This solution is similar to that obtained for a fixed phase, and leads to the same estimates as in (7).

4. In conclusion we present a rough estimate, which illustrates the role of the interaction under consideration for the most unfavorable case, when the ellipticity is quite small (e.g. in (7)). Assuming that the dimension L of the object is equal to the path ct on which the ellipse rotates through $\pi/2$, we can estimate the minimum degree of ellipticity W_1/W_2, starting with which the effect becomes significant. For the Crab nebula, for example, with $W_1 = W_2 = 5$ eV/cm^3 at $\lambda = 2\pi c/\omega \sim 100$ m, $L = 10^{19}$ cm, and $n = 10$ cm^{-3}, we obtain the rather small value $W_1/W_2 \sim 10^{-3}$. An account of this effect becomes even more important for other radio sources with larger emission density, and also in the case of radio wave propagation in the ionosphere, etc.

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1) See [3,4] concerning astrophysical consequences of the decay processes described by this current.

2) We assume here for simplicity that all quantities depend only on t. It is easy to go over to the case when all quantities depend on x, by substituting x/c for t.

3) $\vec{E}_K = \vec{e}_{1K}E_{1K} + \vec{e}_{2K}E_{2K}$, where $\vec{e}_{1K}$ and $\vec{e}_{2K}$ are two unit polarization vectors perpendicular to $\vec{K}$.

4) For random waves, the characteristic time τ of nonlinear interaction should satisfy the condition $\tau \gg 1/\Delta\omega$, where $\Delta\omega$ is the width of the wave spectrum.

INVESTIGATION OF ELECTRON COLLISIONS WITH EXCITED NEON ATOMS

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Submitted 6 December 1965
ZhETF Pis'ma 3, No. 3, 110-114, 1 February 1966

To solve various physical problems connected with high-temperature nonequilibrium plasma (low-pressure gas discharge, lasers, ionosphere, astrophysical problems, etc.) it is necessary to know the effective cross sections for excitation and de-excitation of the atoms as they collide with electrons. The available experimental data pertain exclusively to transitions from

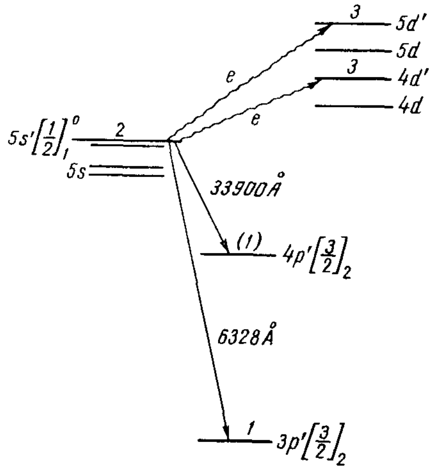

Fig. 1

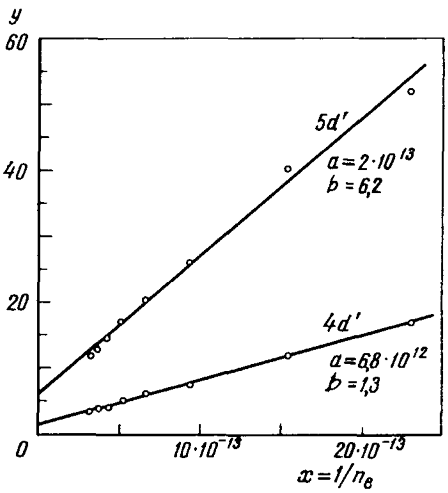

Fig. 2

the ground state; for transition between excited states, in view of the many experimental difficulties, there are no data whatever. The lack of experimental data makes it likewise impossible to evaluate the applicability of various theoretical computation methods [1] to collisions with excited atoms. Gas lasers offer the required information regarding such collisions.

Let us consider a concrete case of a helium-neon laser. The resultant emissions, for example from the transition Ne $5s'[\frac{1}{2}]_1^0 \rightarrow 3p'[\frac{3}{2}]_2$, $\lambda = 6328$ Å, leads to changes ΔN_2 and ΔN_1 of the populations N_2 and N_1 of levels 2 and 1 (Fig. 1). Periodic interruption of the generation (modulation) causes the populations N_2 and N_1 to be modulated with opposite phases, since the signs of ΔN_2 and ΔN_1 are opposite. The intensities of the spontaneous lines that begin from the levels 2 and 1 are modulated together with N_2 and N_1. If any level 3, which does not participate in the generation, is coupled to levels 1 or 2 by collisions or by a spontaneous transition, then the population N_3 should be modulated, and its phase should coincide with the phase of the level (1 or 2) with which the level 3 is coupled.

Such a modulation of the population of the levels that do not participate in the generation was observed experimentally [2-4]. In [2] there was observed modulation of the Ne levels 4s' and 4s, which are close to the upper level $4s'[\frac{1}{2}]_1^0$ of the $\lambda = 1.15\ \mu$ transition. This modulation is due to atom-atom collisions. The cross sections of one of such processes (Ne($4s'[\frac{1}{2}]_1^0$) $\xrightleftharpoons{\text{Ne,He}}$ Ne($4s'[\frac{1}{2}]_0^0$)) were measured in [3]. Electronic collisions of the type

$$\text{Ne}\ (5s'[\tfrac{1}{2}]_1^0) + e \rightleftharpoons \text{Ne}\ (nd') + e \tag{1}$$

were observed in [4] besides the atom-atom collisions with Ne $5s'[\frac{1}{2}]_1^0$ for generation at the transition with $\lambda = 6328$ Å and $3.39\ \mu$ (Fig. 1). We present here the results of an investigation of the process (1) for $n = 4$ and 5.

An analysis of the population balance at levels 3 (nd') in the presence and in the absence of generation yields the following formula for the ratio of the measured modulation signals $y = \Delta I_2/\Delta I_3$:

$$y = M_{23} \left(\frac{W_3^R}{S_{23}^e} + \frac{S_3^e}{S_{23}^e} \right); \qquad M_{23} = \frac{A_2}{A_3} \frac{H_2 \nu_2}{H_3 \nu_3} \tag{2}$$

Here A_2, A_3, H_2, H_3, ν_2, and ν_3 are respectively the transition probabilities, the conversion coefficients of the registration system, and the frequencies for the lines at which the measurements are made, S_{23}^e is the probability of the transition $2 \to 3$ in electronic collisions, S_3^e is the total probability of transitions from the level 3, brought about by electronic collisions, and W_3^R is the total probability of all transitions, not connected with electronic collisions from the level 3. Inserting the expression for the transition probability in collisions, $S_{ik}^e = n_e \langle \sigma_{ik}^e v_e \rangle$, and denoting

$$a = M_{23} \frac{W_3^R}{\langle \sigma_{23}^e v_e \rangle}, \tag{3a}$$

$$B = M_{23} \frac{\langle \sigma_3^e v_e \rangle}{\langle \sigma_{23}^e v_e \rangle}, \tag{3b}$$

we find that the measured quantity

$$y = ax + b \tag{4}$$

is linear in $x = 1/n_e$. This simple relationship is obtained under the following assumptions: (i) The excitation rate Q_3 is assumed independent of the generation; (ii) the atom-atom collisions of the type $2 \rightleftarrows 3$ are excluded from consideration (this is justified when $\Delta E_{23} \gg kT_a$); (iii) the contribution of the electronic collisions of the type $1 \rightleftarrows 3$ is assumed negligibly small; (iv) all cascade processes of the type $2 \rightleftarrows j \rightleftarrows 3$ are excluded from consideration. A criterion for the suitability of this model should be the experimental relation $y = f(1/n_e)$.

From (3) and (4) we get

$$\frac{S_3^e}{W_3^R} = \frac{b}{a} n_e \tag{5a}$$

$$\langle \sigma_{23}^e v_e \rangle = \frac{A_2}{a} \frac{W_3^R}{A_3} \frac{H_2 \nu_2}{H_3 \nu_3} \tag{5b}$$

Thus, the method described enables us to determine important parameters of collision between electrons and excited atoms directly from formulas (3) - (5).

Processes (1) were investigated in a helium-neon laser generating the 6328 Å line. The inside diameter of the discharge tube was 3 mm and the mixture pressure ~1 torr at a Ne/He ratio ≈ 1:7. The discharge current was varied from 10 to 75 mA (the corresponding change in n_e was from 4.3×10^{11} to 3.25×10^{12} cm^{-3}). The electron temperature was $T_e \approx 7$ eV. Figure 2 shows the experimental plots for the Ne levels 4d' and 5d'. The table lists the results of calculations based on (5). In formula (5b), $A_2 = A_{6328\,Å} = 8 \times 10^6$ sec^{-1} [5], and $W_3^R/A_3 \gg 1$. The last column lists therefore the lower limits of $\langle \sigma_{23}^e v_e \rangle$. It is possible to obtain exact values of $\langle \sigma_{23}^e v_e \rangle$ if A_2 and W_3^R/A_3 are known (for example, from theoretical calculations). We see from the table that in a helium-neon laser discharge the electronic de-excitation of the d' levels of Ne can play the same role as radiative transitions. Analogous deductions can also be drawn with respect to the role of electronic collisions in the de-excitation of the Ne

Ne levels	Distance from $5s'[\frac{1}{2}]^{o}_{1}$		S^{e}_{3}/W^{R}_{3}		$\langle \sigma^{e}_{23} v_e \rangle$
	cm^{-1}	eV	i = 10 mA	i = 75 mA	cm^3/sec
4d'	1150	0.14	0.084	0.64	$\gg 6 \times 10^{-7}$
5d'	3630	0.45	0.13	1.0	$\gg 1.5 \times 10^{-7}$

$T_e \approx 7$ eV; $j \approx 2.5$ A/cm^2 and $n_e = 3.25 \times 10^{12}$ cm^{-3} when i = 75 mA.

level $5s'[\frac{1}{2}]^{0}_{1}$.

The described experiments show that even a relatively simple model with a linear dependence $y = f(1/n_e)$ is valid in some cases. These cases can be used for a direct determination of the effective cross sections of individual electronic processes. By making the model more complicated we can extend the range of applicability of the method.

The author is grateful to S. G. Rautian and G. G. Petrash for valuable discussions.

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OBSERVATION OF QUANTUM SIZE EFFECTS IN THIN BISMUTH FILMS

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Submitted 10 December 1965
ZhETF Pis'ma 3, No. 3, 114-118, 1 February 1966

It is well known [1] that quantum effects should be manifest in the behavior of the carriers in semiconductor and metal films whose thickness (d) is comparable with the effective wavelength (λ) of the carriers. In particular, the kinetic and galvanomagnetic coefficients should oscillate when the film thickness is changed. These oscillations are analogous to the oscillations of the same quantities in a quantizing magnetic field. The effects indicated are particularly strongly pronounced at low temperatures.

To observe these quantum size effects it is necessary, besides satisfying the condition $\lambda/d \geq 1$, that the mean free path of the carriers (ℓ) be larger than the film thickness. It is natural to choose for the investigations a material with specular scattering of the carriers from the film boundaries.