FAST-SCANNING FABRY-PEROT INTERFEROMETERS[1]

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The problem of rapid scanning of spectral line profiles with the help of the Fabry-Perot interferometer is discussed and the corresponding results are presented. The measurement of the profile of the Cr I spectral line $\lambda = 425.4$ nm emitted by a pulse discharge in a hollow-cathode was performed by this system and thus the temperature of neutral particles may be calculated.

БЫСТРОСКАНИРУЮЩИЕ ИНТЕРФЕРОМЕТРЫ ФАБРИ–ПЕРО

В работе обсуждается проблема быстрого сканирования формы спектральных линий при помощи интерферометра Фабри–Перо и приведены соответствующие результаты исследований. Произведено измерение формы спектральной линии CrI с длиной волны $\lambda = 425{,}4$ нм, излучаемой во время разрядного импульса в полом катоде, на основе чего произведен расчет температуры нейтральных частиц.

I. INTRODUCTION

Several aparatures and methods using the Fabry–Perot interferometer have already been mentioned. They enable us to measure high-speed phenomena. The above apparatuses according to the methods applied may be divided into three groups:

1. The interference image is projected on a sensitive layer of the TV-camera [1]. In the work mentioned the horizontal scanning is made at a frequency of 15.75 kHz, the vertical one tat 60 Hz. The minimum exposure time of scanning one profile of about 8 mm on the sensitive layer was 20 μS.

2. The method of the rotating mirror [7]. The emitted light having passed through the F—P etalon is focused by a lens on the input slit of the monochromator

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bymeans of the rotating mirror. As reported by the authors the maximum exposition time may be shortened up to 25 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.

3. 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 tubes. The arrangement may have the following specification:

a) The oscillation of the mirror is carried out by three piezoelectric ceramic tubes connected in parallel [2]. The scanning velocity was 1000 orders per second. The amplitude of scanning was 10 orders at a frequency of 100 Hz. The advantage of the above interferometer is that it may be complemented by the automatic parallelism control of the interferometer mirrors. To this purpose there are used either two auxiliary light sources, or a capacitance micrometer [3], [4]. The voltage applied to the piezoelectric elements is governed by the control system so that the mirrors might stay in parallel.

b) The oscillating mirror is cemented to a ceramic tube. In the case where the tube is supplied by a voltage of frequency equal to the resonant one of the assembly piezoelectric element-interferometer mirror, it is necessary to mount the ceramic tube at its centre of mass, where a node of vibration occurs. An effective suspension for such a system may be achieved through clamping the tube either with a rubber O-ring or indium wire [6]. By means of this method it was possible to scan one maximum per 0.1 μs, only.

c) A set of piezoelectric ceramic tubes can also be used cemented together being separated by glass annular spacers [5]. In this work 6 piezoelectric elements were used. This system appears to be advantageous in the case of the above elements with respect to a possible application of reduced voltages. In [5], for example, the linear-ramp voltage supply of the oscilloscope time base was used directly (maximum scanning time was 60 ms).

II. EXPERIMENTAL ARRANGEMENT AND RESULTS OF MEASUREMENT

The problem of scanning high-speed phenomena has been of interest for both the Department of Physical Electronics in Brno and the Department of Optics and Spectroscopy in Sofia. Two methods are, basically, available for experimental procedure: either to adapt the manufactured interferometer, or to employ the manufactured mirrors only and to construct the other parts of the measuring equipment.

The manufactured F—P universal interferometer by Carl Zeiss Jena uses for measurements the movement of one mirror induced by the piezoceramics element. In the primary connection the piezoceramics is supplied by the linear-ramp voltage of about the maximum value of 1000 V. The voltage, however, increases very

slowly reaching its maximum value within several minutes so, that we are able to measure that profile only during the measurement was constant. If the applied voltage increases more rapidly, more fast phenomena may be scanned. However, it is necessary to take into account at which measure limit the shortest scanning time of one profile may be obtained so as not to distort the piezoceramics and the holder of the mirror, since the interferometer was constructed for slow voltage changes only.

For the construction of the interferometer we used apiezoelectric ceramic tube of a diameter of 20 mm and a length of 35 mm, produced by Tesla Hradec Králové. The experimental arrangement used is schematically shown in Fig. 1. The mirror Z_1 remains during measurements at rest, it is situated in a round holder supported by three pointed 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 mirrors Z_1 and Z_2 in parllel. We proceed in the same way with the cheaper professionally produced interferometers, for example the IT-28.

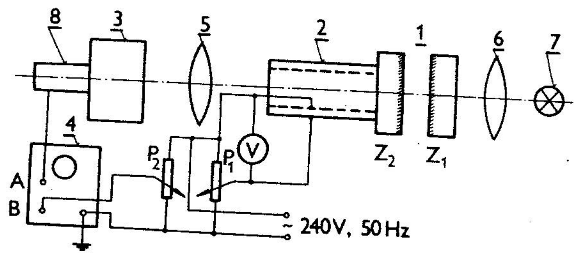

Fig. 1. Experimental arrangement.

The mirror Z_2 is mounted with the help of three springs. These are not inevitable, reduce however, the mechanical stress of piezoceramics, since the weight of the mirror is fairly great. The aluminium holder into which a cut metal ring is inserted is cemented to the back side of the interferometer plate. The piezoceramic tube is fastened to the desk by three screws. The other end of the tube is fastened to the holder.

A sodium lamp has served as the source of light to adjust the two mirrors in parallel. This adjustment was very difficult and laborious, since the moving mirror was greatly sensitive to external vibrations and contacts.

For verifying the working capacity of the interferometer constructed according to the data mentioned above we used the TKG 205 He—Ne laser ($\lambda = 632$ nm). Using the output lens (6) of a variable focal length, we expanded the light beam emitted from the laser (7). After passing through the interferometer (1) and the piezoceramic tube (2), the light beam was focused by a lens (5) of focal length

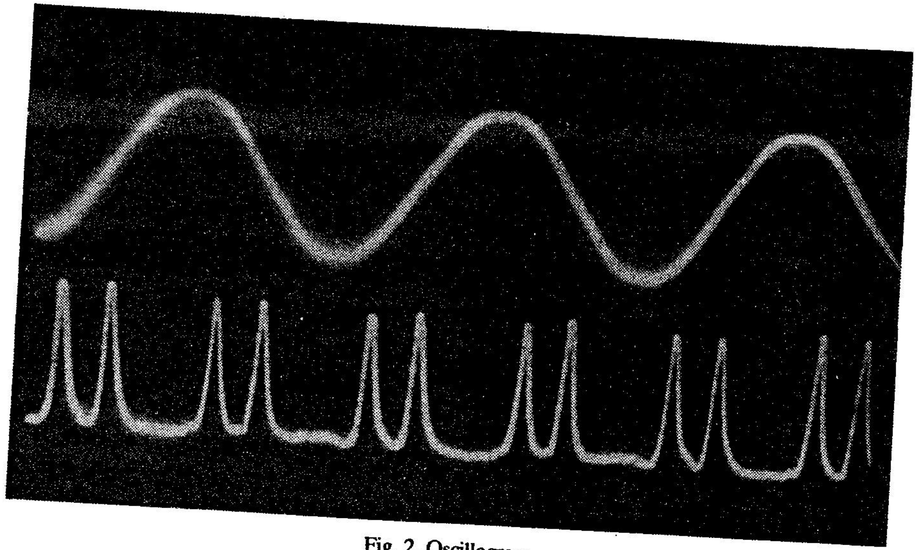

Fig. 2. Oscillogram.

150 mm on the monochromator input slit (3). On the monochromator input slit the image of the interference annular fringes occurs. For this purpose we used the Carl Zeiss SPM 2 monochromator. The signal from the photomultiplier was displayed on the Orion EMG-1546 oscilloscope (4). The TR-4705 two beams input amplifier was applied. The signal from the photomultiplier was transmitted to the input A, then the voltage proportional to that of the piezoceramics to the input B. We used the frequency of 50 Hz as the one mostly available. The oscillogram obtained in connection whose diagram is shown in Fig. 1 is presented in Fig. 2. The monochromator input slit of 0.17 mm was adjusted at the first maximum. The voltage effective value of the piezoceramic element was 250 V. The upper sine curve in the

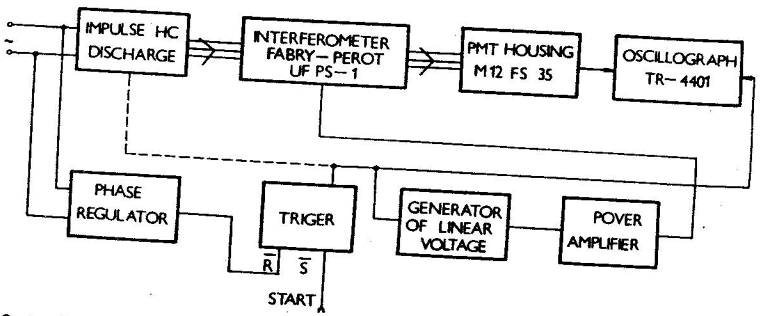

Fig. 3. A schematic drawing of the apparatus (Department of Optics and Spectroscopy, Sofia).

Table 1
The dependence of the half-width $\Delta\lambda$ of the Cr line on the current through the hollow-cathode discharge

CrI 425.4 nm			
Direct	Current	Pulse (10 μs)	
I	$\Delta\lambda$	i_{max}	$\Delta\lambda$
mA	nm	mA	nm
5 6	0.0165 0.0170	100	0.0170
7 8	0.0175 0.0180	200	0.0200
9 10	0.0180 0.0185	300	0.0220
15 20	0.0200 0.0210	400	0.0240

Figure corresponds with the voltage of the ceramic tube, the lower curve represents the signal of the photomultiplier. As evident from the oscillogram two maxima are passing through the slit of the monochromator at a given voltage per one half-period. From the oscillogram mentioned we may obtain the function of the instrument. However, it is necessary to perform a correction, since the oscillogram is disported by the fact that the time base of the oscilloscope increases uniformly, whereas the voltage on the piezoceramics changes according to the sine function. With the interferometer prototype we have not performed measurements using other sources of light, since the working conditions of the above construction were less perfect. Adjusting this apparatus we time-consuming and the measurements were less effective.

The measurements carried out at the Department of Optics and Spectroscopy of the University in Sofia have been carried out with the Carl Zeiss interferometer, which supplied the piezoceramics with short-pulse voltage. Signals of the photomultiplier were displayed on the oscilloscope. The schematic drawing of the experimental set-up is shown in Fig. 3. The CrI line $\lambda = 425.4$ nm emitted by the discharge tube with the hollow-cathode was scanned within the current range of 100—400 mA. Pulses were repeated with a frequency of 1—7 kHz. The length of the pulse was 5—10 μs and the intervals between pulses were 150—600 μs.

The results of calculations are summarized in Table 1. These measurements have made it possible to determine the line profile in the pulse discharge and to compare it with that of the discharge steady state regime.

III. CONCLUSION

Two types of F—P interferometers have been proposed to study high-speed phenomena. A modified interferometer by C. Zeiss was used for the scanning of the spectral line profile of the pulsed discharge and by means of data processing on a computer the value of temperature could be calculated. This method may be used to advantage in the near future as regards a rapid evaluation of line profiles by means of computers.

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