

論文 / 著書情報
Article / Book Information

題目(和文)	発光分光診断によるヘリウムプラズマ電子密度・温度測定における衝突輻射モデルの展開
Title(English)	Advancements in Collisional-Radiative Models for Electron Density and Temperature Determination in Helium Plasma Using Optical Emission Spectroscopy Diagnostics
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学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

論文要旨

THESIS SUMMARY

系・コース : Department of, Graduate major in	電気電子 電気電子	系 コース	申請学位 (専攻分野) : Academic Degree Requested	博士 Doctor of	(Engineering)
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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

This thesis presents pioneering research in the field of optical emission spectroscopy, with a focus on diagnosing the electron density and temperature in helium plasma. Three innovative models are developed, each tailored to different plasma conditions and electron temperature ranges, showcasing their potential for precise and reliable plasma diagnostics.

In the first model, a simplified approach is employed, based on the low-pressure helium collisional-radiative (CR) model. By extracting the dominant processes, simplified rate equations are derived, and the electron density and temperature are determined by inputting the number density of three excited levels. Theoretical and experimental verifications demonstrate the model's accuracy and efficiency, making it a promising tool for diagnosing low-pressure helium plasma with OES measurements. The method shows high accuracy within the electron temperature range of 1.0 eV to 4.0 eV and electron density range of $1 \times 10^{11} \text{ cm}^{-3}$ to $1 \times 10^{12} \text{ cm}^{-3}$.

The second model is tailored for plasma diagnostics in high-temperature environments, particularly in thermonuclear fusion reactor boundary areas. By increasing the number of input lines from three to eight and including the optical escape factor in the CR model, the model significantly improves the conventional three-line analysis. It successfully determines electron density and temperature in low-pressure helium plasma, resolving the disagreement observed in the line at 501.6 nm. The algorithm shows better performance, especially in fitting levels 4^1D and 4^3D . Though slight discrepancies exist in states 3^1S , 3^3S , and 3^1D , future work incorporating statistical weight into the objective function may further enhance the model's precision.

The third model tackles the challenging diagnosis of electron density and temperature in atmospheric-pressure helium plasma. To expand the conventional CR model's validity to atmospheric pressure, atomic collision processes' rate coefficients are included. An algorithm is developed using eight measured states (3^1S , 3^3S , 3^1P , 3^3P , 3^1D , 3^3D , 4^1D , and 4^3D) based on the revised CR model to determine the electron density, electron temperature, and number density of two metastable levels. Experimentally, the algorithm demonstrates accuracy comparable to the probe method in low-pressure microwave-induced helium plasma. Moreover, in atmospheric-pressure non-equilibrium helium plasma experiments, the electron density and temperature determined by the algorithm align well with those obtained through continuum spectrum analysis. This algorithm offers a safe and effective alternative to directly contact the plasma for atmospheric-pressure plasma measurements.

Overall, the developed algorithms present valuable alternatives for diagnosing electron density and temperature in different helium plasma conditions. Their high accuracy, simplicity, and adaptability to various plasma environments make them promising tools for plasma diagnostics and research.

In summary, this thesis significantly contributes to the field of optical emission spectroscopy and plasma diagnostics, offering innovative approaches for determining electron density and temperature in helium plasma. With applications ranging from low-pressure microwave-induced helium plasma to atmospheric-pressure non-equilibrium helium plasma, these models demonstrate their potential to enhance our understanding of plasma behavior and characteristics in diverse settings. The findings open up new possibilities for accurate and efficient plasma diagnosis, paving the way for advancements in fusion research and other plasma-related applications.

備考 : 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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