Absorption methods
Self-absorption

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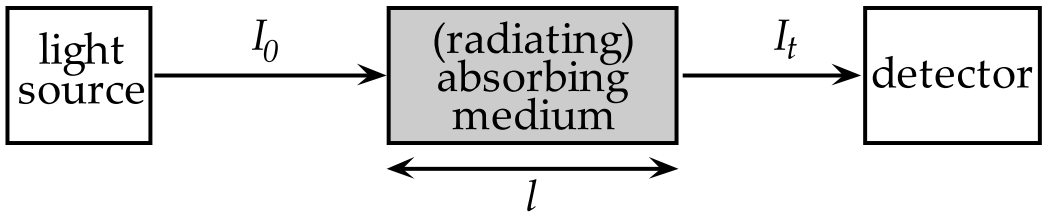
Application of absorption methods in plasma diagnostics

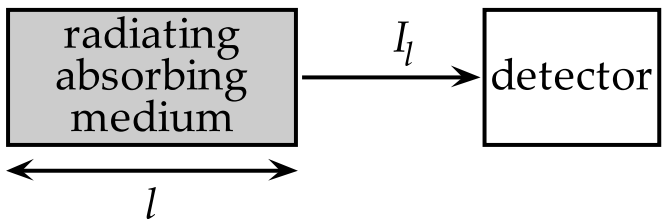
- determination of chemical composition
- determination of density of excited particles, e.g. metastable atoms

Types of absorption methods

- „white light absorption“

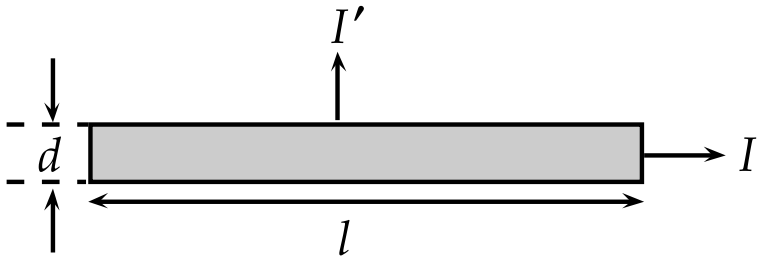


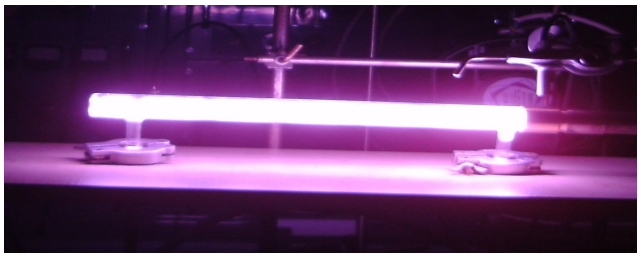
- absorption of radiation by discharge itself



Self-absorption method

- observation in two directions
  1. optically thin (negligible self-absorption)
  2. presence of self-absorption



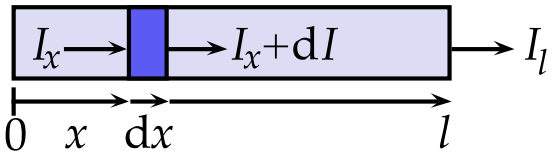


- ratio of total intensities of two lines

$$r(n) = \frac{\frac{I_1}{I_1'}}{\frac{I_2}{I_2'}}$$

- lines 1,2 ending on the same atomic level

- radiation of absorbing medium: $dI = J\mathrm{d}x - k\,I_x\mathrm{d}x$



- dependence on density in absorption coefficient:

$$k(\nu) = P(\nu)\,k_{\mathrm{tot}} = P(\nu)\,\mathbf{n_1}B_{12}h\nu_0/c$$

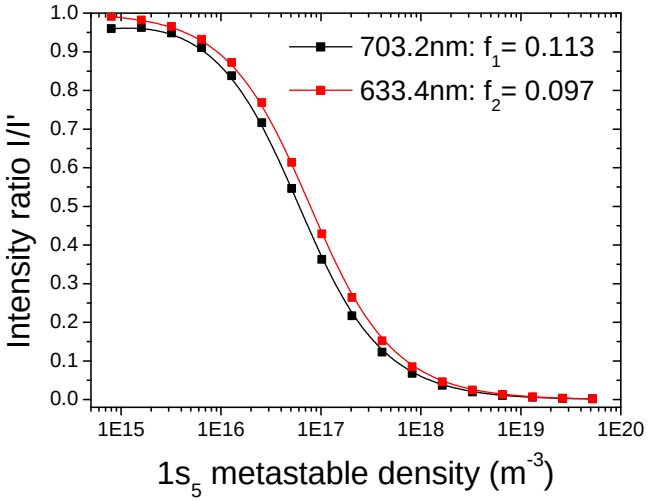
Homogeneous medium

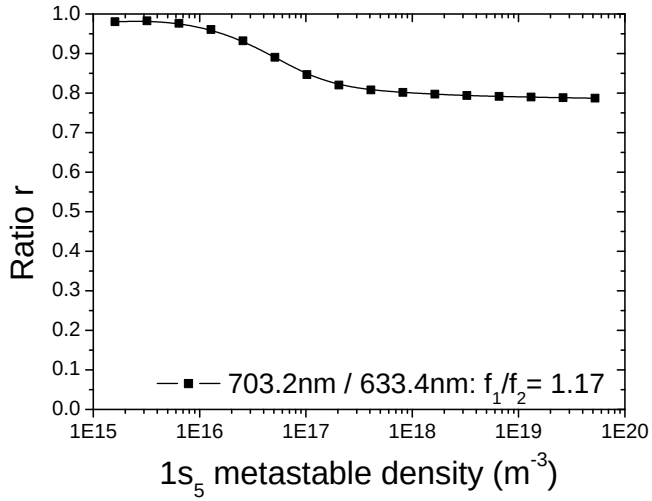
- $\frac{I_l}{I'_l} = \frac{1}{k_{\mathrm{tot}}\,l}\int\limits_{\mathrm{profil}}\left(1-\mathrm{e}^{-k_{\mathrm{tot}}\,P(\nu)\,l}\right)\mathrm{d}\nu$
- $r(n) = \frac{I_1}{I'_1}\Big/\frac{I_2}{I'_2} = \frac{k_{\mathrm{tot}_2}}{k_{\mathrm{tot}_1}}\,\frac{\int\left(1-\mathrm{e}^{-k_{\mathrm{tot}_1}P(\nu)l}\right)\mathrm{d}\nu}{\int\left(1-\mathrm{e}^{-k_{\mathrm{tot}_2}P(\nu)l}\right)\mathrm{d}\nu}$

Neon ($2p^5\,3p \rightarrow 2p^5\,3s$)

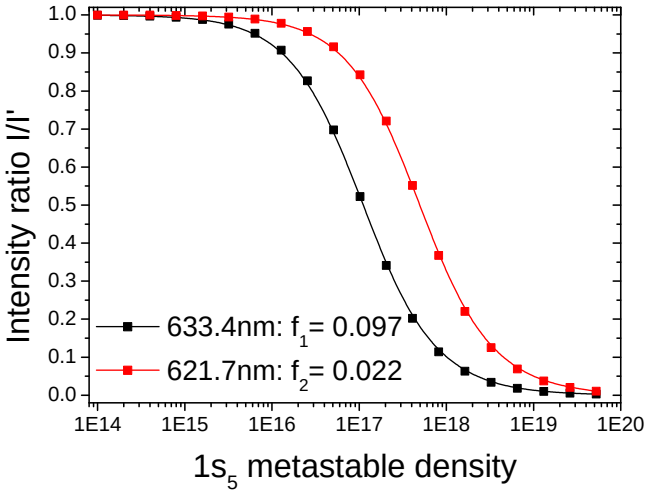
	λ (nm)	E_i (eV)	E_k (eV)	J_i	J_k	f_{ik} (10^{-2})
$1s_3$	616.359	16.72	18.73	0	1	25.0
	626.650	16.72	18.69	0	1	44.0
	653.288	16.72	18.61	0	1	20.7
	743.890	16.72	18.38	0	1	5.75
$1s_5$	588.190	16.62	18.73	2	1	3.58
	594.483	16.62	18.70	2	2	5.99
	597.553	16.62	18.69	2	1	1.13
	614.306	16.62	18.64	2	2	16.0
	621.728	16.62	18.61	2	1	2.22
	633.443	16.62	18.58	2	2	9.69
	640.225	16.62	18.56	2	3	44.2
	703.241	16.62	18.38	2	1	11.3

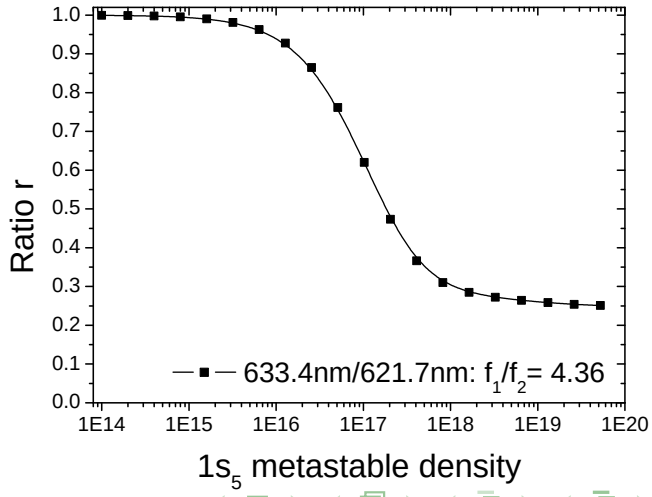
Insensitive pair of lines



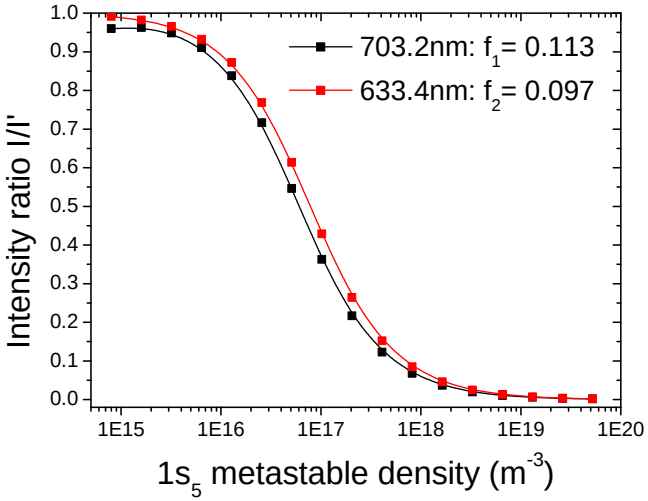


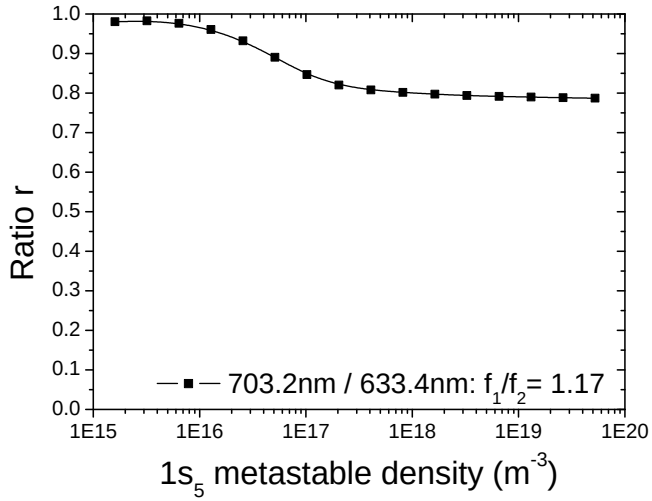
Sensitive pair of lines



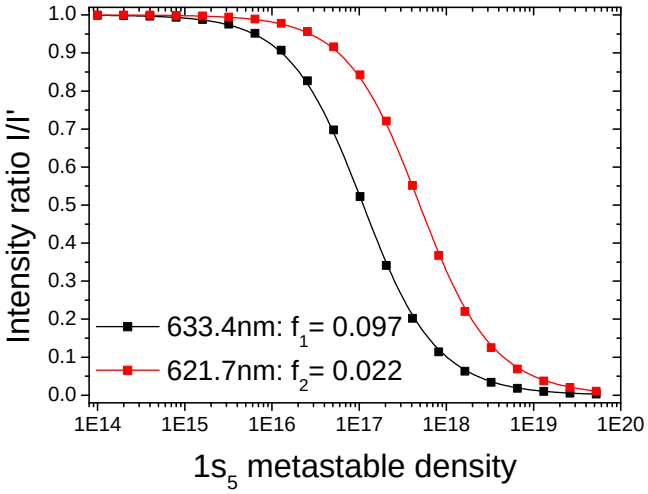


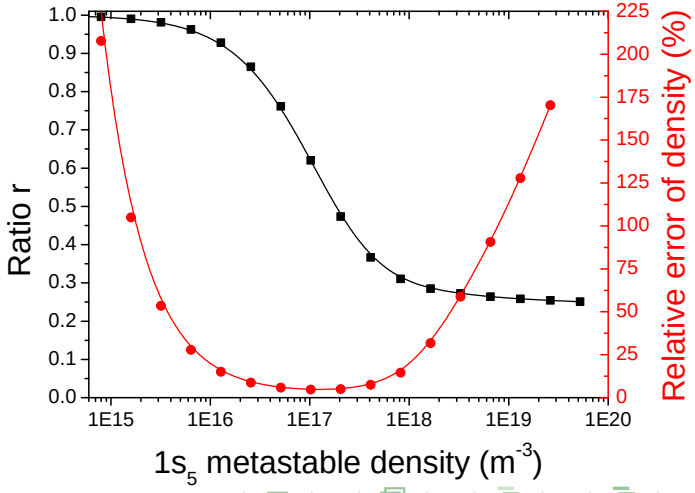
Insensitive pair of lines





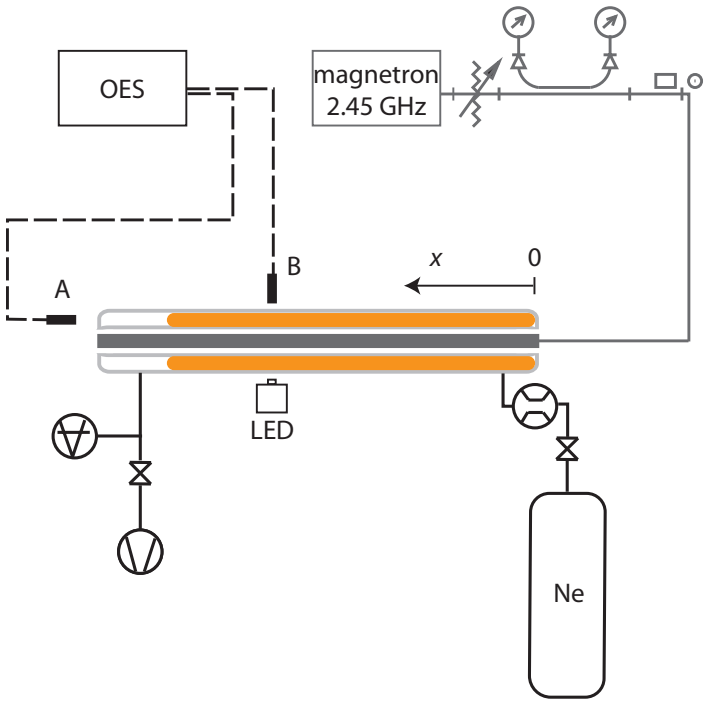
Sensitive pair of lines

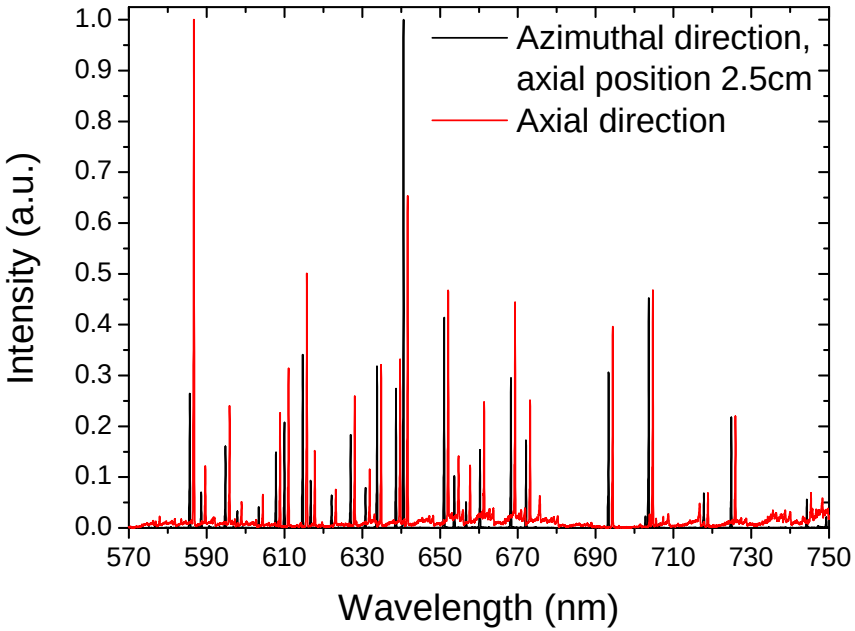


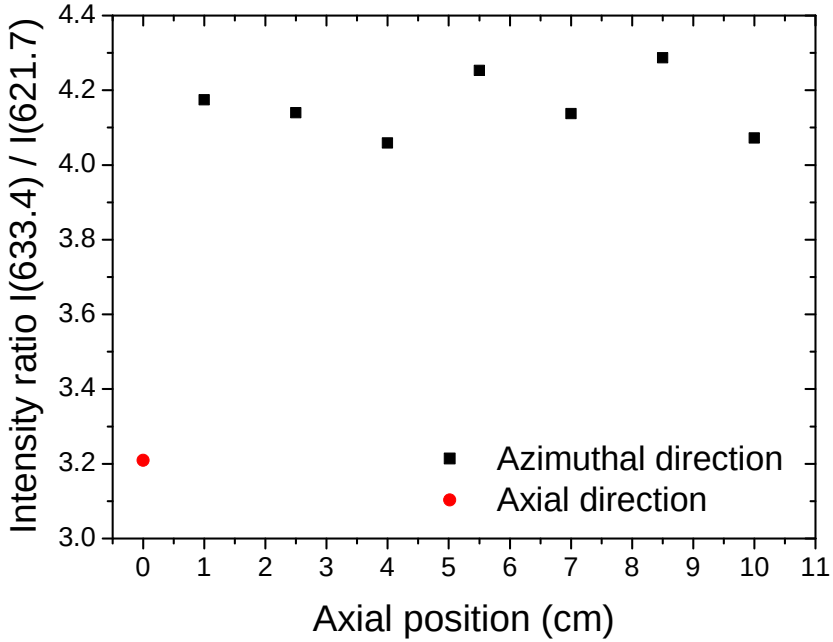


Microwave discharge in neon

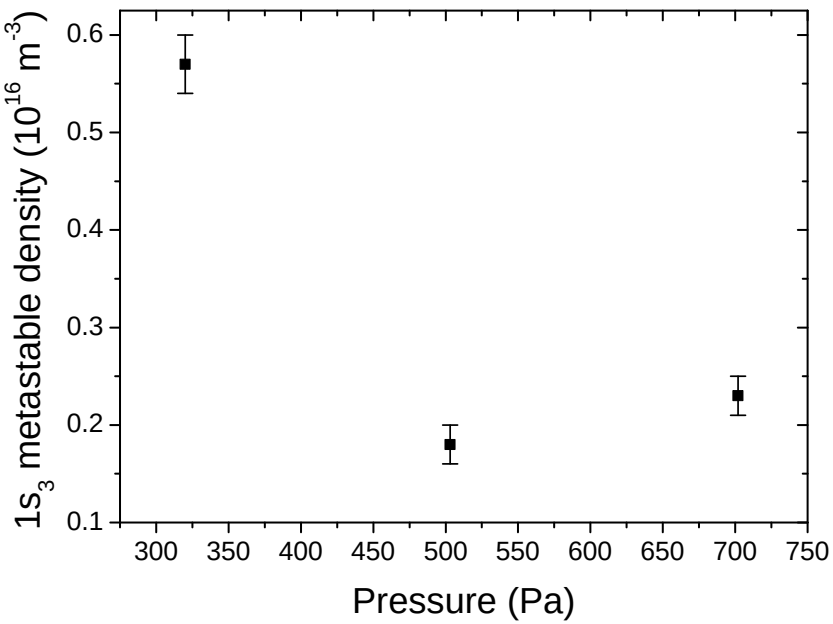
- collaboration with University of Sofia
- two coaxial dielectric tubes with metal rod at their axis
- input power 60 W, pressure 320, 503, resp. 702 Pa, flow rate 6.6, 14.3, resp. 27.0 sccm



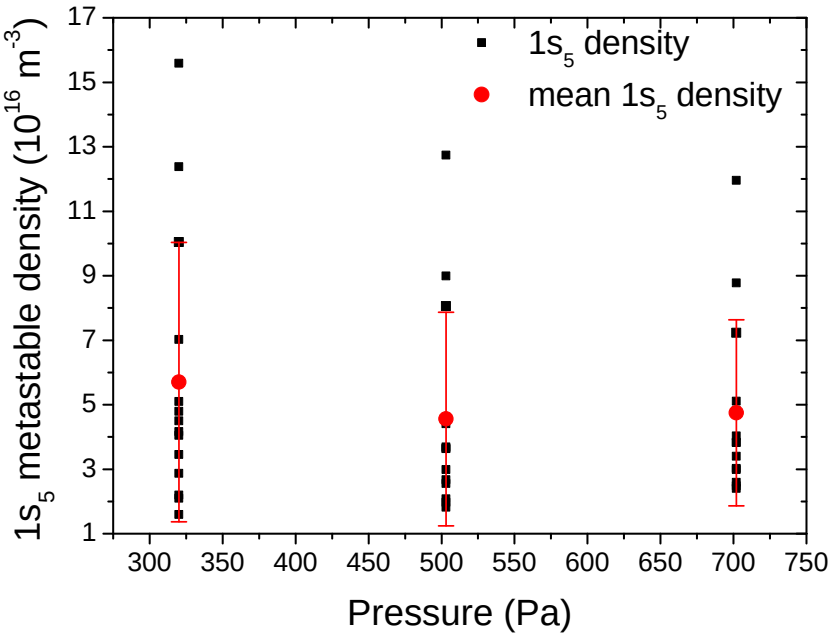

Intensity (a.u.)
Wavelength (nm)
Azimuthal direction, axial position 2.5cm
Axial direction


Intensity ratio I(633.4) / I(621.7)
Axial position (cm)
Azimuthal direction
Axial direction

Metastable state $1s_3$



Metastable state $1s_5$



Meaning of error bars:

intensity measurement error

obtained from various line pairs

- no external light source
- pair of lines with common lower state
- two directions of observation
- spatial inhomogeneity of medium simply counted
- suitable even for weak absorption
- determination of density averaged over the whole volume

Thank you for your attention