Experimental studies of mechanisms of positive column constriction in argon and neon

Yu. Golubovskii[1], A. Siasko[1], D. Kalanov[1], V. Nekuchaev[2]

[1]*Saint-Petersburg State University, 7/9 Universitetskaya nab., St. Petersburg, 199034 Russia*
[2]*Ukhta State Technical University, Pervomaiskaia ul. 13, Ukhta 169300, Russia*

Paper presents latest results of experimental studies of positive column constriction in neon and argon. In particular, measurements of electric fields in neon and argon, densities and radial profiles of the excited states $2p^5 3s$ and $2p^5 3p$ in neon and $3p^5 4s$ and $3p^5 4p$ in argon (1s and 2p in Pashen's notation) were performed. Densities and radial profiles were obtained using classic method of emission and absorption spectroscopy and by line ratios method. The main role in constriction belongs to the nonlinear dependence of ionization rate on electron density due to a competition of the electron-atom and the electron-electron collisions. Basic regularities of the phenomenon and main distinctions of obtained results in constricted neon and argon discharges are discussed.

1. Introduction

Constriction is a phenomenon in gas discharge physics observed as abrupt formation of a thin bright cord with a growth of discharge current, which arises from a strong nonlinear dependence of the ionization rate on the electron density. The nonlinearity is related to a competition of electron-atom and electron-electron collisions during formation of an electron distribution function. As a result, this nonlinear dependence causes ionization instability in the radial direction with simultaneous constriction. Generalized experimental and theoretical knowledge of constriction in inert gases has been discussed in a review [1].

2. Experimental setup

A registration system consisted of a monochromator Acton SpectraPro 2300i. Radial scanning was performed with the high-speed camera pco.1200hs, so an instrumental function of the experimental setup was determined by a pixel size of the camera. Measurements were performed with a reduced gas pressure in argon tube of 98 Torr*cm and neon - filled cylindrical tube with pressure 90 Torr*cm. A second line source necessary for absorption measurements were 2 Torr ICP discharges in argon and neon.

3. Methods of spatial absorption measurements

Radial density profiles of 2s and 2p- states were first measured by classic absorption method. Theoretical description of the method can be found in [2]. For ICP plasma source a Doppler lineshape is assumed and a Voigt lineshape for the main source. The second method was a modified line ratios method, proposed in [3], which allows to determine densities and radial profiles of absorbing atoms by solving a system of emission flux ratio equations.

4. Results

Profiles of excited states in argon and neon measured in different lines show good agreement. Absolute density values of 1s-states in argon are lower than in neon and radial profiles in neon are wider. Distinctions in radial profiles are related to differences in dependencies of ionization rates on the electron density. Nonlinear dependence in argon is much stronger than in neon. Figure 1 compares measured radial profiles of 2p-levels.

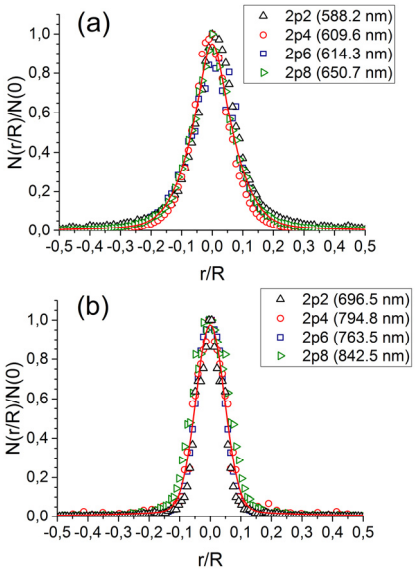

Figure 1. 2p profiles in neon (a) at i/R=40 mA/cm and argon (b) at i/R =17,4 mA/cm in selected emission lines.

5. References

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[3] M. Schulze et al., J. Phys. D. Appl. Phys. **41** (2008) 65206.