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Fig. 1

Figure 1: Fig. 1

Abstract

Full Text

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METHOD FOR DETERMINING THE LOWER LIMIT OF THE SPECTRAL WIDTH OF THE LUMINESCENCE LINE OF THE IODINE ATOM TRANSITION $5^2P_{1/2} - 5^2P_{3/2}$ IN A PHO- TODISSOCIATION OKG

(Presented by Academician I. V. Obreimov, 13 XI 1969)

In studying the operation of an OKG, a very important characteristic is the spectral width $\Delta\lambda$ of the luminescence line of the working transition of the active substance, which is directly related to the gain cross section σ by the known relation (see, for example, ⁽¹⁾)

$$\sigma = \lambda^4 / 4\pi^2 c \tau \Delta\lambda, \quad (1)$$

where c is the speed of light, λ is the wavelength of the center of the luminescence line, and τ is the radiative lifetime of the excited particles.

The unknown quantity in equation (1) is the spectral width of the luminescence line $\Delta\lambda$. Below we describe a method for measuring the spectral width of the line of the generated infrared radiation of a photodissociation OKG ($\lambda = 1.315 \mu$) with the aid of a Fabry–Perot etalon, whose interference pattern is swept in time by a rotating mirror and recorded by a photodiode.

Fig. 1. 1 –tube with the working substance (internal diameter 12 mm, $l_t = 320$ mm); 2 –plane resonator mirrors (reflection coefficients $r_1 = 0.99$, $r_2 = 0.08$), length of which is 1 m; 3 –deflecting plate; 4 –diffuser (polyethylene film); 5 –Fabry–Perot etalon (distance between mirrors 20 mm); 6 –objective ($f = 2500$

Figure 2

Figure 2: Figure 2

Figure 3

Figure 3: Figure 3

mm); 7 –rotating mirror (SFR camera); 8 –slit (0.05 mm × 2 mm); 9 –photodiode (germanium–gold), recording the intensity of the interference maxima; 10 –photodiode (germanium–gold), recording the intensity of the generated radiation

The optical scheme of the setup is shown in Fig. 1. The interference pattern of the Fabry–Perot etalon 5 is localized in the focal plane of objective 6, which in our case coincided with the plane of slit 8. As mirror 7 rotates, the interference maxima pass the slit in succession, and their intensity is recorded by photodiode 9. The sweep speed of the interference pattern was 0.75 mm/μsec. The signals from the photodiodes were fed to a DEO-1 oscillograph, on which, at the same scale,

Fig. 2. In the upper trace, the two right-hand peaks correspond to the interference maxima of the central ring. The lower trace is the generation pulse. The sweep was started at the moment the IFP-5000 flash lamp began to glow. Sweep duration: 100 μsec.

Fig. 3. The signal from photodiode 9 was simultaneously fed to an S1-29 oscilloscope. Figure 3b shows the oscillogram of the first maximum of the central interference ring. Sweep duration: 8 μsec.

the generation pulse and the sequence of interference maxima were recorded in time.

The measurements were carried out in an optical quantum generator with the working substance C₃F₇I at pressures of 38 and 50 torr. A typical oscillogram at a C₃F₇I pressure of 38 torr is shown in Fig. 2. In Fig. 3a the central interference ring is superposed on the oscilloscope screen with the recording of the generation process at a C₃F₇I pressure of 50 torr.

Estimation of the spectral width of the generated-radiation line from the interference pattern (², ³) gives the value $\Delta\lambda_{\Gamma} \simeq 0.04 \text{ \AA}$ for both values of the pressure of the working substance.

The interval between resonator modes $\Delta\lambda_p$ for length $L = 1 \text{ m}$ is

$$\Delta\lambda_p = \lambda^2/2L = 0.0086 \text{ \AA}.$$

The resonator-mode width $\Delta\lambda_m$, determined in our case by the transmission of the mirrors, is

$$\Delta\lambda_m = \frac{\lambda^2}{4\pi L} \ln \frac{1}{r_1 r_2} = 0.0035 \text{ \AA}.$$

Thus, the spectrum of the generated radiation consists of 4–5 modes. It is not possible to resolve these modes on the oscillogram because of the insufficient resolving power of the photodiode ⁽⁴⁾ and the Fabry–Perot etalon.

The measured spectral width of the generated radiation $\Delta\lambda_\Gamma \simeq 0.04 \text{ \AA}$ makes it possible, using equation (1), to obtain an upper limit for the amplification cross section. For the transition of the iodine atom $^2P_{1/2} \rightarrow ^2P_{3/2}$, for which $\tau = 0.13$ sec. ⁽⁵⁾, we obtain $\sigma \leq 5 \cdot 10^{-18} \text{ cm}^2$.

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