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Simple pulsed dye laser with 2GHz linewidth

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An improvemed N_2-laser pumped dye laser is described. Linewidth as narrow as 2GHz can be easily obtained without using very expensive commercial elements. Wide range of tuning (180 GHz) and high power make this laser very attractive for spectroscopic experiments.

Since their invention the tunable dye lasers have been applied succesfully in many different areas of sciences. N_2-laser is very often used as a pumping source for this type of lasers because of its simple construction and relatively low cost. The earliest constructions of N_2-laser pumped dye lasers provided high power short pulses. Since, however, spectral linewidth was rather wide [1] some efforts have been made to obtain narrow linewidth without decrease in power [2].

The best spectral characteristic can be obtained with a grating as a dispersive element. Lasers based on gratings with Fourier limited pulses have been reported in [3]. These constructions, however, require a telescope to increase spectral selectivity of laser cavity. Such a system has some disadvantages arising from a long laser cavity and power losses in the telescope. Recently an ingenious solution of the problem has been proposed [4] in which an enormously high dispersion of a grating placed almost parallel to the laser beam has been utilized. The construction was simpler and laser efficiency was high. It seemed to suit our purposes very well. The aim of our work was to build a tunable, powerful laser with a narrow line.

The scheme of our laser is shown in fig. 1. The dye laser system consists of a laser and amplifier. Stilben 3 and coumarine 2 were employed as lasing dyes. The former one is very cheap, convenient (soluble in water) and extremely efficient [5]. It enables a very wide tuning (410–470 nm). However, we have found out that at the wavelength of our interest (4550 Å) the laser light contains a lot of superfluorescence which have attributed to the fact the laser operation at the slope of gain profile. In fact, spectraj purity of the laser beam was considerably increased, when coumarine 2 (maximum gain around 460 nm) was used. Hence it may be concluded that a proper dye or a mixture of dyes with maximum gain at required wavelength should be used.

1 MW, 15 Hz repetition rate nitrogen laser was used as pumping source. About 30% (or 15% without FP in the cavity) of N_2-laser beam was directed to the laser. The remaining part of the ultraviolet beam pumped the amplifier. The appropriate delay of this beam was provided. The dye laser pulse was a little shorter than N_2-laser pulse which was measured to be 8 ns.

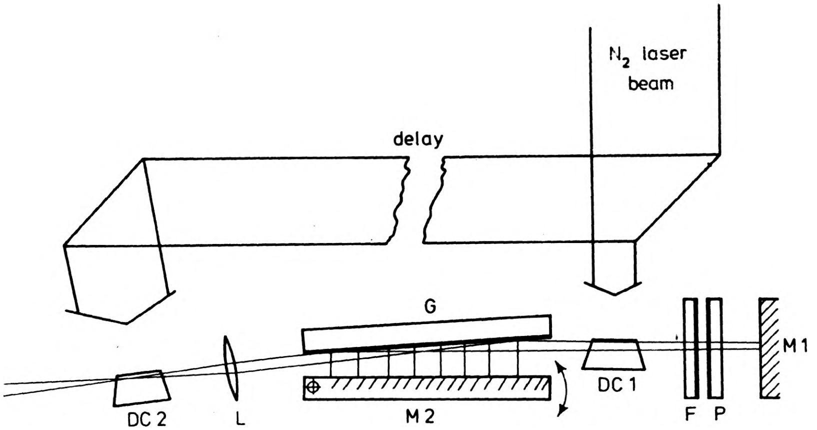

Fig. 1. Schematic view of laser system. G — 1800 lines/mm Bausch and Lomb grating blazed at 500 nm, with the efficiency of about 70% at the wavelength of interest; M1, M2 — 100% mirrors, CD1 — laser dye cell, DC2 — amplifier dye cell, FP — Fabry-Pérot interferometer, L — lens

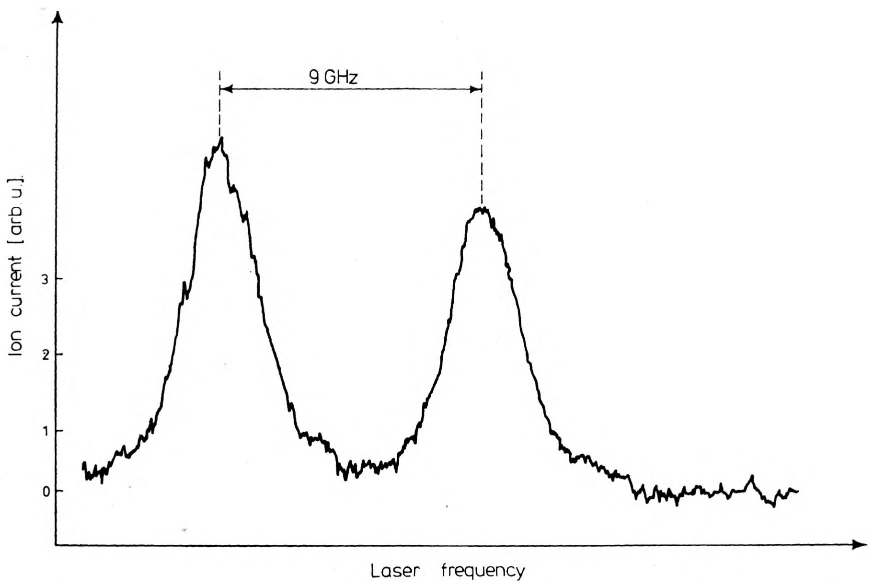

Fig. 2. Ion current dependence on laser frequency near $6S_{1/2} - 7P_{3/2}$ resonance

The output power of the generator was high enough to saturate the amplifier. This is essential for our construction since in the opposite case a two stage amplifier is required. However, due to a strong pumping the laser runs well above the threshold and the single mode operation cannot be obtained.

At first the laser worked without FP interferometer. Tuning was realised by the piezoceramic-mechanical system rotating mirror M1. Application of 600 V voltage caused the tuning of the frequency in the range of about 180 GHz ($\lambda = 455$ nm). Unfortunately, the actual laser linewidth could not be measured. The effective linewidth (with jitter) was about 8 GHz. Furthermore, it was stated that the jitter contribution was considerably smaller than the actual laser linewidth. Although the efficiency of the laser system was high, it was not satifactory considering linewidth of the laser.

To get narrower laser line an FP interferometer of the finesse 9 was put into the cavity. A decrease of the laser power, which was observed can be partially attributed to poor quality of the interferometer. In order to achieve the amplifier saturation it was necessary to direct 30% of pumping light into oscillator.

The interferometer length was controlled by a piezo. Simple electronic system allows a synchronous scan of FP and M1 mirror, so that the previous (180 GHz) scanning range can be preserved. No noticeable changes of laser power were observed in the tuning region.

This laser system was used in the experiment with resonant two-photon ionization of Cs atoms (through $7P_{3/2}$state). Figure 2 shows an example of ion signal dependence on the laser frequency. The two peaks correspond to hyperfine splitting of the caesium ground state (energy difference about 9 GHz). The details of the experiment will be published elsewhre.

By applying an FP interferometer of higher finesse a linewidth below the typical Doppler width of atomic lines can be easily obtained.

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Лазер на красителе с шириной 2ГГц

В работе описан лазер на красителле с накачкой от азотного лазера. Получена ширина линии меньшая чем 2 ГГц, без использования дорогих элементов. Благодаря широкому диапазону пересеткой (180 ГГц) и большой мощности, этот лазер может найти широкое применение в лазерной спектроскопии.