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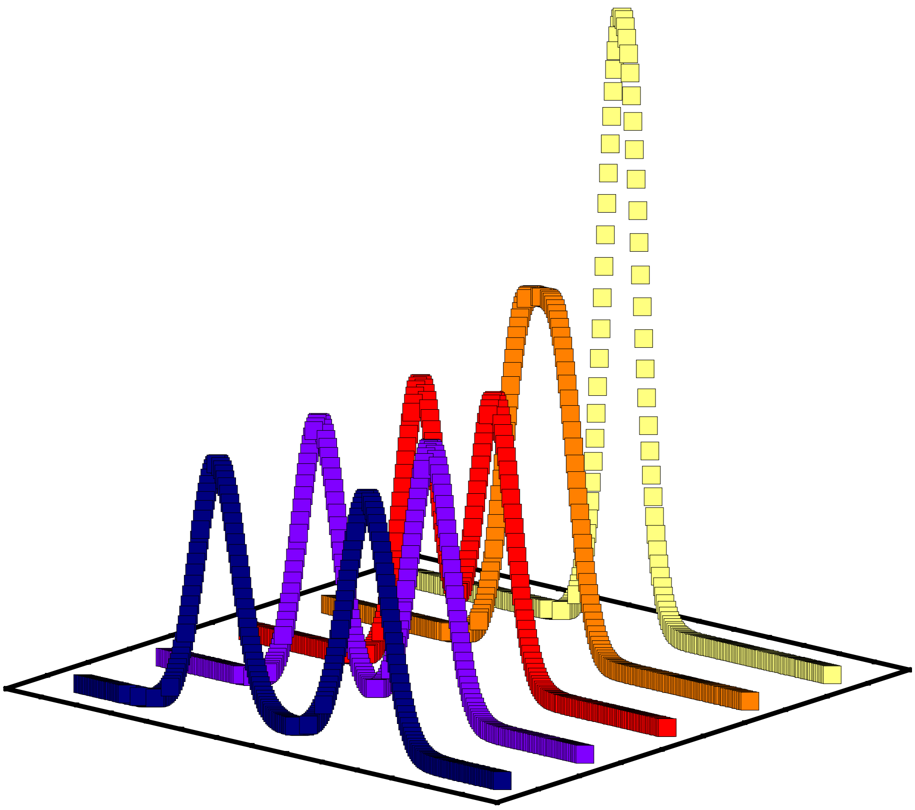
SPECTROSCOPIC INVESTIGATIONS OF THE ABNORMAL GLOW DISCHARGE PARAMETERS RELEVANT FOR METAL-VAPOR LASERS

Master of Science Thesis



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Abstract

The results of the systematic spectroscopic investigations of some parameters and elementary processes in the cathode dark space of the Grimm-type abnormal glow discharge are presented. The special attention is devoted to the measurements of the external electric field strength axial distribution and excited hydrogen atoms temperature. Discharges in pure hydrogen and in argon with small admixture (3%) of hydrogen are studied.

Theoretical basis of these measurements is the linear Stark effect coupled with Doppler broadening, applied to the atomic hydrogen H_β and H_γ spectral lines in the external electric field of the cathode dark space. On these foundations, the fitting algorithm for polarization-dependent H_β and H_γ line profiles is developed, which simultaneously provides the results of the local electric field strength and the temperature of the emitters – excited hydrogen atoms. With the experimentally determined electric field strength spatial distributions, the testing of two theoretical models of the cathode dark space is performed: well-known Davis and Vanderslice model and Wronski's solution of the Boltzmann equation for the ions generated in charge exchange processes in the cathode dark space.

Measurements of the electric field strength axial distributions, in pure hydrogen discharge, show consistency of the results obtained by spectra recordings of differently polarized H_β and H_γ line profiles. Some difficulties in applying Stark spectroscopy for the diagnostics of spatially inhomogeneous electric field inherent to the Grimm glow discharge, particularly pronounced in argon-hydrogen mixture, are discussed in detail. Testing of the Davis-Vanderslice and Wronski theories shows that both models, each with its own advantages and lacks, yield reasonable good description of the electric field spatial distribution in the cathode dark space.

The results of the Doppler spectroscopy of the H_β and H_γ lines show that, in pure hydrogen discharge, at least two groups of high-energetic excited hydrogen atoms, with significantly different velocities, exist: so-called "slow", with energies ranging from 3.4 to 8.2 eV, and "fast" hydrogen atoms, whose temperatures are between 80 and 190 eV. Relative concentrations of "slow" and "fast" excited hydrogen atoms in the cathode dark space are determined. In addition, the relative concentration of hydrogen atoms with temperatures around 0.1 eV, excited in the plasma of the negative glow region, is also determined. The origin of "slow" and "fast" hydrogen atoms is related to the presence of H_3^+ and H^+ ions, respectively. These ions are accelerated in the strong electric field of the cathode dark space and neutralized and fragmented into atoms in collision with the cathode surface. Neutral atoms, created in this way, are back-reflected into discharge and excited in collisions with the molecules of the carrying gas. In the cathode dark space of argon-hydrogen mixture discharge, excited hydrogen neutrals with energies between 32 eV and 43 eV are detected only. Their origin is assigned to the dominant role of H_3^+ ion in this discharge. For both gases, approaching the negative glow region, the "increase" of the exited hydrogen atoms temperature is detected, and explained by the additional excitation of high-energetic neutrals in collisions with electrons.