scan using the developed spectrum analyzer.

III. CONCLUSION

The developed spectrum analyzer has many advantages. It is of a compact physical size, stable, no further adjustments are required by experimental work and low cost. By proper choice of materials the mirrors positions can be well defined thermally and mechanically. The technique of adjustment eliminates essentially all distortions, allows fixed mirror spacing, is mechanically rigid. The mirrors cannot be distorted since no forces can be presented on the mirrors. The confocal optical analyzer chief advantage is insensitivity to alignment. This fixed resonator provides extremely good mechanical stability, extremely stable thermally.

REFERENCES

[1] J. Houghet al: Appl. Phys. B *33* (1984), 179.
[2] S. Morleyet al: Appl. Opt. *5* (1966), 823.
[3] R.W.P. Dreveret al: Appl. Phys. B *31* (1983), 97.
[4] J. Helmckeet al: Appl. Phys. B *43* (1987), 85.
[5] H. El-Kashef: Submitted to J. Phys. E, (1991).
[6] H. El-Kashefet al: Bulg. J. Phys. *18* (1991), XXX.
[7] H. El-Kashefet al: J. Mod. Opt. *39* (1992), XXX.

Received April 28th, 1992
Accepted for publication June 30th, 1992