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FINE STRUCTURE OF THE DISTRIBUTION FUNCTION OF AN ELECTRON BEAM INTERACTING WITH A PLASMA

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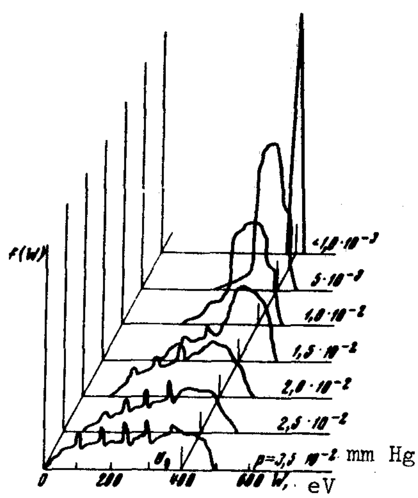
Most reported [1 -3 and others] measurements of the distribution function of an electron beam interacting with a plasma were made by the decelerating-field method, which is known to have low resolution. We have used in the present investigation for the analysis of the energies a cylindrical capacitor with a resolution of about 1%, as a result of which we were able to observe the fine structure of the distribution function against the background of the produced plateau.

The investigations were carried out with an electron beam of 5 mm diameter, and a current 10 - 20 mA; the accelerating voltage could be varied from 300 to 1200 V. The measurements were performed without a magnetic field. The electron beam passed along the axis of a glass tube of 35 mm diameter and 300 mm length, filled with hydrogen at $p = 10^{-4} - 5 \times 10^{-2}$ mm Hg. The plasma was produced by the beam itself (beam plasma); the plasma parameters could be measured with Langmuir probes; the microwave oscillations were detected with a helix introduced inside the tube.

The electrons, after passing through the plasma, entered the cylindrical capacitor through an opening of 1.5 mm diameter drilled at the center of the electron collector. The volume in which the capacitor was located was evacuated to 10^{-5} mm Hg.

A typical family of distribution functions, with the gas pressure as the parameter, is shown in the figure. The curves show clearly the plateau-formation dynamics described in [4]. At the same time, a number of periodically spaced peaks forming the fine structure of the distribution functions can be seen against the background of the plateau. These peaks appear at $p \geq 1.5 \times 10^{-2}$ mm Hg and develop further with increasing pressure. The average interval between them is about 50 - 100 V.

The energy corresponding to the fine-structure peaks varies little with changing gas pressure. On the other hand, if the parameter of the family is the beam current i or the accelerating voltage U_0, then the position of the peaks shifts toward higher energies with increasing U_0 or i.



Family of measured energy distribution functions of the beam electrons. The parameter of the curves is the gas pressure. $U_0 = 400$ V, i = 8 mA.

The fine structure is seen quite distinctly on the distribution function. However, on the delay-current curve, which we could obtain either experimentally by the decelerating-field method or by integrating the measured distribution function, the fine structure makes an almost unnoticeable contribution, lying at the limit of the measurement accuracy. This is apparently why the fine structure remained hitherto unobserved by experimenters using the decelerating-field method.

The formation of the plateau on the distribution function and the appearance of the fine structure took place only when the presence of the microwave oscillations could be detected. The oscillation spectrum consists of the main peak, the frequency of which corresponds to the Langmuir frequency of the beam plasma in the region where the beam passes, and a smaller peak observed at lower frequencies. The latter is apparently due to the interaction of the beam with the surface of the plasma-waveguide wave.

The nature of the fine structure is still not clear, but it can be assumed that the discrete singularities on the distribution function are due to the discrete character of the spectrum of the Langmuir oscillations with respect to k, which should result from the finite length of the system.

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MEASUREMENT OF THE LEVEL RELAXATION CONSTANTS BY THE METHOD OF THREE-LEVEL LASER SPECTROSCOPY

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1. A new trend in spectroscopy, using the singularities of the resonant interaction of the atoms and molecules with a strong monochromatic field - laser spectroscopy - is now being intensely developed. Most methods using nonlinear effects in a gas placed in a strong field are based on the phenomenon of formation of dips (peaks) in the velocity distribution of the atoms [1] and a dip in the center of the amplification (absorption) line in the standing-wave field [2]. Effects of saturation in two-level systems (the Lamb dip on the frequency dependence of a gas-laser generation power, the generation-power peak in a laser with nonlinear absorption, the dip at the center of the absorption line in an external cell in a standing or weak opposing wave, etc.), or in three level systems (for example, spontaneous emission in a neighboring transition from the gas-laser resonator) have made it possible to observe experimentally the spectral-line structure, which is masked under ordinary conditions by the Doppler broadening, and to use it for the solution of a number of spectroscopic problems.

However, as before, knowledge of the shape and width of the emission line of an individual atom or molecule in transitions between excited states does not yield any information on the relaxation constants characterizing each level separately. We report here an experimental investigation of a new spectroscopy method, using a 3-level scheme, which makes it possible to measure the relaxation constants of individual levels.