Absorption methods
Self-absorption

Lenka Dosoudilová
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“

\[
\text{light source} \quad I_0 \quad (\text{radiating}) \quad \text{absorbing medium} \quad I_t \quad \text{detector}
\]

- absorption of radiation by discharge itself

\[
\text{radiating} \quad \text{absorbing} \quad \text{medium} \quad I_t \quad \text{detector}
\]
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
Absorption methods
Self-absorption method
Conclusion

radiation of absorbing medium: \( dI = Jdx - kI_x dx \)

dependence on density in absorption coefficient:

\[
  k(\nu) = P(\nu)k_{\text{tot}} = P(\nu)n_1B_{12}\hbar\nu_0/c
\]

Homogeneous medium

\[
  \frac{I_l}{I'_l} = \frac{1}{k_{\text{tot}}l} \int_{\text{profil}} \left( 1 - e^{-k_{\text{tot}}P(\nu)l} \right) d\nu
\]

\[
  r(n) = \frac{I_1}{I'_1} / \frac{I_2}{I'_2} = \frac{k_{\text{tot}2}}{k_{\text{tot}1}} \frac{\int \left( 1 - e^{-k_{\text{tot}1}P(\nu)l} \right) d\nu}{\int \left( 1 - e^{-k_{\text{tot}2}P(\nu)l} \right) d\nu}
\]
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Principle of self-absorption method
Determination of density of absorbing particles
Choice of the spectral lines
Application on microwave discharge
Determined density for homogeneous medium

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

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<th>( \lambda ) (nm)</th>
<th>( E_i ) (eV)</th>
<th>( E_k ) (eV)</th>
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<th>( f_{ik} ) ( (10^{-2}) )</th>
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</table>
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Insensitive pair of lines

Sensitive pair of lines

\[ \frac{703.2\text{nm}}{633.4\text{nm}}: \frac{f_1}{f_2} = 1.17 \]

\[ \frac{633.4\text{nm}}{621.7\text{nm}}: \frac{f_1}{f_2} = 4.36 \]
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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
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![Graph showing intensity vs wavelength and intensity ratio vs axial position]
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Metastable state 1s₃

Metastable state 1s₅

Meaning of error bars:

- intensity measurement error
- obtained from various line pairs

Lenka Dosoudilová

Absorption methods
▶ 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