Substituting r_0^* in (3) we obtain the characteristic magnetic field

$$B^* = 1.108 B_c \frac{1 - r_k^2/R_a^2}{\left(\log \dfrac{R_a}{r_k}\right)^{1/2}}. \tag{5}$$

Naturally, the characteristic magnetic field B^* must be lower than B_c. This condition is satisfied only if $r_k/R_a<0.534$.

In our experiments[2] we used the magnetron diode with $R_a=17.5$ mm and $r_0=0.5$ mm, so the ionization phenomena increase at $B^*=0.587\,B_c$.

References

1) P. K. Cibin, 4th Yug. Symp. Phys. Ionized Gases (1968), p. 26;
2) D. Đ. Tošić, Publ. El. Fak. Beograd, **244** (1969).

3.32 Proposed laser application of the gas magnetron discharge

V. I. MILJEVIĆ, *Institute of Nuclear Sciences "Boris Kidrič", Beograd, Yugoslavia*

The behaviour of ionized gas in the cylindrical magnetron diode strongly depends on the intensity of the axial magnetic field. Between collisions the electrons move along cycloidal paths around the cathode, leading to an increase of the collision probability. Thus there is an effective shortening of the electron mean free path, which can be attributed to an apparent increase of the gas pressure. When the magnetic field reaches the critical value $B=B_{cg}>>B_c$, the arc current is cut off, where B_c is the well known cutoff magnetic field for the vacuum case $B_c=(8mU_a/e)^{1/2}/R$ (U_a -anode voltage, R-anode radius).

Spectroscopic investigations were undertaken to get more insight in the state of the ionized gas within the diode[1]. Spectra were registered in a hot cathode magnetron diode, filled with argon, operated in stationary and pulsed regimes, along and across the lines of the magnetic field. Working conditions of a stationary regime were: the anode voltage up to 150 V, the anode current up to 10 A. In the pulsed regime a condenser bank (5 μF, 800 V) was discharged through the magnetron diode. In both cases the cathode heating current was up to 55 A and magnetic field up to 1 kG.

It was found that the spectrum at $B>B_c$ contains only ion lines of argon AII, while atomic spectral lines were not registered, not even with very prolonged exposures. Those results were obtained in a wide pressure region, of the order of

10^{-4}— 1 torr. The dependence of the local values of relative intensity of the ion spectral lines AII 4765, 4847 and 4880 Å on the magnetic field, is presented in Fig. 1 (full lines). The anode current dependence is given by the dashed line. The anode voltage increase leads to considerable change of the intensities of the spectral lines. For U_a=120 V, p=6 · 10^{-4} torr the line AII 4765 Å is more intense than AII 4880 Å. Besides, intensities of the spectral lines depend on the gas pressure. The dependence of the intensities of the spectral lines AII 4880 and 4765 Å on magnetic field at anode voltage, U_a=30 V and p= = 10^{-2} torr, is given in Fig. 2.

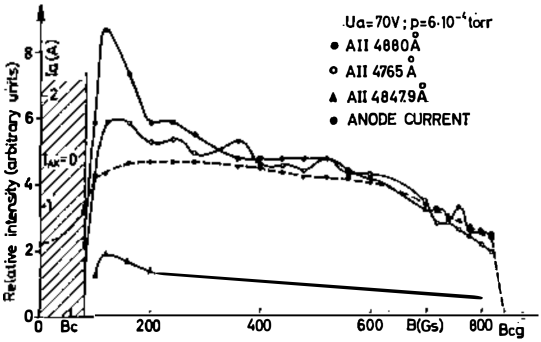

Fig. 1

The spectrum of the pulsed discharge contains the ion spectral lines only (atomic lines were not registered). The optical spectrum contains also very intense lines of ionized oxygen OII, which is present as residual gas. The spectrum contains only the lines in the wave length region λ>3900 Å, which is not the case in the stationary discharge. In table I are presented some of the identified spectral lines, their relative intensities (tabular values), intensities in the spectrum of the pulsed discharge, energies of the upper levels and corresponding transitions. As it can be seen, all spectral lines have 4 p (AII) and 3 p (OII) upper energy levels. We can conclude that the excited ions are obtained in the magnetron discharge by direct collisions of atoms in the ground state with a group of fast electrons (about 36 eV), due to the existence of an unequilibrium velocity distribution. The selective excitation of the relatively small number of energetic levels, with absence of atomic lines, points out to the inverse population in the magnetron discharge. The lines AII 4880, 4765 Å, as well as the lines which are marked by an asterisk in table I are laser transitions.

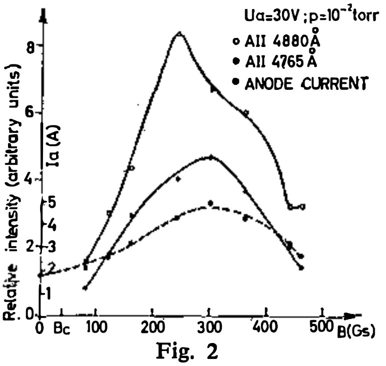

Fig. 2

In conclusion, the gas magnetron diode can be used as an inverse medium. High ion densities (of the order of 10^{13} cm^{-3}, corresponding to full ionization) and the selective excitation of upper laser levels can be achieved. It is possible to enhance certain lines with respect to others using correct combinations of electric and magnetic fields. A large number of high energy electrons participate in the excitation of a relatively small number of energy levels, which results in absence of atomic lines and gas heating and inversion of line intensities, as well as small halfwidth of spectral lines. All this contributies to the high optical efficiency of the discharge[2].

TABLE 1

Spectrum of the pulsed discharge

$p = 5 \times 10^{-4}$ torr, $U_a = 800$ V, $B = 600$ Gs, spectrograph STE-1; 3 rd order spectra w. 1. range 3165—4660 Å; inverse disp. 6.4 Å/mm

spect. line	w. 1. Å	rel. int. I_r	puls. sp. I	E_2 (eV)	transition	J
OII	4347.425*	(6)	2	28.51	$3\,s'^2D$—$3\,p'^2\,D^\circ$	3/2—3/2
AII	4348.063	(50)	2	19.49	$4\,s^4\,P$—$4\,p^4\,D^\circ$	5/2—7/2
OII	4351.269*	(6)	2	28.51	$3\,s'^2\,D$—$3\,p'^2\,D^\circ$	5/2—5/2
AII	4370.751*	(15)	2	21.49	$3\,d^2\,D$—$4\,p'^2\,D^\circ$	3/2—3/2
AII	4371.329	(20)	2	19.26	$3\,d^4\,D$—$4\,p^4\,P^\circ$	5/2—3/2
OII	4414.909*	(10)	4	26.25	$3\,s^2\,P$—$3\,p^2\,D^\circ$	3/2—5/2
AII	4545.045*	(25)	3	19.87	$4\,s^2\,P$—$4\,p^2\,P^\circ$	3/2—3/2
AII	4579.346*	(25)	3	19.97	$4\,s^2\,P$—$4\,p^2\,S^\circ$	1/2—1/2
AII	4609.560*	(25)	4	21.14	$4\,s'^2\,D$—$4\,p'^2\,F^\circ$	5/2—7/2
OII	4649.139*	(10)	3	25.66	$3\,s^4\,P$—$3\,p^4\,D^\circ$	5/2—7/2

Remark: The forth column gives the intensities of the spectral lines in the pulsed discharge by the following: 1-weak, 2-moderate, 3-strong, 4-very strong. The asterisk corresponds to the laser wavelengths.

References

1) V. I. Miljević, Proc. III Yugoslav Symp. on Phys. of Ionized gases, Niš (1966) 81;
2) V. I. Miljević, Phys. Lett. **32** A (1970) 353.

3.33 The interaction of an extraordinary wave with inhomogenous anisotropic plasma column at the lower hybrid resonance

S. S. PEŠIĆ, *Départment de Physique du Plasma et de la Fusion Contrôlée, Service d'Ionique Générale, Centre d'Etudes Nucléaires, Grenoble, France*

Abstract

In the frame of cold plasma theory the interaction of an extraordinary wave with an inhomogeneous anisotropic plasma column at the lower hybrid frequency range is investigated. The linear wave transformation mechanism at the resonant singularity leads to an appreciable energy transfer from the electromagnetic wave to the plasma. The influence of the magnetic field strength, plasma density, effective collision frequency and column dimension on the efficiency of the wave energy transfer is examined in a wide range of their variation. The plasma column exhibits a series of geometric resonances in the medium frequency domain which are characterized by strong wave absorption. The interaction in the high frequency domain gives rise to a marked main resonance in the absorption spectrum. A detailed study of the resonance pattern is carried out and the conditions of its existence are established.