In this work populations of the first two metastable and first two resonant atomic states in CCP Ar discharge have been measured using two independent optical emission methods. The first method is based on the comparison of radiation self-absorption effects for plasmas with two different effective sizes. The second method is based on the measurements of intensity ratios of certain lines which are sensitive to plasma parameters. It was shown, that the first method is preferable to use. The dependencies of level populations on the different plasma parameters were obtained. For description of such populations’ behaviors the collisional-radiative model, containing the first 14 exited atomic states in Ar, has been built. The behaviors of level densities on plasma parameters in gas mixtures (we added H2, N2 and O2 gases to pure Ar) were also investigated.

### Two spectroscopic methods

#### Method 1 (based on the comparison of radiation self-absorption effects for plasmas with two different effective sizes)

\[
\frac{I_{2}}{I_{1}} = f(n_{e}, n_{i}, \gamma, g, \sigma_{f}),
\]

\[
\frac{I_{2}}{I_{1}} = r \left( 1 - \frac{\exp(-\lambda_{f} \sigma_{r} n_{e})}{1 + 1} - 2 \lambda_{f} \sigma_{r} n_{e} \right) \left( 1 - \frac{\exp(-\lambda_{r} \sigma_{a} n_{i})}{1 + 1} - 2 \lambda_{r} \sigma_{a} n_{i} \right) + 1
\]

- \(I_{2}\) - (here intensity measured with mirror \(I_{1}\) - here intensity measured without mirror; \(g\) - Concentration of level; \(\lambda_{f}\) - Einstein coefficient; \(\lambda_{r}\) - wavelength of line; \(\sigma_{f}\) - statistical weight of level; \(\sigma_{r}\) effective plasma and \(\sigma_{a}\) - absorption coefficient of the mirror.

Usage of different lines based on the same lower level provides set of independent measurements of this level populations.

#### Method 2 (based on the measurements of intensity ratios of certain lines)

\[
\frac{I_{j}}{I_{m}} = f(n_{e}, n_{i})
\]

Four intensity ratios provide set of equations with four unknown lower level concentrations.

### Measurements results (method 1)

<table>
<thead>
<tr>
<th>N_1s3, 10^9 cm^-3</th>
<th>N_1s4_751, 10^9 cm^-3</th>
<th>N_1s4_810, 10^9 cm^-3</th>
<th>N_1s5_706, 10^9 cm^-3</th>
</tr>
</thead>
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<tr>
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The population density of 1s3 level versus the electron density, Ar, 50 mTorr.

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The population density of 1s4 level versus the electron density, Ar, 50 mTorr.

### Conclusions

- The population densities of the first four excited states in Ar were measured under different plasma conditions by means of two OES-methods.
- It was shown that the method based on comparison of line intensities with different effective size is preferable to use.
- The population densities of all 4s1-levels reduce with increase of admixture fraction (as admixture we used hydrogen, oxygen and nitrogen).

This research was supported by the SRC (Contract 2012-KJ-2280) and by Russian Foundation of Basic Research (12-02-00536-a).