is determined by the degree to which the frequency of the atomic resonance remains static. A generator of this type can be used as a highly stable optical frequency standard. Another possible application is for the investigation of laser action in substances which cannot be produced in the form of homogeneous large crystals (powders).

The author is deeply grateful to N. G. Basov for support of this work.

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LEVEL POPULATION IN PULSED ARGON-ION LASER

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Submitted 17 January 1967
ZhETF Pis'ma 5, No. 8, 265-269 (15 April 1967)

It is known that the line widths depend essentially on the optical thickness of the emitting layer. In the case of an absorbing medium, the line width increases with increasing optical thickness of the layer. An increase in the optical thickness of a layer of an amplifying medium, i.e., a medium with inverse population, leads to a decrease in the line width. This dependence of the line width on the optical thickness of the layer is used in the present communication to determine the difference in level population in the plasma of a pulsed gas discharge used to obtain generation at the argon-ion lines.

The experimental setup consisted of a glass tube of 100 cm length and 4.5 mm inside diameter, with windows inclined at the Brewster angle. In most experiments, the discharge tube was filled with a mixture of Ar and He. Many experiments were made with pure argon. The gas-discharge tube was fed from a circuit generating rectangular pulses of ~4.5 msec duration and a voltage 5 - 10 kV. The pulse repetition frequency was 40 Hz.

A plot of the charged-particle density, determined from the Stark broadening of the H_β hydrogen line, is shown in Fig. 1. As seen from the figure, the density increased from 0.5×10^{14} to 4×10^{14} cm^{-3} when the current increases from 70 to 200 A. This indicates that the degree of ionization reaches 10% even if we disregard the forcing out of the gas from the capillary (which certainly takes place).

Simultaneous oscillography of the current and of the spontaneous emission or of the current and the generation emission has shown that both the spontaneous emission and the generation occur simultaneously with the current. To the contrary, when the current drops to zero, both the spontaneous and the stimulated emission exist for several microseconds.

Generation was observed at six Ar II lines. The experiment has shown that at a fixed current strength, as the initial pressure of the mixture is decreased from 0.085 to 0.050 Torr (i.e., with increasing E/p), the sequence with which the Ar II lines appear is as follows: λ 4765, 4965, 4880, 4579, 5145, and 5017 Å. This agrees qualitatively with Bennett's hypothesis that the 4p-configuration of Ar II is directly populated from the ground state of Ar I. This conclusion follows from a comparison of the experimental cross sections for the excitation of the upper levels [1] of these lines and from an account of their transition probabilities [2]. An increase the current at a given fixed pressure led to a decrease in the generation intensity of the lines, or to cessation of the generation. This clearly indicated a decrease in the inverse level population, due to an increase in the role of the electron collisions.

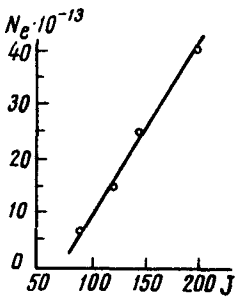

Fig. 1. Charged particle concentration vs. current.

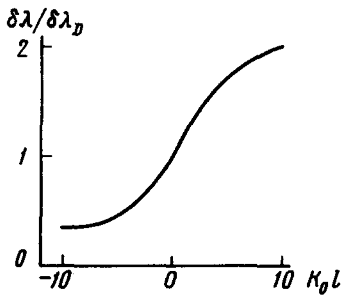

Fig. 2. Line width vs. optical thickness of layer, k_0 - coefficient of absorption at center of line, l - layer thickness. Positive values of $k_0 l$ correspond to absorption, negative ones to amplification.

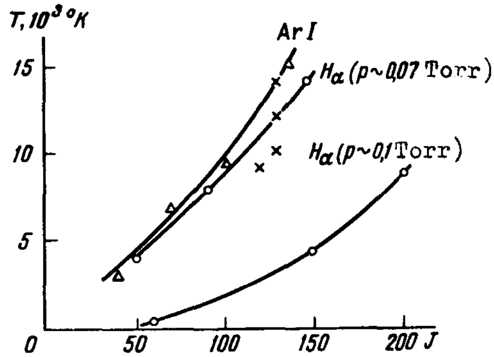

Fig. 3. Gas temperature, determined on the basis of different lines, vs. current: Δ - on basis of Ar I, × - Ar II 5009 Å, o - H_α (for two directions).

A study of the contours of the six Ar II lines in spontaneous emission, the lines being recorded from the end of the tube, has shown that they have a Doppler shape. It has turned out, however, that the three lines 4765, 4965, and 4880 Å, which terminate at the 4s ^2P levels and are observed in generation, yield systematically lower temperatures than the lines 4736, 4848, and 5009 Å, which terminate at the levels 4s ^4P and are not observed in generation. It would be natural to assume that in the case of generating lines, the line widths registered from the end of the tube are decreased as a result of the amplification effect, while those observed in generation are broadened as a result of reabsorption.

If this is the case, then our results can be used to estimate differences in level populations. To this end, Fig. 2 shows a plot of the line width against the optical thickness of the layer for Doppler broadening. The line widths are expressed in units of the Doppler width

$$\delta\lambda_D = 7{,}15 \cdot 10^{-7} \lambda \sqrt{T/\mu}. \tag{1}$$

As seen from the figure, when $k_0 \ell$ is of the order of unity, an absorbing medium leads to a broadening by 40% and an amplifying medium to a narrowing by 30%. To determine $k_0 \ell$ for each transition with the aid of Fig. 2, it is necessary to know $\delta\lambda_D$.

For this purpse, the gas temperature T_2 was determined from the broadening of the lines H_α (registration from the side) and Ar I (registration from the end). The measurement results are shown in Fig. 3. It has turned out that the ion temperature, determined from the λ 5009 Å Ar II line, also agrees satisfactorily with the temperature T_2. Therefore we used for T_2, in the data reduction, the value determined from the λ 5009 Å Ar II line. This is natural, since this line has the lowest transition probability of all the investigated lines and therefore its width is least distorted by reabsorption.

After determining the value of $\delta\lambda/\delta\lambda_D$ from the measured line widths, and the values of $k_0 \ell$ with the aid of Fig. 2, we could determine the difference $(N_i/g_i - N_k/g_k)$ in the expression

$$K_0 = \frac{2e\sqrt{\pi \ln 2}}{mc} \frac{\lambda^2}{\delta\lambda_D} f_{ik} g_i (N_i/g_i - N_k/g_k) . \qquad (2)$$

The results of the values determined in this manner are listed in the table. As seen from the table, the inversion density for the three generating lines is of the order of 10^9 cm^{-3} and decreases with the current J in almost all cases (see the table). For the lines which are not observed in generation, the population of the lower level is larger than the population of the higher level by 10^9 cm^{-3}, and this difference increases with increasing current.

T a b l e

Difference of level populations for Ar II lines

		$N_k/g_k - N_i/g_i$			
λ, Å	Transitions	$J = 120\,a$	$J = 230\,a$	$J = 140\,a$	$J = 160\,a$
4880	$4p\,^2D_{5/2} - 4s\,^2P_{3/2}$	$1{,}5 \cdot 10^9$	$8{,}6 \cdot 10^8$	$3{,}8 \cdot 10^8$	no inversion
4765	$4p\,^2P_{3/2} - 4s\,^2P_{1/2}$	$2{,}3 \cdot 10^9$	$2{,}1 \cdot 10^9$	$1{,}9 \cdot 10^9$	$1{,}3 \cdot 10^9$
4965	$4p\,^2D_{3/2} - 4s\,^2P_{1/2}$	$2{,}0 \cdot 10^9$	$4{,}6 \cdot 10^9$	$7{,}5 \cdot 10^8$	no inversion
		$N_i/g_i - N_k/g_k$			
4736	$4p\,^4P_{3/2} - 4s\,^4P_{5/2}$	$9{,}6 \cdot 10^8$	$1 \cdot 10^9$	$3{,}4 \cdot 10^9$	$4{,}2 \cdot 10^9$
4848	$4p\,^4P_{1/2} - 4s\,^4P_{3/2}$	$7{,}5 \cdot 10^8$	$2{,}2 \cdot 10^9$	$2{,}4 \cdot 10^9$	$2{,}7 \cdot 10^9$

Our data on the inverse population of the generating lines agrees with the results of Bennett [1] concerning the level populations in a cw laser and with the values of the gain obtained by him for a pulsed laser [3].

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ROLE OF MAGNETIC BREAKDOWN IN GALVANOMAGNETIC PHENOMENA

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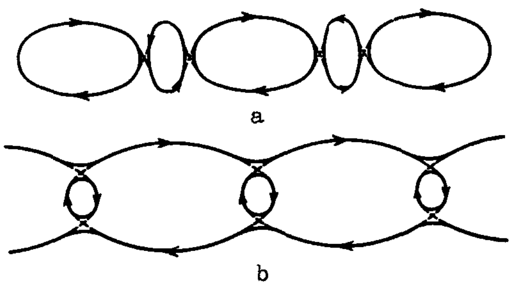
Submitted 17 January 1967
ZhETF Pis'ma 5, No. 8, 269-271 (15 April 1967)

As is well known, magnetic breakdown, occurring in relatively weak fields [1,2], changes the character of electron trajectories in a magnetic field. This circumstance can exert an appreciable influence on the dependence of the components of the electric conductivity tensor on the magnetic field [3,4]. Naturally, the role of magnetic breakdown is most important in those cases when a closed trajectory turns into an open one or vice-versa (see the figure).



We shall henceforth assume that breakdown results in open trajectories (Fig. a). In the opposite case (Fig. b) it is simply necessary to move from stronger to weaker fields.

In constructing a theory for galvanomagnetic phenomena with allowance for breakdown, Falicov and Sievert [5] started from the following assumptions: 1) The system of electron trajectories is strictly periodic; 2) the breakdown between classical trajectories is described by a probability p - the relation between the phases of the quasiclassical wave functions on neighboring trajectories was not taken into account.

We note that the first assumption is satisfied only for strictly fixed directions of the magnetic field. A slight tilt of the latter changes greatly the character of the trajectories. As to the second assumption, it has applicability limits which were not stipulated by the authors of [5]. Indeed, a connection between the quasiclassical sections of the trajectories denotes that breakdown can result in a certain quantum nonlocalized state, similar to the band state in a crystal lattice [6,7]. In this case, in calculating the galvanomagnetic characteristics it is necessary to start from a new band structure, the parameters of which depend essentially on the breakdown probability and on the relation between the phases of the wave functions on the quasiclassical sections of the trajectories. Estimates show [7] that the conductivity-tensor component perpendicular to the direction of the open section is of the order of $p^2\sigma_0$ (σ_0 - electric conductivity at H = 0), and the corresponding resistance-tensor component increases quadratically with the magnetic field.