SOME PHYSICS DEMONSTRATIONS

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1. The Fabry-Perot demonstration interferometer with a plate gap of 4 mm, described in [1], makes it possible to show the hyperfine structure of spectral lines and the Zeeman effect. For demonstrations at the Tomsk University, use is made of a homemade collimator, consisting of two tubes fitting into one another, a wide slit cut in cardboard, and an objective with $F \approx 35$ cm. A stage with three screws is placed behind the collimator, and the Fabry-Perot apparatus is placed on it in a sheet-metal channel. A direct-viewing prism is placed in front of this (for example, a student's prism), and is viewed through a transit telescope. A PRK mercury lamp source fed from an induction coil is used with the apparatus. The spectral lines obtained in this case are very sharp. The apparatus is first adjusted without the interferometer: the direct-viewing prism is set in place and a sharp image of the slit is obtained for the yellow line of mercury with the telescope set for infinity. Then the interferometer is set in the path of the rays. By tilting it slightly, the central part of the equal-slope fringe pattern is viewed. The interferometer is finally adjusted by means of the screws. If the prism is correctly located, then there is seen immediately the hyperfine structure of the yellow line of mercury (5461 Å), due to the presence of isotopes—together with each sharp yellow ring, two much weaker ones can be seen (Fig. 1). For observation of the Zeeman effect, this same source is placed between the poles of an electromagnet with a rectangular iron yoke, weighing 150 kg, and with two coils of 1300 turns of copper wire of 1.8-mm diameter. The poles are set at a sufficient distance so that a mercury lamp (~2.5 cm) can be placed between them. A protective strut—a brass rod—was placed between the poles. When the current is turned on in the windings of the electromagnet, the yellow line is split into a number of components which are clearly seen at a current of 7.5 A (Fig. 2). For observation of the normal effect, the telescope is so set that rings of equal inclination are observed (from the yellow lines of mercury). Here it is unfortunate that the mercury spectrum has two yellow lines ($\Delta\lambda = 20$ Å), each of which has its own set of fringes. It is therefore convenient to turn the interferometer a little and observe fringes farther from the center, where the second set of fringes does not hinder the observation. The normal splitting is easily seen at a current of 4.5—5 A) (Fig. 3).

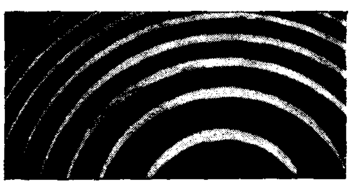

FIG. 1

FIG. 2

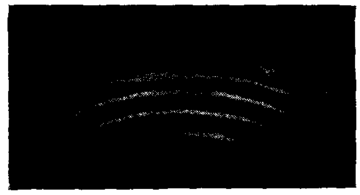

FIG. 3

If a polaroid is inserted in the path of the beam, with its principal cross section oriented in either the horizontal or the vertical plane, then it is seen that for normal and anomalous Zeeman effects in mercury the central component is polarized parallel to the field and the outside components are perpendicular to it (Figs. 4-5).

To make the demonstration in a large auditorium, one must use a powerful source of monochromatic radiation of the laser type (which emits red light) or use commercial television apparatus. (In the demonstration of the picture of lines of equal inclination by means of the Fabry-Perot etalon, it is not necessary to use a spherical mirror or lens for focusing, because the interference pattern is obtained with sufficient clarity without them.)

FIG. 4

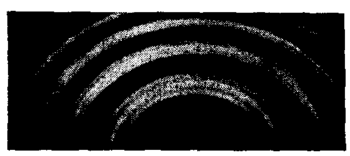

FIG. 5

2. In the study of Fourier expansions of periodic pulses, students frequently perceive only the mathematical side of the problem, while the physical part remains incomprehensible. Therefore, it is useful to show an experiment which demonstrates graphically the real existence of the harmonic components of the spectrum of a pulse and their relative amplitudes. For this purpose, one can use spectrum analyzers, the analysis in which can be made instantaneously or successively. In apparatus of the first type, there are oscillating circuits or resonators with different natural frequencies. If a periodic series of pulses is applied to the set, then an appreciable voltage is excited only across the circuits whose natural frequencies correspond to the harmonics contained in the pulse spectrum. The second type of analyzer contains a generator of the frequency in question and a narrow-band circuit tuned to some particular frequency (say 3 kcs). Swinging-frequency oscillations are mixed with the pulses, their sum is detected, and the oscillations at the difference frequency are fed to the narrow band circuit. Every time when the swinging frequency differs by 3 kcs from the frequency of the harmonics contained in the pulse spectrum, an appreciable voltage is obtained, proportional to the amplitude of the corresponding harmonic. This voltage is fed to the vertical deflecting plates of a cathode-ray tube, the time base of which is synchronized with the variations of frequency of the generator.

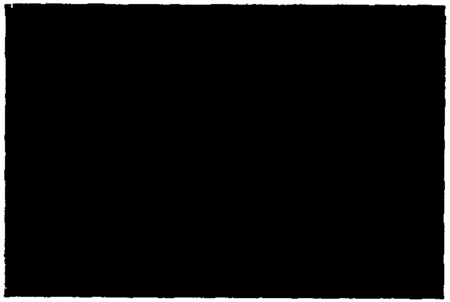

FIG. 6

The harmonic spectrum of the signal under study is thus obtained on the screen. The ASCh Kh-1 (SK 4-3) analyzer operates on this principle. It is convenient to use it to demonstrate the principle of harmonic expansion. By feeding periodic sawtooth pulses to the input of the analyzer, say from the oscilloscope sweep generator, one can demonstrate the spectrum shown in Fig. 6. It is advantageous to show also the spectra of short and rectangular pulses at different pulse lengths and different repetition rates, and also modulated oscillations.

[1] B. Sh. Perkal'skis and V. L. Larin, Usp. Fiz. Nauk 79, 743 (1963), Soviet Phys. Uspekhi 6, 326 (1963).

Translated by R. T. Beyer