Selection and amplification of separate spectral emission lines in the low-pressure acoustoplasma discharge

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At the modulation of the discharge current in the plasma arise acoustic oscillations, these acoustic oscillations interact with the plasma itself, in which flows modulated current.

At the resonant frequency the discharge tube is formed the acoustic resonator.

In plasma is formed standing waves and acoustic grating – as a result plasma is moved in new- acoustoplasma state in which can behave like as condensed medium.

Change not only the mechanical, electrical and thermodynamic parameters of the plasma. Also change the emission and absorption spectra, ie, chahging the quantum-mechanical parameters in acoustoplasma environment.

This report is dedicated to the optical spectra.

Investigated the emission spectra of discharge by low pressure nitric acoustoplasma in water cooled discharge tube and in magnetron acoustoplasma in helium.

Schematic of the experiment with the discharge tube is shown in Fig.1.

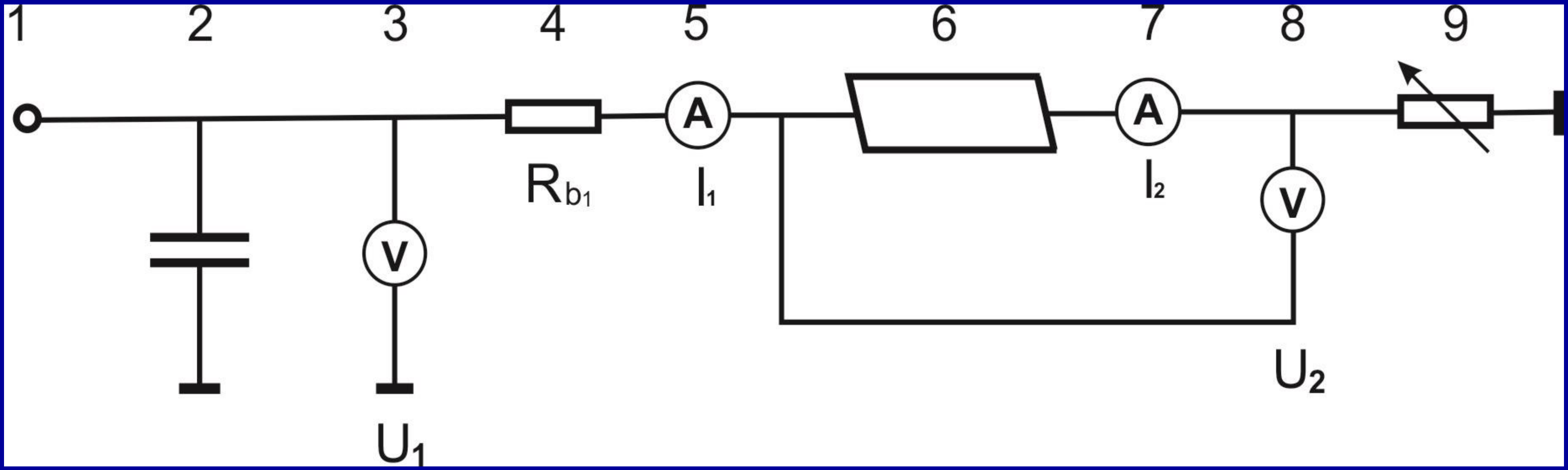
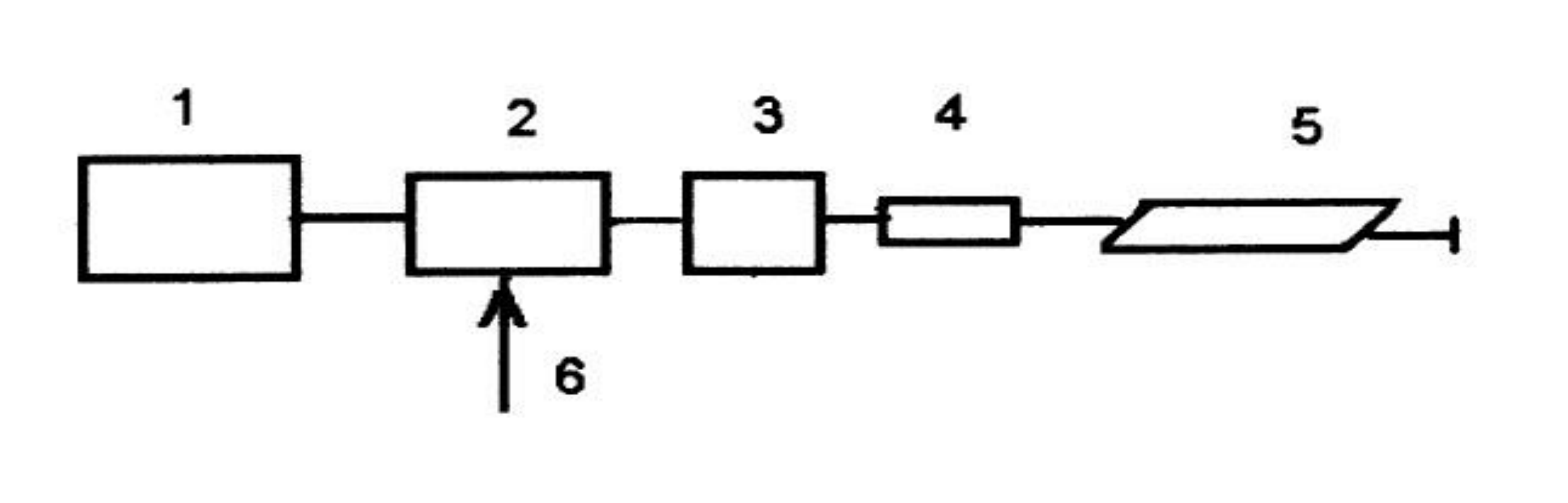


Fig.1

Voltmeter 3 measures the high voltage U1, by the power supply 1 on a capacitor filter 2. Protective ballast resistance 4 limits the maximum current in the circuit. Ammeter 5 shows the current I1, which flows into the anode of the discharge tube 6. Ammeter 7 shows the value of current I2, which flows from the cathode of the discharge tube 6.

Voltmeter 8 shows the voltage U_2 at the anode-cathode-distance of the discharge tube. Variable resistance 9, is assembled on a high-voltage electron lamp and defines the current, which flows from the cathode of the discharge tube. A high capacity capacitor 2 of lfilter provides the closure of the alternating current component in a sequential circuit over the entire range of modulation frequencies of the 9 resistance.

The experiment with the magnetron is shown schematic in Fig.2.



To the control input of the PWM converter 2 is given the modulating frequency 6. Small resistive ballast 4 serves to overload protect the magnetron 5. Multiplier 3 capacitors are selected so, that the high output voltage which supplied to the magnetron 5, comprises a constant and variable components and repeats the shape of the curve modulating signal 6.

The discharge tube had a length of 250mm and inner diametr of 5mm. In experiments with the discharge tube used magnetized and no magnetized plasma. In experiments with the magnetron used plasma with magnetic field. The design of the magnetron in this work is not considered.

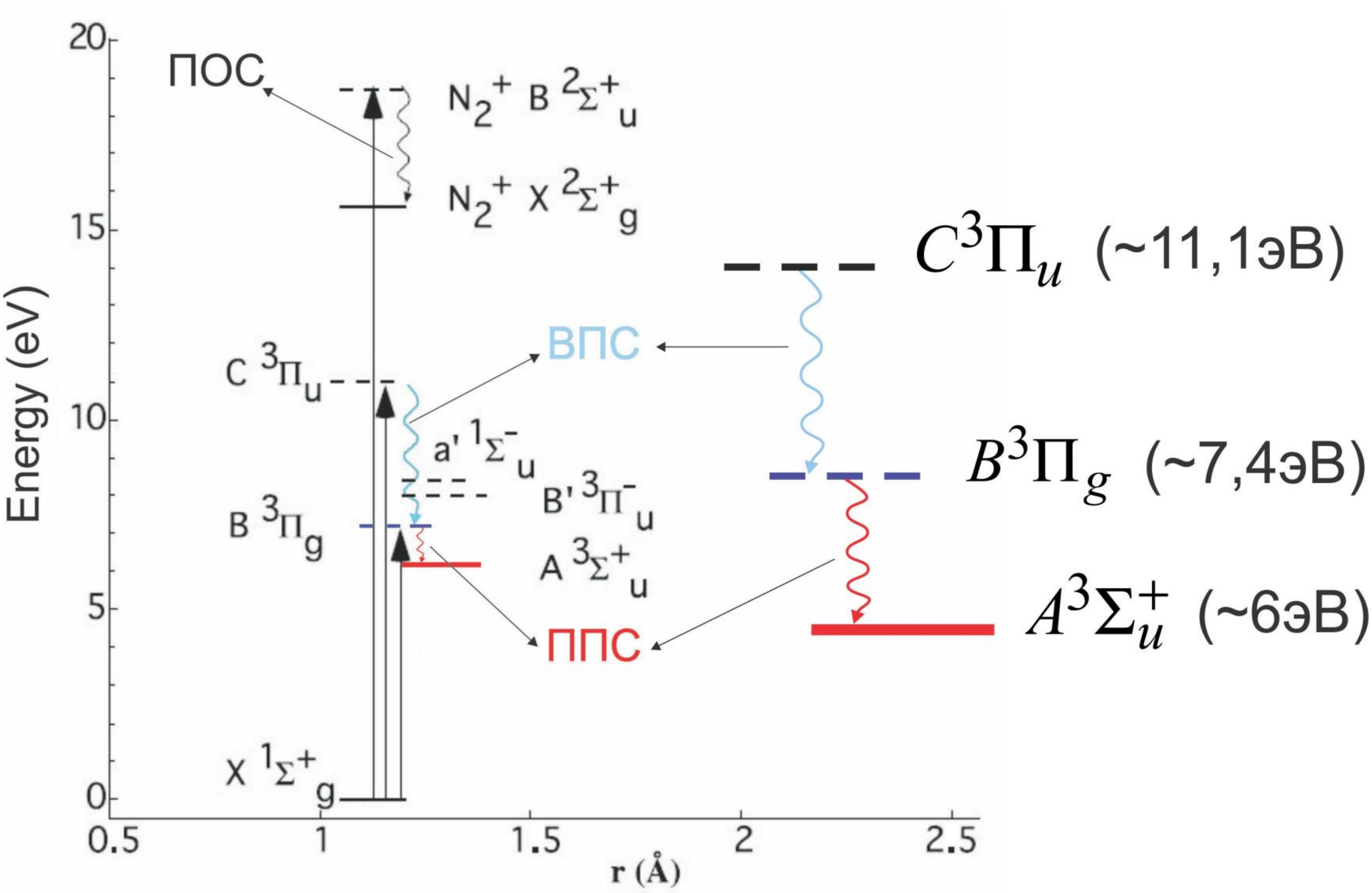
In the experiments with the discharge tube pressure was about 0,1torr. With such a low pressure purely acoustic phenomena are not evident, however acoustoplasma phenomena are not only preserved but also enchanced.

In the experiment with the magnetron chamber pressure was varied from 0,05 to 25torr.

The radiation from the discharge was fed to a spectrometer by the fiber. To measure the optical spectra used computer spectrometer OCEAN OPTICS 2000PC (measurement error ±1nm) and converted Russian spectrometer ISP-51. Was made the new output tube, the focal plane with the image projected on a receiving range of CMOS matrix ordinary WEB-camera, without any alteration. The image of the spectrum is displayed. For the mathematical treatment of the spectra used specially designed software. Measurement error <0,1nm.

The next slide shows a diagram of the energy levels and optical transitions in nitrogen.

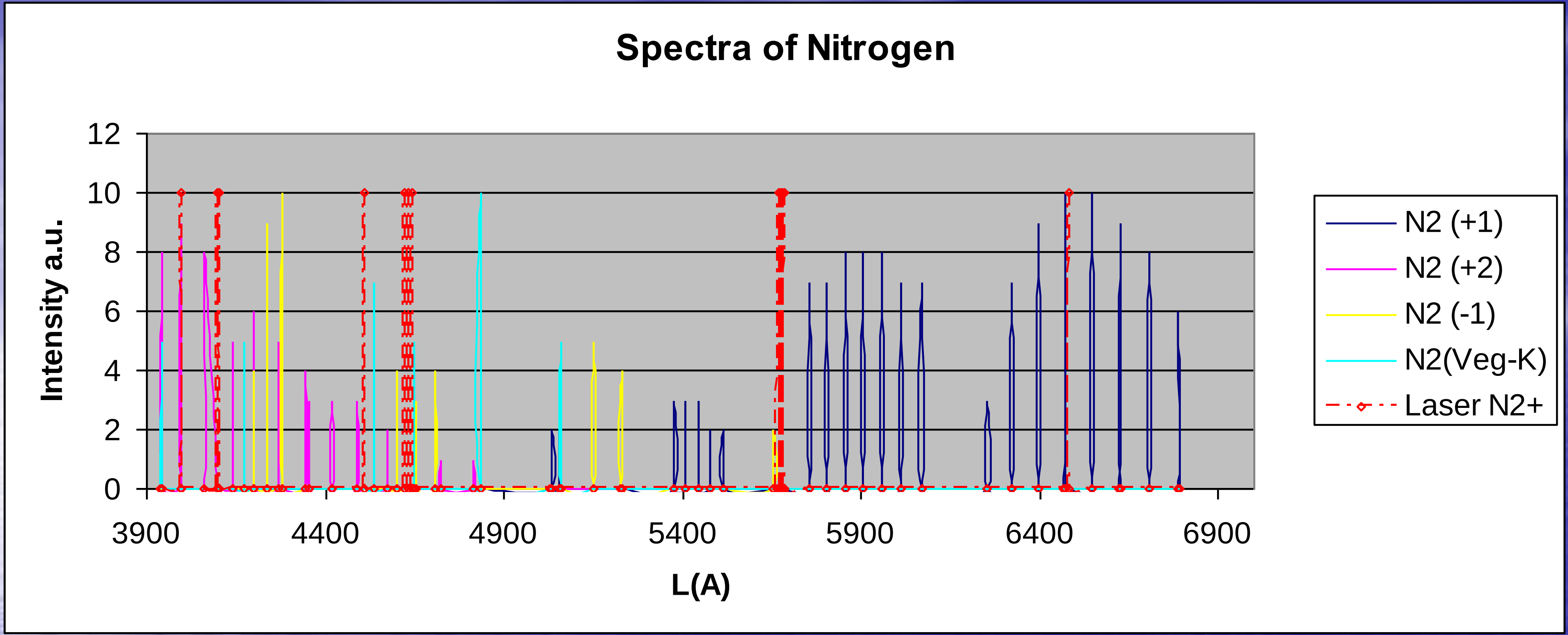
8. Диаграмма уровней азота



ППС-is FPS- first positive system of nitrogen, ВПС-SPS-second positive system, ПОС-FNS-first negative system. FPS and SPS are neutral excited molecule of nitrogen, FNS- to the singly ionized nitrogen molecule.

Right in Figure are shown the transitions with the increase, for readability. The abscisse is the distance between atoms in a molecule of nitrogen, and the ordinate is the energy levels in eV. On the upper levels of excitation molecules are raised, either by direct electron impact-single ionization or stepwise ionization. At a gas pressure 0,1torr available as single and the step ionization. At the pressure greather than 1torr-just step ionization.

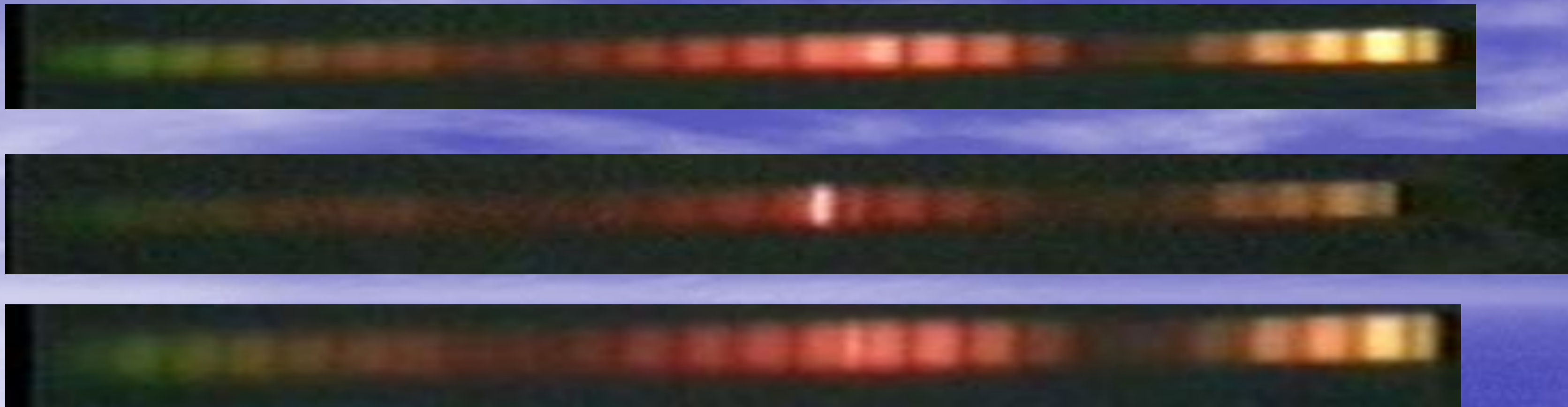
The next slide shows the spectrum of nitrogen in the wavelength range 3900-6800A.



Dark blue- the FPS spectral lines, pink-SPS, yellow-FNS characteristic lines (i.e., not all), blue- lines of band Veghard-Kaplan, red is most powerful laser lines in the ionized nitrogen. Shows that near the 6500A line of FPS neutral nitrogen λ=6468,5A and a line of FNS λ=6482,07A (laser line) are difficult to distinguish, that is, it is difficult to determine is the corresponding

To the neutral molecule, or a single-ionized molecule. Furthemore, it is expected that in addition to λ=6482,07A, due to the spectral banding in the area of the spectrum can occur and other lines of ionized molecules. Therefore, detailed look at FPS.

In next slide, the Fig.5 shows spectrograms of the FPS, obtained in a discharge tube with acoustoplasma at a pressure 0,1torr with upgraded spectrometer ISP-51.



a)

The upper spectrum corresponds acoustoplasma regime without applied magnetic field, modulation

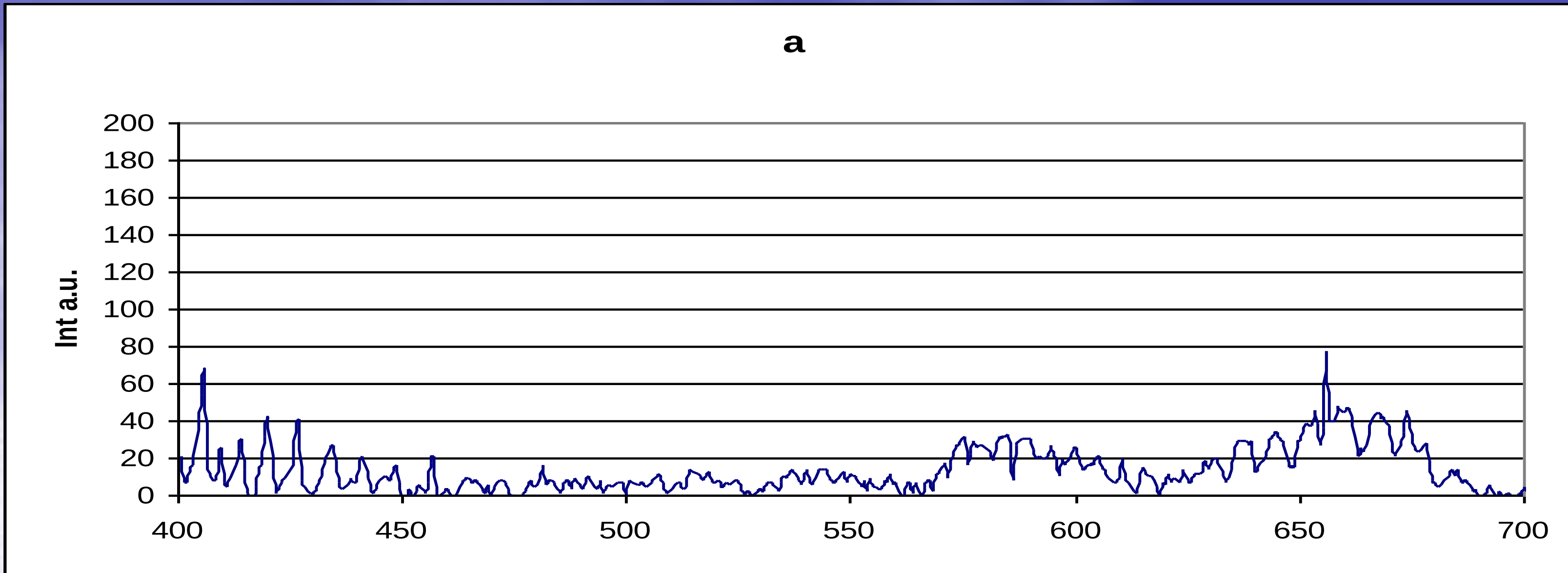
b) frequency=30kHz. The second spectrum corresponds acoustoplasma regime at a magnetic field perpendicular to the discharge, the modulation with

c) two frequencies simultaneously f=200Hz+100Hz. Third spectrum- magnetic field is the same, but the frequency modulation =2kHz+100Hz.We see how the spectra are very different, strong line on the second spectrum.

At a pressure of 0,1torr the mean free path is sufficient for the electron to gain energy for direct ionization of single impact (16eV). Therevor is logical to assume that a strong line corresponds to a molecular nitrogen ion.

To identify the spectral lines similar experiment was carried out at a pressure of 4torr. At this pressure, the mean free path less than 10 mkm and the electrons energy between two suggessive collisions less than 0,2eV, excitation process will be step-ionization, and the probability of radiation in the band FNS is much smaller than for the bandwidth FPS.

Fig.6 shows the spectra of nitrogen acoustoplasma at a pressure of 4torr. Measured by the computer spectrometer OCEAN OPTICS 2000PC.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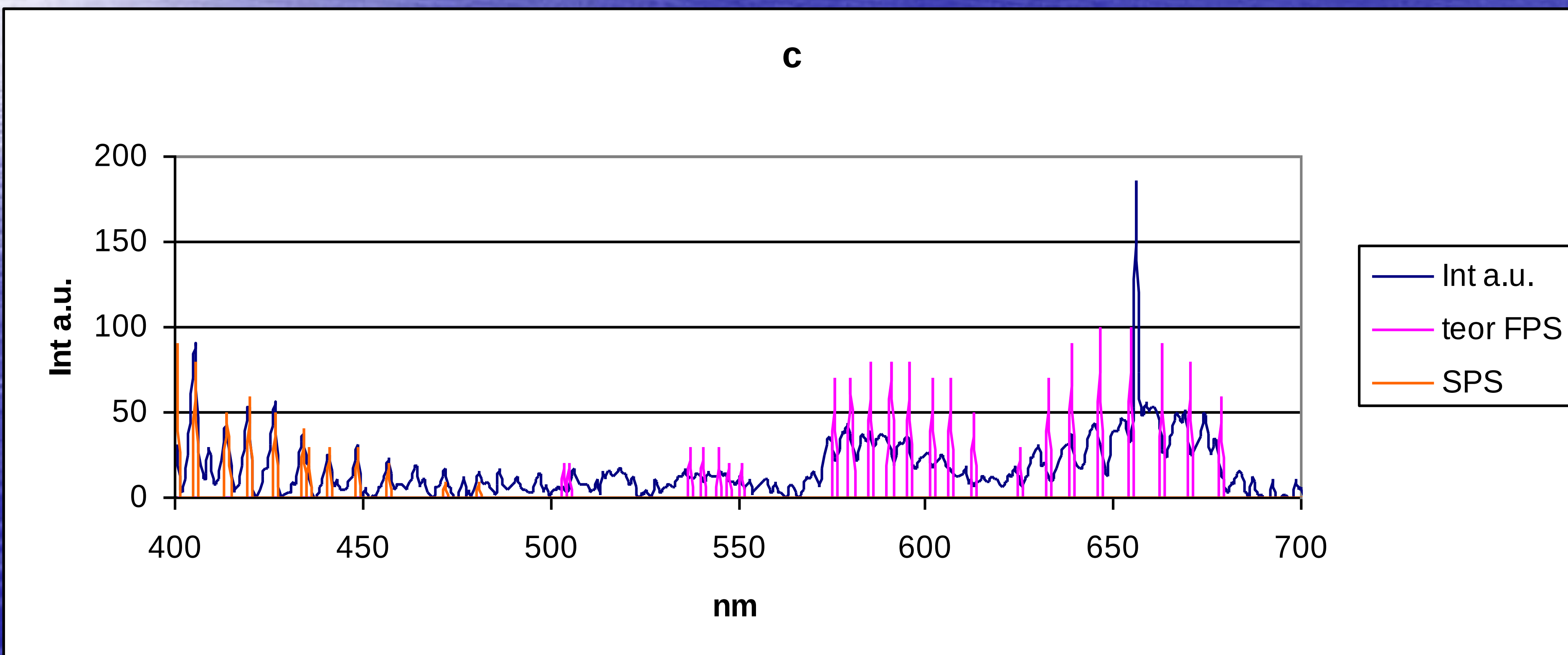
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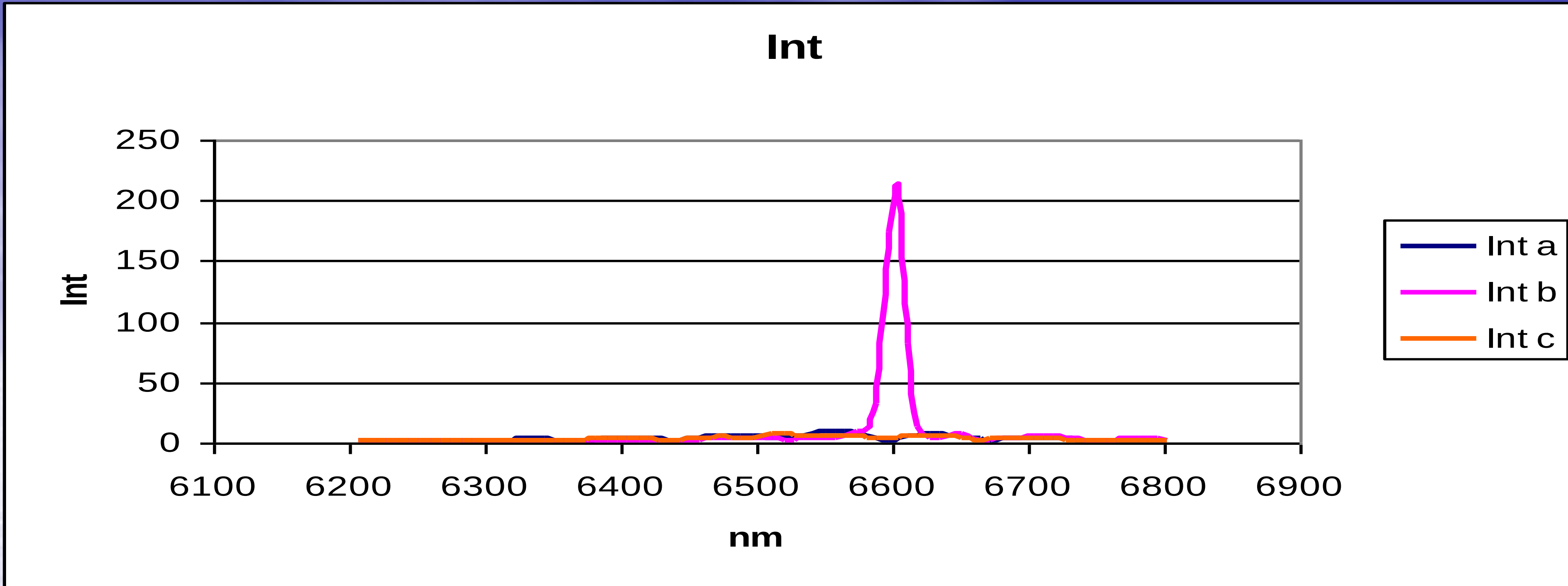
a) DC discharge Io=20mA, c) acoustoplasma Io=20mA, I~20mA,f=20kHz. Overlaid with the theoretical spectrum FPS and SPS. Comparing Fig.6a, and c shows that in AP regime more than 2-fold increased spectral line with the FPS λ≈6545A. . We can also say that the transition to acoustoplasma regime intensity of the lines across the strip FPS is almost unchanged, but at a the same time abrupt increasing a separate line. For the parameters given in Fig.6, the intensity of all the lines of SPS is not changed in the transition to acoustoplsama regime, i.e., the pumping of the upper level of FPS due to radiation SPS has not changed and the intensity of the line is due to acoustoplasmic selection states of the quantum system. If the increased efficiency of the destruction

If the increased efficiency of the destruction of the lower metastable state, it would increase the intensity of the entire band of FPS. Using Tables of spectra, we can say a strong line belongs FPS λ=6548A, using the transition between the vibrational numbers 7-4.

Let us return to the spectrograms shown in Fig.5. Fig.7 shows the spectra corresponding to Fig.5 spectrograms.

Next slied, Fig.7. The spectra corresponding to spectrograms of Fig.5 a and b.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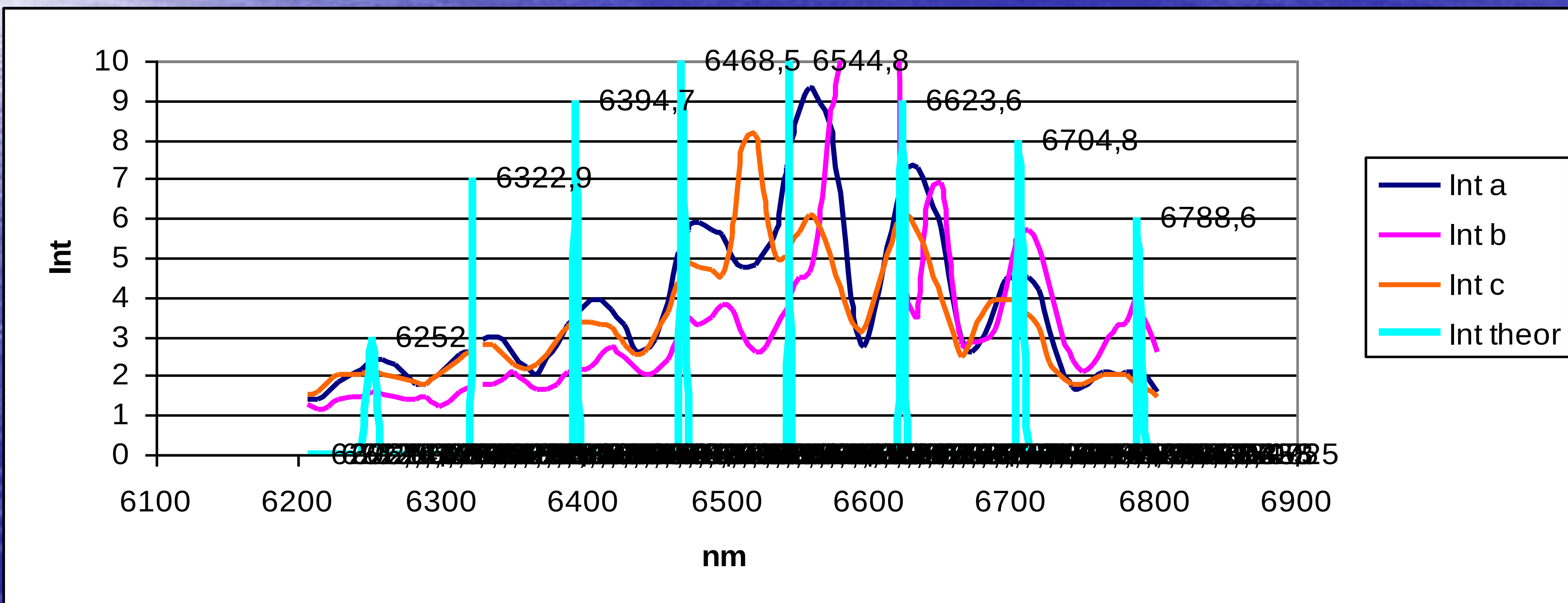
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6788,6
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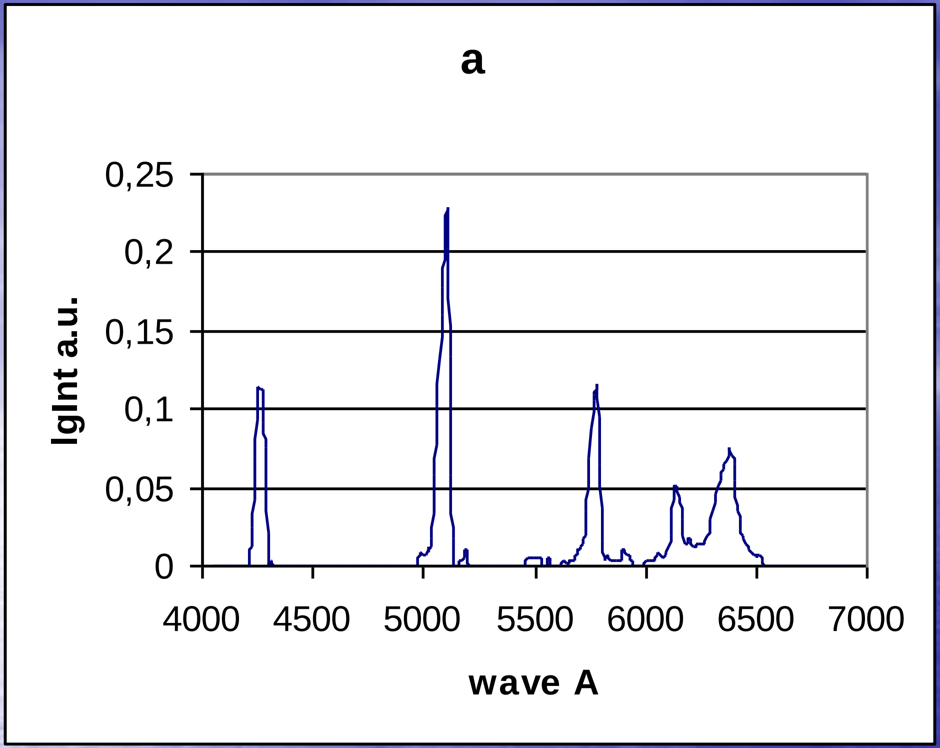
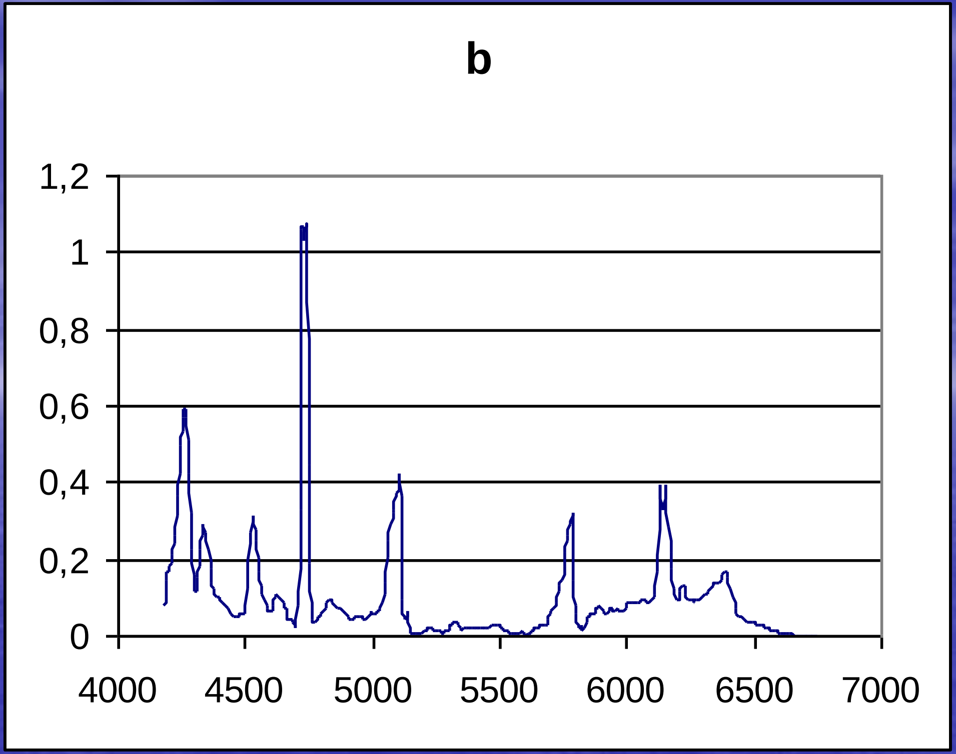
Fig.7A shows that, for case (Fig.5b) obtain one line with a strong intensity in relative units to 20 times greater than for the other cases. Fig.7B shown on the lower part of the spectrum. Blue lines shows the standard emission lines in the band of FPS. Colored lines correspond to the experimentally obtained spectral lines for the cases of Fig.5a, b, c, respectively. Case "a" corresponds to acoustoplasma without magnetic disturbance. We see that only the strong central line 6468,5A (corresponding to the transition between the vibrational quantum numbers 8-5) has a small shift (~10A). For the cases of "b" and "c" have magnetized acoustoplasma. We can see that the edges of the band (6252-6788A) experimental and theoretical lines are the same, but for the strong lines is character shift and narrowing.

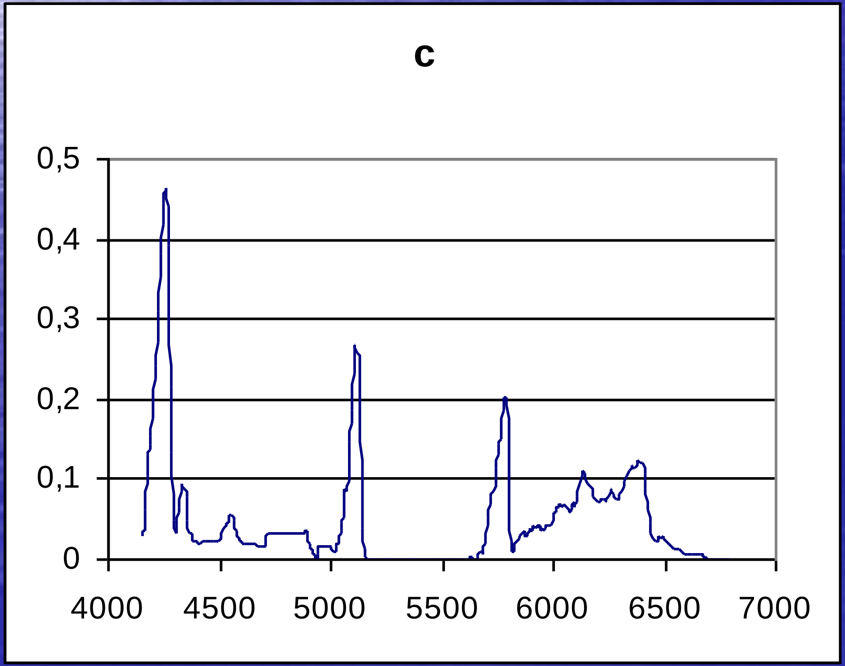
For lines of the vibrational spectrum (without the permission of the rotational spectrum) width of line at half-maximum of intensities is 50-60A. To the narrow down lines 15-30A. A theoretical line of 6544,8A in the experiment shifted to 6600A (at 55A) and 6623,8A line is shifted to 27A. Moreover, the theoretical line of 6623,6A passes through a minimum between adjacent experimental lines. The narrowing of the experimental lines probably due to a modification of the rotational spectrum due to the decrease in the number of degrees of freedom.

Fig.8 shows the spectra of the magnetron acoustoplasma in low-pressure helium discharge.

In the last spectra shows the identification of the lines.



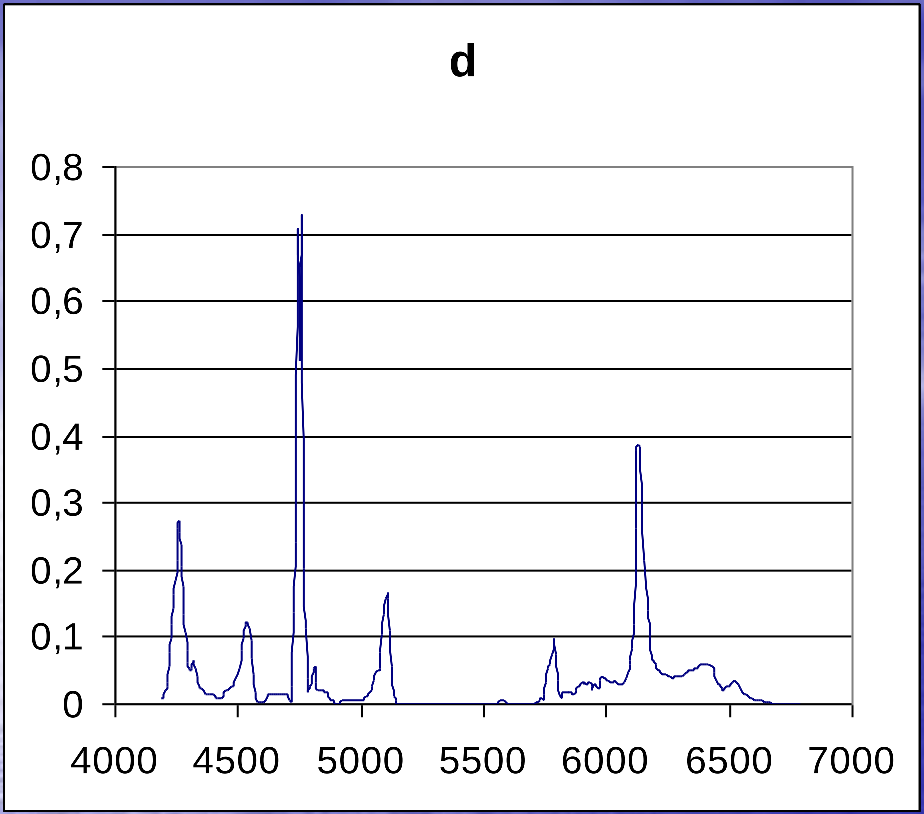


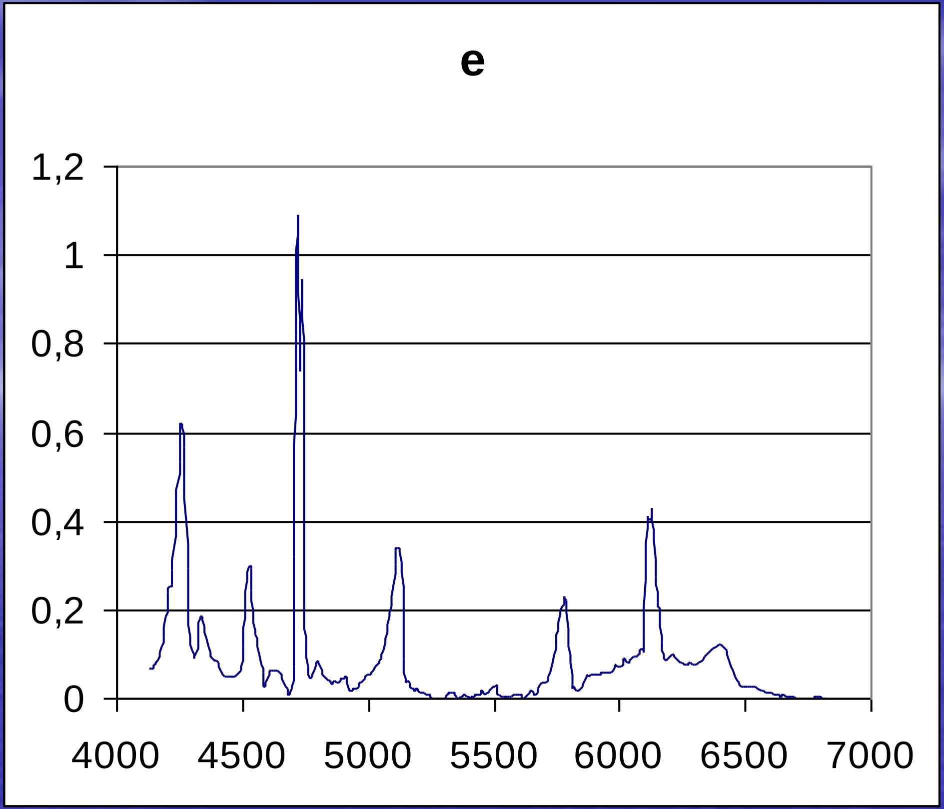


a)He, 0,1torr, DC,Io=80mA

b) f=1kHz, Io=100mA, I~25mA

c)f=10kHz,Io=100mA, I~70mA





d)He, Po=2torr,DC,
Io=100mA

e)He,2torr, f=10kHz
Io=150mA, I~50mA

The ordinate axis logarithms intensity (in arbitrary units). By the logarithmic scale we can see all the lines and strong, and weak.

We see that the intensity of the Cooper lines are everywhere around 0,1-0,2. The intensity of the lines of molecular helium is strongly dependet on the discharge regime. And in acoustoplasma regime can be more or less than the in DC discharge.

- Thus we have shown the possibility of selection of the individual lines of molecular bands by selecting the discharge regime.

THANKS
FOR
ATTENTION