

# **Rapid Scanning of the Spectral Line Profile With Fabry-Perot Interferometer**

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## **Abstract**

The problem of rapid scanning of spectral line profiles with help of Fabry-Perot Interferometer, and to investigate the physical parameters of these profiles is discussed. For the construction of the interferometer we used a piezoceramic tube connected to one of the interferometer's plate.

## **Introduction**

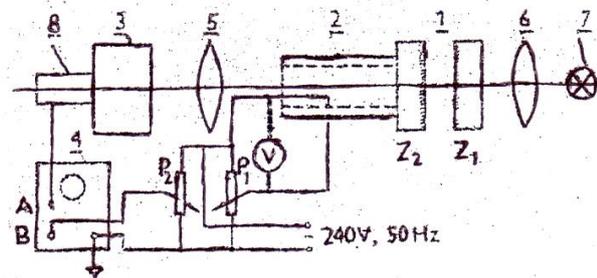
There are different methods for diagnostic of plasma which depend on the determination of profile of appropriate spectral lines. When the widening or the displacement of the spectral line is so little with the imperative, it must be to use apparatus with high dispersion power. For this purpose, the Fabry-Perot etalon crossing with other spectral device of prism or diffraction elements frequently be used. The registration can be done photo-graphically or photo-electrically using device of slowly scanning spectral line profiles. Except changing the pressure of the gas between the plates of Fabry- Perot interferometer, frequently is using suitable piezoceramic. One of the mirrors of the interferometer cemented to the piezoceramic tube, and the another one is movable, to making the fine adjustment. If we supply strictly linear voltage to the piezoceramic tube, the spectral line profile can be registrate. The time recording of the interference order must be less than the typical time of the particular process keeping the structure of the particular line profile without any change during the time of registration. To study the rapid process, it need rapid registration with some difficulty which is connected with using the special scheme which join with realization of installation of strictly to give the linear voltage to the piezoceramic tube, and to synchronize the investigation process of the electronical scanning. But the time of registration have some border, because at very high vibration of the plate, there will be some deformation to the mirror and to the instrumental contour. The conical lens (acsicon) (Hirschblerg et al., 1965) is used solidity division of neighboring spectral elements. Some other authors (Hirschblerg, 1967) suggested a system with special element which called

in literature “the system of Fabry-Perot”. Other authors (Jacquinot, 1954; Katchen et al., 1967; Cooper & Greig, 1963, 1962 and Platisa & Puric, 1972) were suggested several different methods for scanning of spectral line profiles. The interference image is projected on a sensitive layer of the TV camera (Gagneé et al., 1973), the minimum exposure time of scanning one profile of about (8) mm on the sensitive layer was (20)  $\mu\text{s}$ . In the method of rotating mirror (Ludmirsky et al., 1979) which the emitted light having passed through the Fabry-Perot etalon focused by a lens on the input slit of the monochromator, the maximum exposition time may be up to (20) ns. However, the problem of this method is in the synchronization of the mirror with the display on the oscilloscope. These details have not been discussed by the authors so far. The most frequently used method has been that of the oscillating mirror of the interferometer. To oscillate the mirror a piezoeffect is used, obtained by piezoelectric ceramic tube. The oscillating mirror is carried out by three piezoelectric ceramic tube connected in parallel (Ramsay, 1962). The scanning velocity was (1000) order per second. The amplitude of scanning was (10) orders at frequency of (100) Hz. The advantage of above interferometer is that it may be complemented by the automatic parallelism control of the interferometer mirror. For this purpose there were used either two auxiliary light sources, or a capacitance micrometer (Asenbaum, 1979; Ramsay, 1966). The voltage applied to the piezoelectric elements is governed by the control system so that the mirrors might stay in parallel. A set of piezoelectric ceramic tubes can also be used cemented together being separated by glass annular spacers (Jackson & Pike, 1968), in which (6) piezoelectric element were used, and the maximum scanning time was (60) ms. Using two high-finesse (De Rosa et al., 2002), Fabry-Perot interferometer for determination of the frequency dependence on the photo-thermal effect. Thermal fluctuation in the mirror over three decades of frequency range has been measured (Numata et al., 2003). Some authors used the Fabry-Perot resonance in far-infrared transmission spectra (Ruf et al., 2000), to investigate the refractive index ( $n$ ), of diamond for temperature up to (925) K. Special significance is the blue shifting observed as shifts of Fabry-Perot etalon fringes of order of ( $0.05 \text{ cm}^{-1}$ ) (Holmlid, 2001). The opto-mechanical properties of a Fabry-Perot interferometer has been investigated with a mirror mounted on a spring (Metzger et al., 2008). Other authors was investigated experimentally and theoretically the plane mirror Fabry-Perot resonators field using photonic crystal (Staliuans et al., 2007). A high-finesse Fabry-Perot cavity was developed (Caniard et al., 2007), to investigate the radiation-pressure effect in ultra-sensitive displacement. The

mirror relative motion of suspended Fabry-Perot cavity (Vergilo et al., 2007), is studied in the frequency range of (3-100) Hz.

### **Experimental**

Our experimental scheme is shown in fig.1, which it give the possibility to investigate the processes with duration of millisecond, and with some difficulty with microsecond. In the primary connection the piezoceramics is supplied by the linear voltage of about the maximum value of (240) v. The voltage however increases very slowly reaching it's maximum value within several minutes, so we are able to measure that line profile only during the measurement which was constant. If the applied voltage increases more rapidly, more fast phenomena may be scanned.



**Fig. (1): Experimental arrangement**

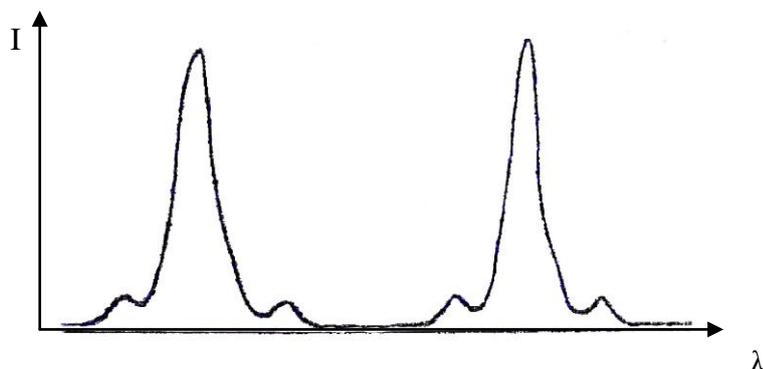
However it is necessary to take limit of the shortest scanning time of one line profile to may obtained, so not to distort the piezoceramics and the holders of the mirror, since the interferometer was constructed for slow voltage changes only. For the construction of the interferometer was used piezoelectric ceramic tube of a diameter of (20) mm and a length of (35) mm. The mirror  $Z_1$  remains during measurements at rest, situated in a round holder supported by three ends. The interferometer plate is attached to these points by three springs in the form of moon. Using regulating screws, it is then possible to adjust the mirror  $Z_1$  and  $Z_2$  in parallel. The mirror  $Z_2$  is mounted with the help of three springs. These are not inevitable to reduce however the mechanic stress of piezoceramics, since the weight of the mirror fairly great. The aluminium holder into which a cut metal ring is inserted and cemented to the back side of the interferometer plate. The piezoceramic tube is fastened to the desk by three screws, and the other end of the tube fastened to the holder. A sodium hollow-cathode lamp has served as the source of light to adjust the two mirrors be parallel. This adjustment was very difficult and laborious, since the moving mirror was greatly sensitive to external vibration. For verifying the constructed according to the data mentioned above, we used the TKG 205 He-Ne laser ( $\lambda=632.8$  nm) to get the instrumental function of the apparatus. Using output lens (6) of a variable focal length, we expanded the light beam

emitted from laser (7), passing through the interferometer (1) and the piezoceramic tube (2), and the light beam was focused by a lens (5) of focal length (150) mm on the monochromator input slit (3) and the image of the interference annular fringes occurs. For this purpose we used the Carl-Zeiss SPM-2 monochromator. The signal from the photomultiplier tube (8) was displayed on orion EMG-1546 oscilloscope (4). The signal from the photomultiplier was transmitted to the input A, then the voltage proportional to that of the piezoceramics to the input B. The frequency of (50) Hz is the one mostly available. The oscillogram must be obtained in connection to get the diagram of the spectral line profile. The monochromator input slit of (0.17) mm is best to get as well as the fine line profile. The effective voltage value of the piezoceramic element is (240) v. It must to get two maximum from the oscillogram passing through the slit of the monochromator at a given voltage for one half period. From the oscillogram mentioned it may obtain the function of the instrument. However, it is necessary to perform a correction, since the oscillogram is distorted by the fact that the time base of the oscilloscope increases uniformly whereas the voltage on the piezoceramic changes according to sine function.

### **Results and Discussion**

In the present work it has been studied Cr hollow cathode discharge tube.

The spectral line profile, emitting from hollow cathode discharge tube, Cr ( $\lambda = 425.4$  nm), scanned with D.C current of (5-20) mA, which compared with that of pulse current (100-400) mA. Pulses repetition was (5-10)  $\mu$ s, and the interval's time between pulses was (150-600)  $\mu$ s. The registering photomultiplier tube has been cooled with liquefied nitrogen using the system described in previous work (Dunchev et al., 1980). The instrumental function of the apparatus has been determined (Mohamad & Petkov, 1979), using precise He-Ne laser working in single-mode regime. The spectral line profile which we get it graphically is shown in fig. (2).



**Fig. (2): The spectral line profile of hollow cathode discharge tube, Cr ( $\lambda = 425.4$  nm)**

For calculation of the half-width ( $\delta\lambda$ ) of the spectral line, emitting from Cr hollow-cathode discharge tube, it has been used contours correction  $\delta\lambda = (\lambda^2/2t) \cdot (\Delta\lambda/dL)$ , (Minkowski et al., 1935), where  $\Delta\lambda$ - is the middle of experimental half-width of both profiles,  $dL$ - is the separation between both maximum of profiles,  $\lambda$ - is the emitting wavelength of the spectral line from Cr discharge tube, and  $t$ - is the separation of interferometer mirrors. The results of our calculation are shown in table 1.

**Table (1): The dependence of half-width of Cr line ( $\lambda= 425.4\text{nm}$ ) on the current through hollow-cathode discharge tube**

D.C current (I) mA	Half-width $\delta\lambda$ nm	Pulsed current (I) mA	Half-width $\delta\lambda$ nm
5	0.0165	100	0.0170
6	0.0170		
7	0.0175	200	0.0200
8	0.0180		
9	0.0180	300	0.0220
10	0.0185		
15	0.0200	400	0.0240
20	0.0210		

The result of half-width of the spectral line in this work is in a good agreement with those which has been done by other authors (Kleinman & Cajko, 1970; Bruce & Hannaford, 1971 and Kreye & Roesler, 1970). From table 1, we see that the half-width ( $\delta\lambda$ ) of the spectral line which we get it by using D.C current is smaller than that which we get it by A.C pulse current. These results are useful for atomic absorption spectral analysis investigation with help of Zeeman effect, which it need discharge sources of suitable line profile and suitable work condition. Also one can use the results of these line profiles to study other parameters of the plasma of the discharge tube like (temperature, density).

### **Conclusion**

A modified interferometer by Carl-Zeiss is obtained to use it for rapid scanning of spectral line profile of the pulsed discharge tube and by means of data processing on computer, the value of temperature of the plasma could be calculated. This method may be used to advantage in the near future as regards a rapid evaluation of spectral line profiles by means of computer. This work has been performed in University of Sofia, Faculty of Physics, Sofia, Bulgaria. The author would like to thank Petrakiev, A. and all members of the Faculty of Physics for their partial support to perform this work.

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### **الخلاصة**

تم التسجيل السريع للخطوط الطيفية باستخدام جهاز التداخل Fabry-Perot ، كذلك دراسة الخصائص الفيزيائية للخطوط الطيفية. لتصميم جهاز التداخل استخدم أنبوب سيراميك كهربى ضغطى مرتبط بإحدى ألواح الجهاز .