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SELECTIVE EXCITATION OF NEON ATOMS UPON ADDITION OF HELIUM

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In the work of White and Rigden ([1]) it was noted that the neon transition line $3s_2$—$2p_4$ at $\lambda\,6328$ Å is greatly intensified when helium is added. This indicates that the population of the neon level $3s_2$ increases.

The increase in the population of the $3s_2$ level may be explained either by collisions of metastable helium atoms with neon atoms in the process

$$\mathrm{He}(2^1s) + \mathrm{Ne} \rightarrow \mathrm{Ne}(3s_2) + \mathrm{He}, \tag{1}$$

or by facilitation of excitation of the $3s_2$ level through collisions of normal neon atoms with electrons:

$$\mathrm{e} + \mathrm{Ne} \rightarrow \mathrm{Ne}(3s_2) + \mathrm{e}. \tag{2}$$

It is not known to us which of these two processes plays the more important role. As Bennett found ([2]), in some analogous processes both reactions play an equal role:

$$\mathrm{He}(2^3s) + \mathrm{Ne} \rightarrow \mathrm{Ne}(2s_2) + \mathrm{He}, \tag{3}$$

$$\mathrm{e} + \mathrm{Ne} \rightarrow \mathrm{Ne}(2s_2) + \mathrm{e}, \tag{4}$$

whereas in processes (1) and (2) this cannot be determined, since the decay time of the population (2^1s) is shorter than the electron heating time.

Since the number of neon states close to $\mathrm{He}(2^1s)$ is greater than in the case of $\mathrm{He}(2^3s)$, it is of considerable interest to consider other transitions from these states.

Fig. 1. Change in the intensity of the 6401 Å line $(\mathrm{He} + \mathrm{Ne}\ (10:1))$ *with time at absolute pressures of 0.6 mm (1) and 3 mm (2).*

This question is the subject of the present work. For the experimental study, a discharge tube 1 m long and 7 mm in diameter was used. It was powered by direct current of 35 mA at a voltage of 1.1 kV. The radiation from the tube was directed onto the slit of a DFS-3 spectrograph with high resolving power. At the exit of the spectrograph, the signal was recorded by an FEU-22 and amplified by a narrow-band amplifier. The spectrum was recorded with an EPP-09 self-recording instrument.

The measurement results are presented in Table 1, where the amplification coefficient is defined as the ratio of the line intensities in the case of a helium-neon mixture to the intensity in the case of pure neon at the same pressure (He + Ne (1 : 1), 0.6 mm Hg).

Table 1

λ, Å	Transitions in Paschen notation	Transitions in Racah notation	Enhancement coefficient
5939	$3s_2$—$2p_8$	$5s'[1/2]^0_1$—$3p[2^1/2]_2$	
6046	$3s_{2,3}$—$2p_7$	$5s'[1/2]^0_{1,0}$—$3p[1^3/2]_1$	
6118	$3s_2$—$2p_6$	$5s'[1/2]^0_1$—$3p[1^1/2]_2$	
6294	$3s_2$—$2p_5$	$5s'[1/2]^0_1$—$3p'[1^1/2]_1$	
6328	$3s_2$—$2p_4$	$5s'[1/2]^0_1$—$3p'[1^1/2]_2$	
6352	$3s_2$—$2p_3$	$5s'[1/2]^0_1$—$3p[1/2]_0$	
6401	$3s_2$—$2p_2$	$5s'[1/2]^0_1$—$3p'[1^1/2]_1$	
6214	$3s_4$—$2p_8$	$5s[1^1/2]^0_1$—$3p[2^1/2]_2$	
6410	$3s_4$—$2p_6$	$5s[1^1/2]^0_1$—$3p[1^1/2]_2$	
5690	$3s_5$—$2p_{10}$	$5s[1^1/2]^0_2$—$3p[1/2]_1$	
6182	$3s_5$—$2p_9$	$5s[1^1/2]^0_2$—$3p[2^1/2]_3$	
6247	$3s_5$—$2p_8$	$5s[1^1/2]^0_2$—$3p[2^1/2]_2$	
6445	$3s_5$—$2p_6$	$5s[1^1/2]^0_2$—$3p[1^1/2]_2$	
6314	$3s_3$—$2p_5$	$5s'[1/2]^0_0$—$3p'[1^1/2]_1$	
5919	$4d_3$—$2p_7$ $4s_1$—$2p_3$	$4d[1^1/2]^0_2$—$3p[1^1/2]_1$ $4d'[1^1/2]^0_1$—$3p[1/2]_0$	
5988	$4d_3$—$2p_6$	$4d[1^1/2]_2$—$3p[1^1/2]_2$	
5872	$4s''_1$, $4s'''_1$—$2p_5$	$4d[1^1/2]^0_2$, $4d'[2^1/2]^0_2$—$3p[1^1/2]_1$	
5965	$4s''_1$—$2p_2$	$4d'[1^1/2]^0_2$—$3p'[1/2]_1$	
5914	$4d_2$—$2p_7$	$4d[1^1/2]^0_1$—$3p[1^1/2]_1$	
6001	$4d_2$—$2p_6$	$4d[1/2]^0_1$—$3p[1^1/2]_2$	
5764	$4d_4$, $4d'_4$—$2p_9$	$4d[3^1/2]^0_{3,4}$—$3p[2^1/2]_3$	
5820	$4d_4$—$2p_8$	$4d[3^1/2]^0_3$—$3p[2^1/2]_2$	
5992	$4d_4$—$2p_6$	$4d[3^1/2]^0_3$—$3p[1^1/2]_2$	
5804	$4d''_1$, $4d'_1$—$2p_8$	$4d[2^1/2]^0_{2,3}$—$3p[2^1/2]_2$	
5945	$2p_4$—$1s_5$	$3p'[1^1/2]_2$—$3s[1^1/2]_2$	
6143	$2p_6$—$1s_5$	$3p[1^1/2]_2$—$3s[1^1/2]_2$	
6334	$2p_8$—$1s_5$	$3p[2^1/2]_2$—$3s[1^1/2]_2$	
6096	$2p_4$—$1s_4$	$3p'[1^1/2]_2$—$3s[1^1/2]_1$	
6678	$2p_4$—$1s_2$	$3p'[1^1/2]_2$—$3s'[1^1/2]_1$	
6305	$2p_6$—$1s_4$	$3p[1^1/2]_2$—$3s[1^1/2]_1$	
6929	$2p_6$—$1s_2$	$3p[1^1/2]_2$—$3s'[1^1/2]_1$	
6506	$2p_8$—$1s_4$	$3p[2^1/2]_2$—$3s[1^1/2]_1$	
7174	$2p_8$—$1s_2$	$3p[2^1/2]_2$—$3s'[1^1/2]_1$	
7245	$2p_{10}$—$1s_4$	$3p[1/2]_1$—$3s[1^1/2]_1$	
7032	$2p_{10}$—$1s_5$	$3p[1/2]_1$—$3s[1^1/2]_2$	
5882	$2p_2$—$1s_5$	$3p'[1/2]_1$—$3s[1^1/2]_1$	
6030	$2p_2$—$1s_4$	$3p'[1/2]_1$—$3s[1^1/2]_1$	
6652	$2p_3$—$1s_2$	$3p[1/2]_0$—$3s'[1/2]_1$	
6128	$2p_5$—$1s_4$	$3p'[1^1/2]_1$—$3s[1^1/2]_1$	
6717	$2p_5$—$1s_2$	$3p'[1^1/2]_1$—$3s'[1^1/2]_1$	
6382	$2p_7$—$1s_4$	$3p[1^1/2]_1$—$3s[1^1/2]_1$	

Table 2

λ, Å	Transitions in Paschen notation	Transitions in Racah notation	Enhancement coefficient
6328	$3s_2$—$2p_4$	$5s'[1/2]_1$—$3p'[1^1/_2]_2$	40
6096	$2p_4$—$1s_4$	$3p'[1^1/_2]_2$—$3s[1^1/_2]_1$	2
6678	$2p_4$—$1s_2$	$3p'[1^1/_2]_2$—$3s[1^1/_2]_2$	2
5945	$2p_4$—$1s_5$	$3p'[1^1/_2]_2$—$3s'[1/2]_1$	0.5
6118	$3s_2$—$2p_6$	$5s'[1/2]_1$—$3p[1^1/_2]_2$	40
6305	$2p_6$—$1s_4$	$3p[1^1/_2]_2$—$3s[1^1/_2]_1$	2
6929	$2p_6$—$1s_2$	$3p[1^1/_2]_2$—$3s[1^1/_2]_2$	2
6143	$2p_6$—$1s_5$	$3p[1^1/_2]_2$—$3s[1/2]_1$	0.5
5939	$3s_2$—$2p_8$	$5s'[1/2]_1$—$3p[2^1/_2]_2$	7
6506	$2p_8$—$1s_4$	$3p[2^1/_2]_2$—$3s[1^1/_2]_1$	2
7174	$2p_8$—$1s_2$	$3p[2^1/_2]_2$—$3s[1^1/_2]_2$	2
6334	$2p_8$—$1s_5$	$3p[2^1/_2]_2$—$3s'[1/2]_1$	0.5

It is seen from the table that:

1. In addition to the 6328 Å line (with which a gas laser has been successfully realized), other lines from the $3s_2$ level are also enhanced.
2. Lines from the $3s_3$, $3s_4$, $3s_5$, and $4d$ levels are enhanced, but to a lesser extent.
3. It is interesting to note that the lines of the $2p$—$1s$ transition are enhanced, except for the 5945, 6143, and 6334 Å lines, which are weakened by a factor of 2. These lines have a common lower level and belong to the groups of the 6328, 6118, and 5939 Å lines.
4. Comparing the $3s$—$2p$ and $2p$—$1s$ transitions of the three groups of lines 6328, 6118, and 5939 Å, it may be noted that the influence of He on these transitions has a general character (see Table 2).

In addition to the measurements presented in Table 1, we investigated the dependence of the amplification coefficient on pressure and current strength.

It is interesting to note that, at a certain pressure, the intensity of the 6401 Å line changes strongly with time. It is seen from Fig. 1 that, for the same He : Ne ratio (10 : 1), but at different absolute pressures, the behavior of the intensity of the 6401 Å line with time is entirely different. This question requires further investigation.

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2. W. R. Bennett, Appl. Optics (USA), Suppl. 1 (1962).

Note: Figure translations are in progress. See original paper for figures.