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Study of the 777 nm Lines Profile of Atomic Oxygen Using Laser-Induced Plasmas

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CONTEXT & OBJECTIVES

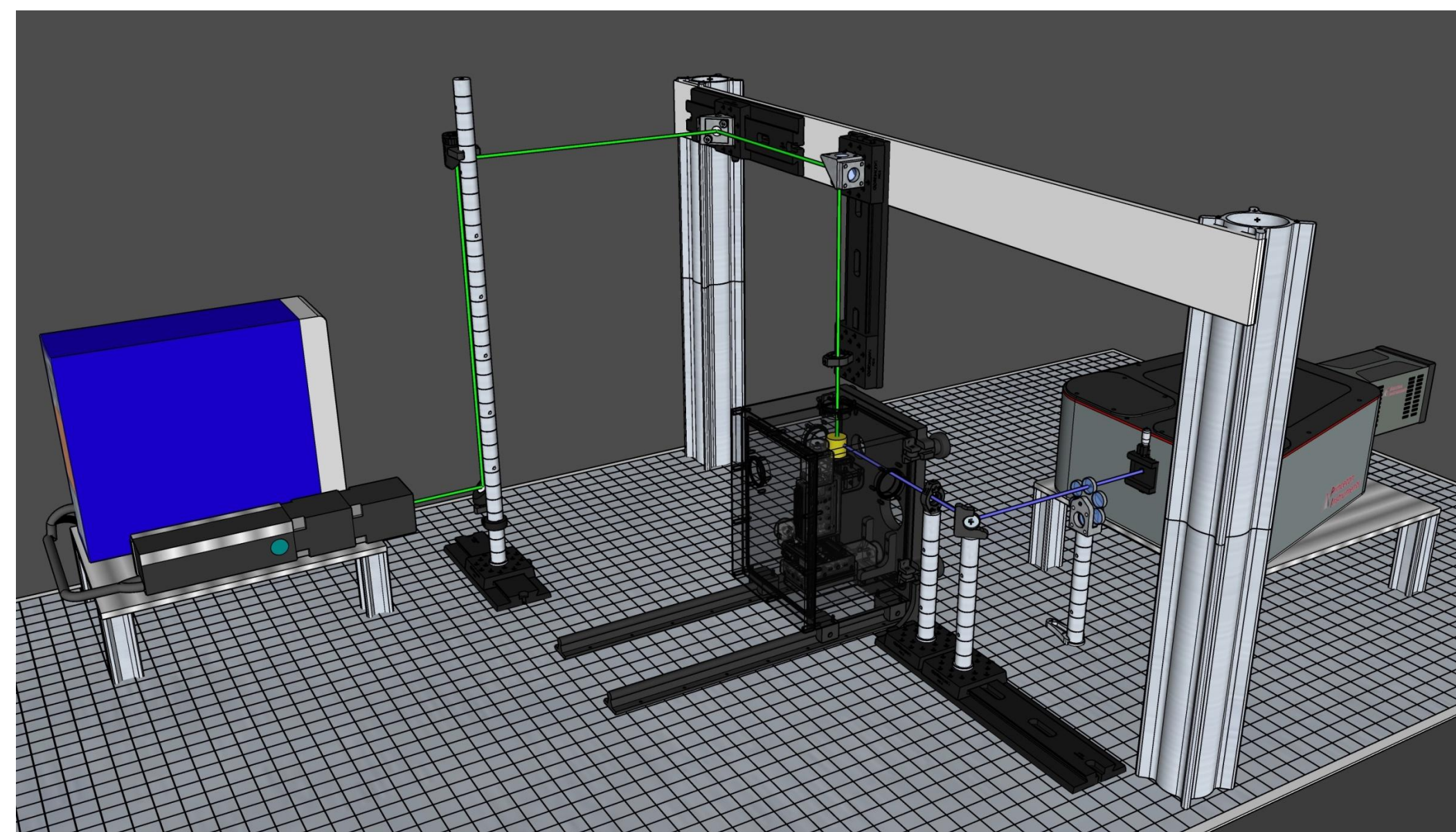
Diagnostic technique

The lines of the O I triplet at 777.4 nm represent one of the most important radiative contributions in the spectrum of a plasma containing oxygen. Indeed, the upper levels of the related transitions can be easily populated (their excitation energy is of the order of 10.7 eV) and their Einstein coefficient is significant (of the order of $4 \times 10^7 \text{ s}^{-1}$). The triplet can therefore be used to diagnose the plasma, i.e. to determine the electron temperature (T_e) and density (n_e), if no hydrogen line can be detected in the spectrum.

Objectives and methodology

New line Stark parameters (broadening ω_s and shift $\Delta\lambda_s$) are investigated. Laser-induced plasmas are produced in an Aceton-Argon mixture and the profile of the O I triplet is studied in order to correlate the Stark parameters and n_e . Comparisons are made with Griem's parameters.

EXPERIMENTAL SETUP



The laser pulse (1064 nm, 30 ps, 14 mJ) is focused to produce a plasma in an Aceton-saturated Argon (80 % - 20 % vol.) atmosphere (black chamber) at atmospheric pressure. The plasma is formed (lifetime of the order of 10 μs). Its radiation is collected along a second optical axis and analyzed using an Isoplane SCT-320 spectrometer over the [200, 850] nm spectral range.

n_e AND T_e EVOLUTIONS

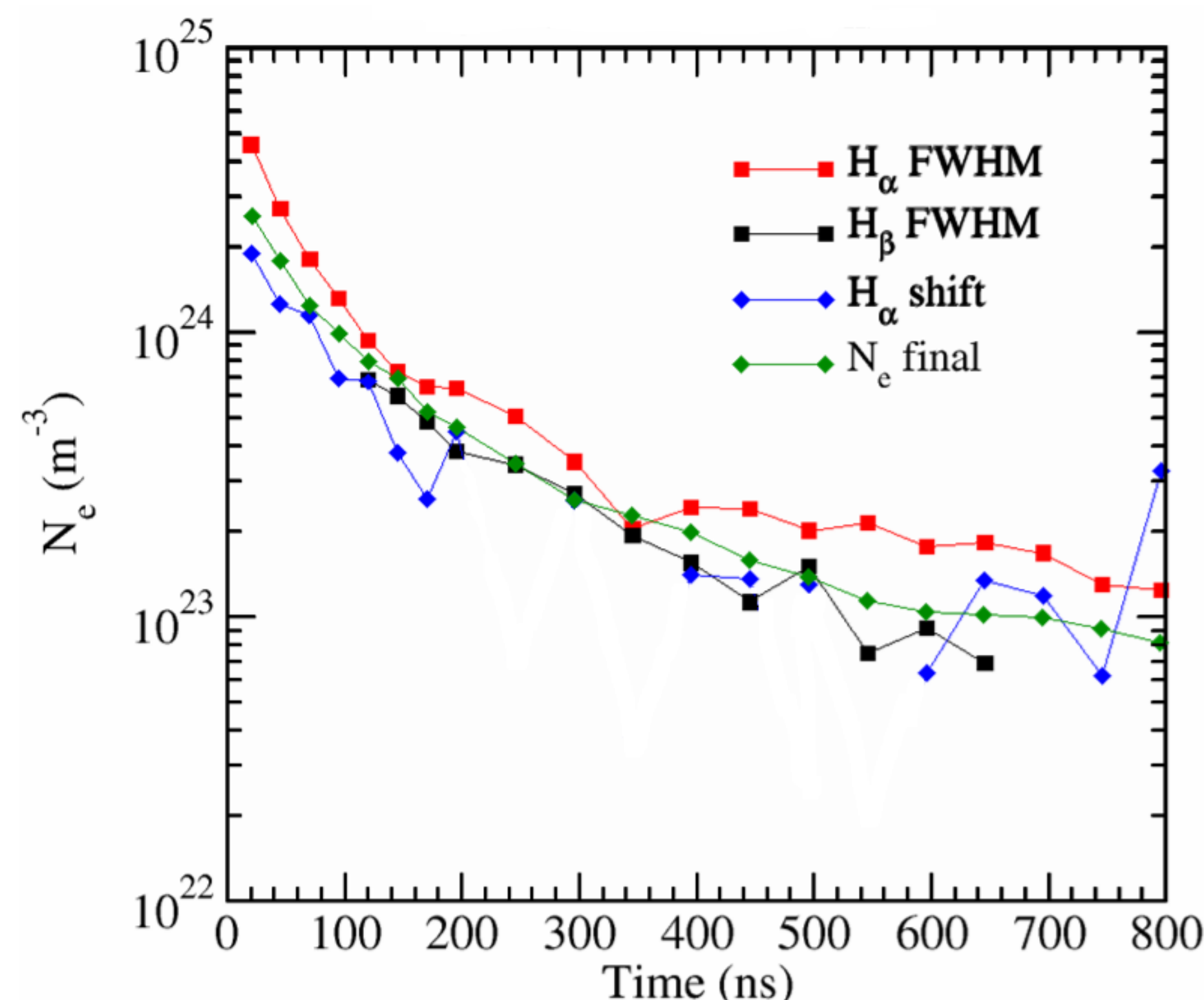
Electron temperature

T_e is of the order of 15000 to 20000 K.

Electron density

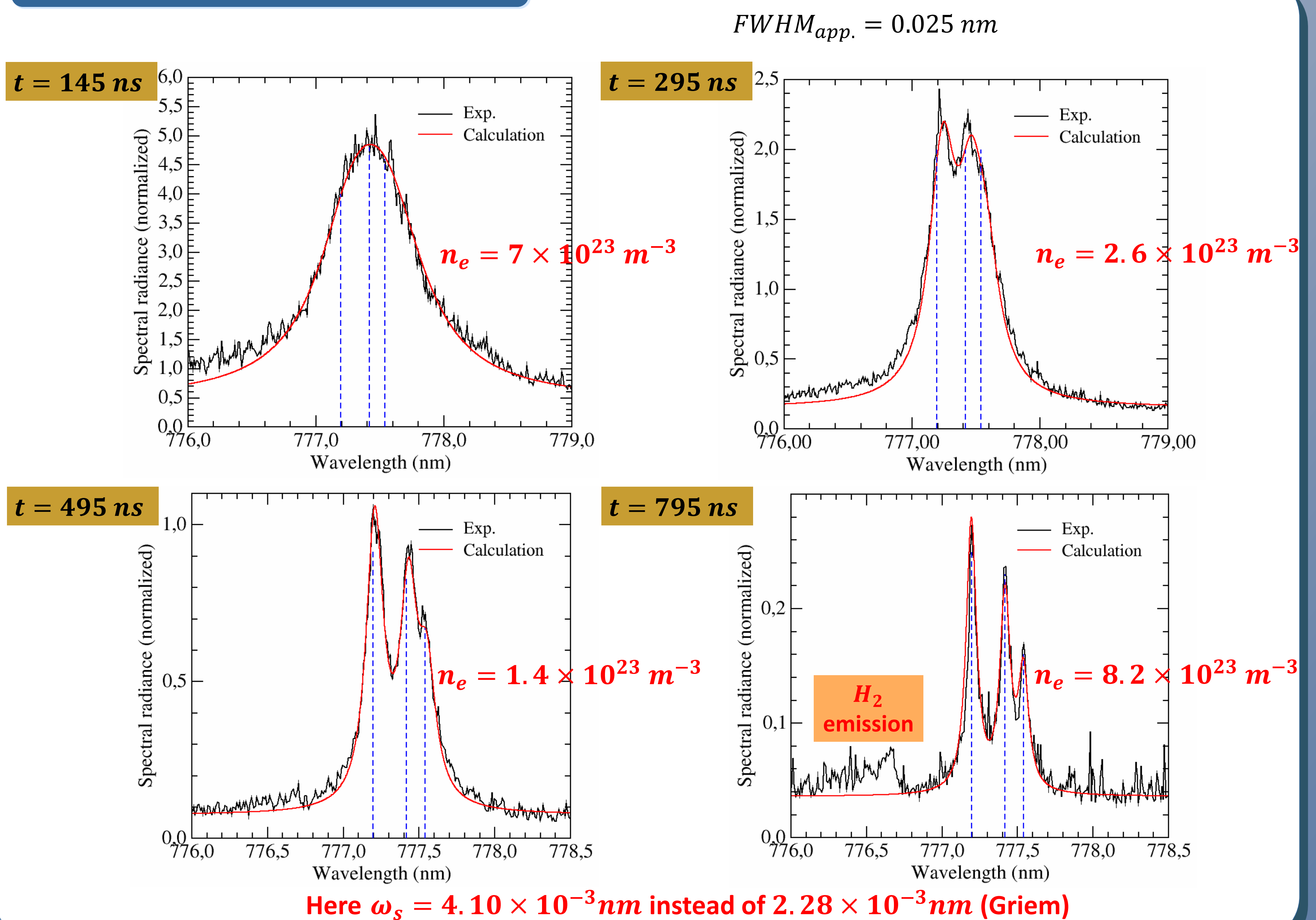
The determination of n_e is based on

- The FWHM of the H_α line,
- The FWHM of the H_β line,
- The shift of the H_α line.

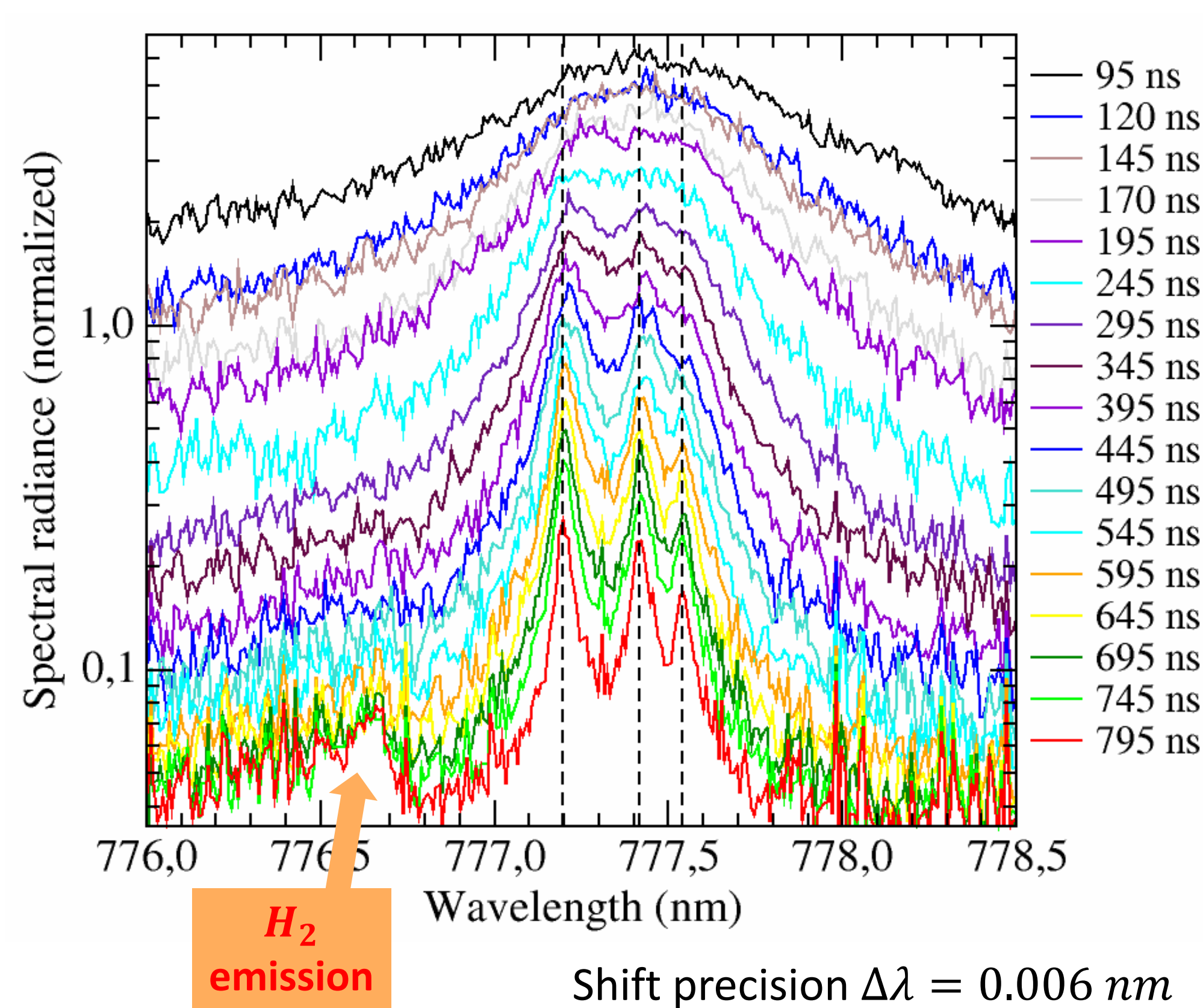


The uncertainty on n_e from the H_α FWHM is taken as twice the one from the H_β FWHM. The final n_e values are plotted in green.

WIDTH OF THE O I 777 NM TRIPLET



SHIFT OF THE O I 777 NM TRIPLET



Redshift observed

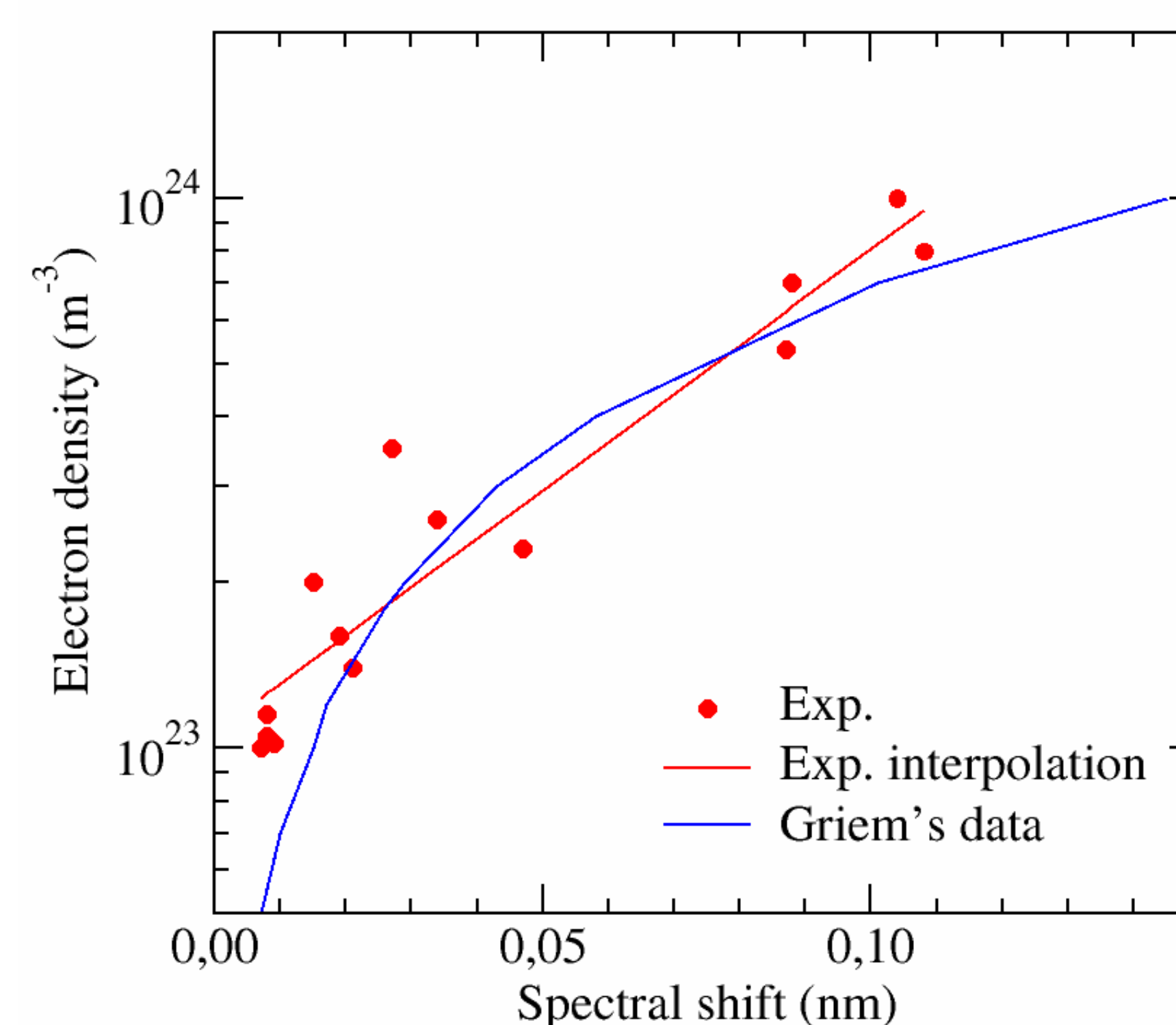
Classical behavior.

Shift considered

From the FWHM of the triplet since the lines overlap for high values of the electron density.

Shift dynamics

Non linear shift towards n_e .



For $n_e < 10^{24} \text{ m}^{-3}$

Satisfactory agreement with Griem's results.

For $n_e > 10^{24} \text{ m}^{-3}$

No experimental result available here. But Griem's shift increases rapidly. Griem's dynamics would lead to too strong values of the shift?

$$n_e [\text{m}^{-3}] = 1.0714 \times 10^{23} e^{\frac{\Delta\lambda_s [\text{nm}]}{0.0494}} \text{ for } n_e < 10^{24} \text{ m}^{-3}$$

CONCLUSION & PERSPECTIVES

Conclusion

- Laser-induced plasmas produced with spectra involving the emission of the O I triplet at 777.4 nm
- Stark broadening parameter obtained for $n_e < 10^{24} \text{ m}^{-3}$ almost twice of the value of Griem
- Stark shift parameter obtained for $n_e < 10^{24} \text{ m}^{-3}$ in good agreement with the value of Griem

Perspectives

- Assessment of the departure from equilibrium using Ar lines
- Validation of the n_e values by comparison with equilibrium calculations