time. Since the pulse groups propagating in the ring resonator in opposite directions are separated by the passive shutter from different noise pictures, the temporal structures of these groups will be different and statistically independent. Consequently the structures of the spectra of the radiations propagating in opposite directions should also be different and irregular. To confirm this, simultaneous investigations were made of the spectra of the radiations propagating in opposite directions. To this end, the radiation from both channels was projected on different sections of the spectrograph slit, and independent spectra of the radiation in the two directions were obtained during each flash. Each spectrum revealed an irregular structure that did not repeat from flash to flash; more importantly, the structures corresponding to opposite directions were always different. By way of examples, Figs. 2b and 2c show typical microphotographs of such "double" spectra, which show clearly the difference in the structure.

The case $\tau_{rel} > (c\Delta\nu)^{-1}$ is thus realized for the dyes used in our experiment, and it is therefore practically impossible to obtain complete self-synchronization of the modes with broad emission spectra. The relation $\tau_{rel} \ll (c\Delta\nu)^{-1}$, under which complete mode locking has a noticeable probability for our dyes, can be satisfied, for example, by decreasing $\Delta\nu$. As shown by us in [3], a decrease of the spectrum width $\Delta\nu$ from 20 to 2 cm^{-1} increases the probability of complete mode locking appreciably, at the expense of increasing the USP duration. The most promising, however, from the point of view of obtaining single pulses of high power at considerable spectrum widths, is the search and the use of dyes whose relaxation time τ_{rel} is shorter than the UPS duration $\Delta t \sim (c\Delta\nu)^{-1}$.

[1] V. S. Letokhov, Zh. Eksp. Teor. Fiz. 55, 1943 (1968) [Sov. Phys.-JETP 28, 1026 (1969)].
[2] T. I. Kuznetsova, ibid. 57, 1673 (1969) [30, 904 (1970)].
[3] V. I. Malyshev, A. V. Masalov, and A. A. Sychev, ibid. 59, 48 (1970) [32, 27 (1971)].

OPTICAL FREQUENCY STANDARD WITH A BEAM TYPE ABSORBING CELL

Yu. M. Malyshev, V. M. Tatarenkov, and A. N. Titov
Institute of Physicotechnical and Radio Measurements

Submitted 5 April 1971
ZhETF Pis. Red. 13, No. 11, 592 - 595 (5 June 1971)

Lasers with nonlinearly absorbing gas cells saturated by the field of an electromagnetic wave, besides having spectroscopic applications, play an especially important role in the development of optical frequency standards [1]. The best results from the point of view of reproducibility of laser radiation have been obtained to date with an He-Ne laser (λ = 3.39 μ) with an internal methane absorbing cell, stabilized against the top of the power peak that arises when the rotational-vibrational transition $\nu_3[P(7)]$ of the methane molecule is saturated [2]. One of the main sources of errors in the reproducibility of the frequency of a laser of this type is the shift of the absorption line as a result of the collisions between molecules. The desire to reduce this shift makes it necessary to work at very low gas pressures in the absorbing cell. This, however, greatly decreases the amplitude of the peak, reduces the signal/noise ratio, leading in turn to a limitation on the attained stability and reproducibility of the gas-laser frequency.

The spectral-line shift due to the collisions between the particles can be eliminated in practice by using atom or molecule beams instead of gas. In the visible and in the infrared, however, the molecular-beam absorption line remains Doppler-broadened, owing to the residual beam divergence, and its width exceeds the homogeneous line width by many times. Therefore, just as in the case of a nonlinearly-absorbing gas cell, to obtain extremely narrow power resonances it is advantageous to use the saturation of the Doppler absorption line by the field of the electromagnetic wave.

The present paper is devoted to the first observations of the absorption of a molecule beam in resonant interaction with the radiation field of a gas laser. The experiments were performed with an He-Ne laser with emission wavelength 3.39 μ and with a beam of methane molecules. The employed vibrational-rotational transition $\nu_3[P(7)]$ of the CH_4 molecules has a rather small radiative width, making the methane molecule a suitable and interesting object for similar investigations.

Let us note the distinguishing features of the experimental setup shown in Fig. 1. Its main element is a vacuum chamber in which the molecule beam is produced by a multichannel source comprising a stack of glass capillaries 0.1 mm in diameter and 3.5 mm long. The effective length of the source was 200 mm, and its height 2.5 mm. The beam intensity was regulated by varying the pressure in the source chamber. The molecule beam was perpendicular to the laser resonator axis, since the power peak was due to the particles crossing the light beam at right angle.

The laser amplifying tube was filled with a mixture of helium and neon at a partial-pressure ratio 20:1 and a total pressure 5.4 Torr. The use of the natural mixture of the isotopes Ne^{20} and Ne^{22} at this pressure makes it possible to align the peak of the gain line with the $\nu_3[P(7)]$ transition of the methane molecules [3]. The field density inside the resonator was chosen experimentally to obtain optimal saturation of the observed molecular transition. The laser output intensity was dependent on the generation frequency. The generation frequency was scanned by varying the resonator length with piezoceramic cylinders on which the laser mirrors were fastened.

A very narrow resonant power peak was reliably registered in the laser output radiation at a total molecule flux 6×10^{17} molecules/sec from the source, and increased with increasing beam intensity. The maximum peak was 0.4% of the total output laser power and corresponded to

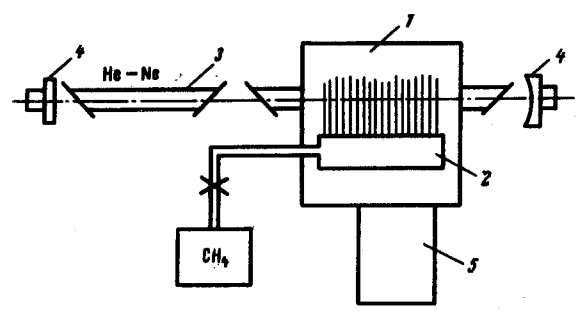

Fig. 1. Block diagram of setup: 1 - vacuum chamber, 2 - molecular beam source, 3 - amplifying tube, 4 - laser mirrors, 5 - vacuum unit.

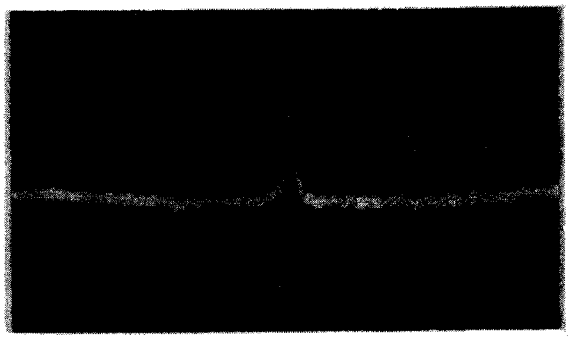

Fig. 2

a flux of (5 - 6) x 10^{18} mol/sec. A typical oscillogram of the laser output intensity is shown in Fig. 2. The total width of the power peak at half-height is about 60 kHz (Q at peak approximately 1.5 x 10^2) and is practically independent of the intensity of the molecular beam. In our case, the resonance width was determined by the time of interaction of the molecules with the electromagnetic field.

It must be emphasized that the use of a molecular beam instead of a gaseous medium makes it possible to obtain a much more contrasty power peak, for in the case of a molecular beam the number of molecules resonantly interacting with the field is much larger at the same number of particles per cm^3. The relative magnitude of the power resonance can be greatly increased (compared with the present experiment) by using a more perfect beam source and a vacuum system with greater productivity.

We note that observation of the saturation effect in the absorption line of the molecular beam is possible also with other molecules having small radiative widths and having a transition frequency that falls in the laser generation region, for example saturation of the absorption line of SF_6 molecules with the radiation field of a CO_2 laser.

A laser with a beam-type nonlinearly-absorbing cell, besides its use as an optical frequency standard, also uncovers possibilities of organizing new experiments in the optical band. For example, experiments are possible where ultranarrow lines are obtained by the Ramsay method [4], or the realization of a laser with two resonators in tandem for the study of the emission features of molecules in a mixed energy state, in analogy with the known experiments in the radio band [5].

In conclusion, the authors are deeply grateful to G. A. Elkin for supplying the vacuum equipment and for valuable advice, and to N. I. Golynskii and I. M. Karasev for help in preparing and performing the experiment.

[1] N. G. Basov and V. S. Letokhov, Usp. Fiz. Nauk 96, 585 (1968) [Sov. Phys.-Usp. 11, 855 (1969)].
[2] J. L. Hall, IEEE J. Quant Electr. QE-4, 638 (1968).
[3] N. B. Koshelevskii, A. F. Mukhamedgalieva, V. M. Tatarenkov, and A. N. Titov, Izmerit. tekhnika No. 8, 38 (1970).
[4] N. F. Ramsay, Molecular Beams, Oxford Univ. Press, 1956.
[5] N. G. Basov, A. N. Oraevskii, G. M. Strakhovskii, and V. M. Tatarenkov, Zh. Eksp. Teor. Fiz. 45, 1768 (1963) [Sov. Phys.-JETP 18, 1211 (1964)].

THRESHOLDS OF TWO-STREAM INSTABILITY OF CURRENT IN A STRAIGHT DISCHARGE

A. I. Karchevskii and Yu. I. Strakhov
Submitted 12 April 1971
ZhETF Pis. Red. 13, No. 11, 595 - 599 (5 June 1971)

If conditions for electron runaway are created in a strong-current straight discharge, then an instability is excited and leads to the transport of the entire discharge current by