OPTICAL EMISSION SPECTROSCOPY OF H2 IN A TOROIDAL MAGNETISED PLASMA

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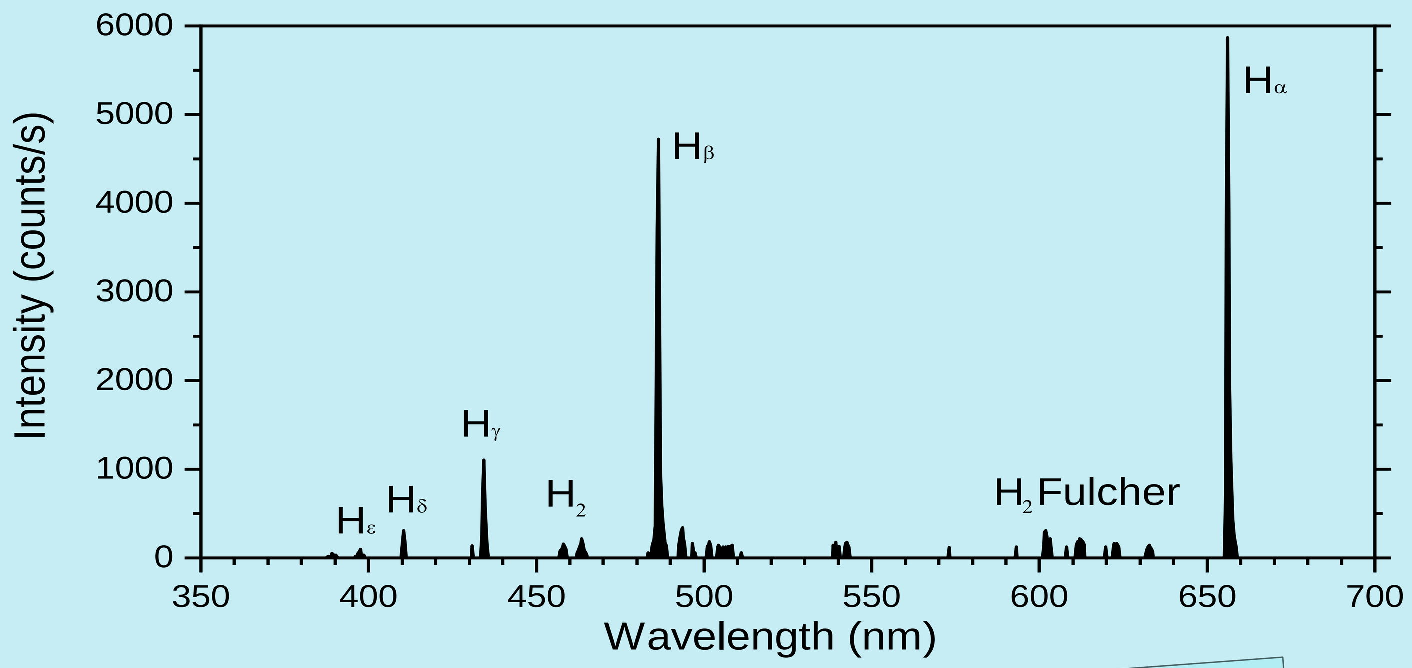
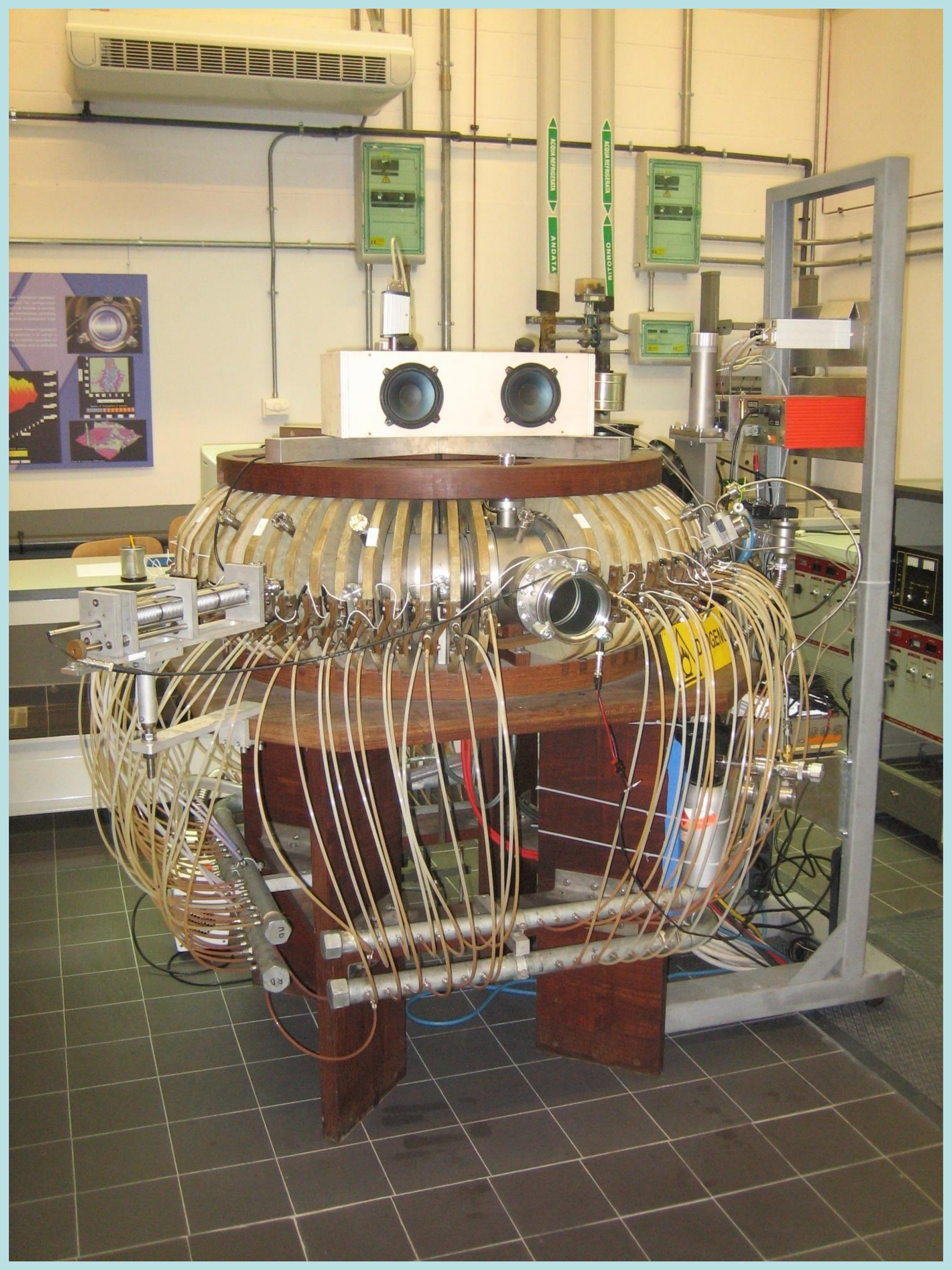
OES of H2 plasmas

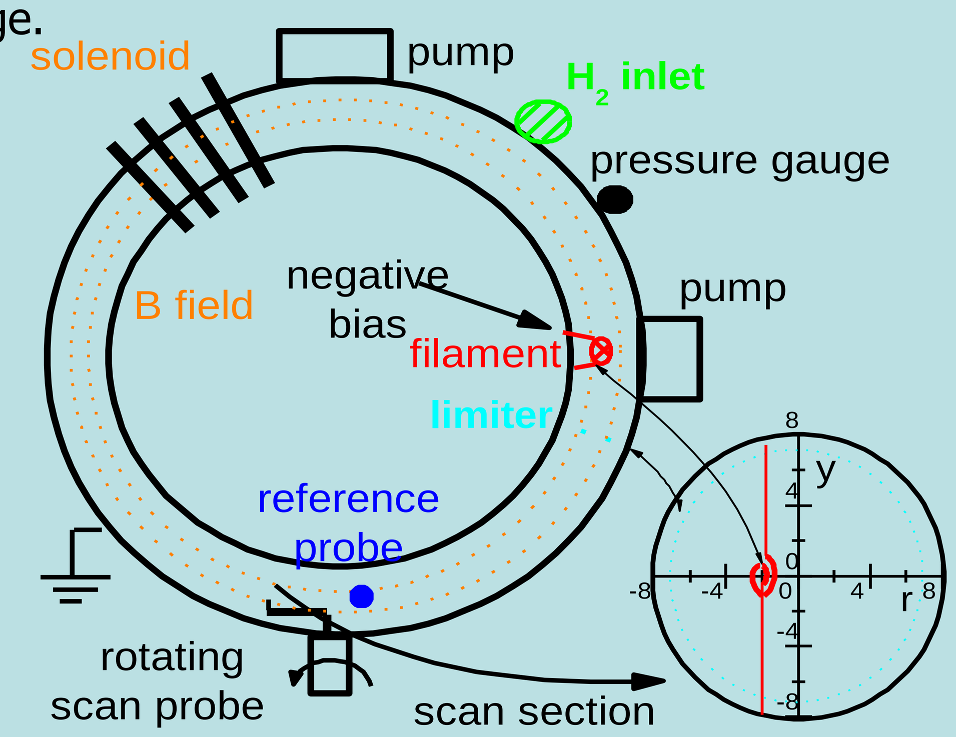
Thorello plasma typical emission spectra: apart from the more prominent Balmer lines, it is possible to spot the lines corresponding to the Fulcher-α diagonal bands. They are the more bright ones, at 602.0, 612.3, 622.6 and 632.9 nm [(n,n)-Q1 with n=0…3], corresponding to the transitions from subsequent excited vibrational levels of the 3c state.



Thorello

In the Thorello device plasma is formed by feeding a hot cathode discharge in low pressure hydrogen in a toroidal vacuum chamber (R=40 cm, a=8.5 cm). The discharge is sustained by thermoionic emission of a spiral tungsten filament heated by a steady current. A set of external coils provides a purely toroidal magnetic field configuration, with B up to 0.2 T. A low temperature, low β, high density plasma column is steadily mantained and a turbulent regime with large amplitude intermittent fluctuations of the plasma parameters sets in. Average parameters of this plasma are T_e~1-4 eV, T_i~0.1-0.3 eV, n_i~5×10^{11} cm^{-3} on the column axis decreasing by two order of magnitude in the edge.

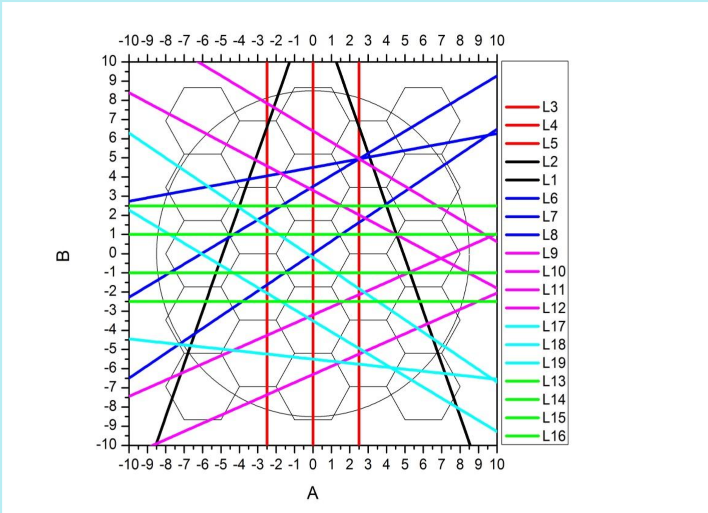




Mean emissivity profiles

Tomographic reconstruction

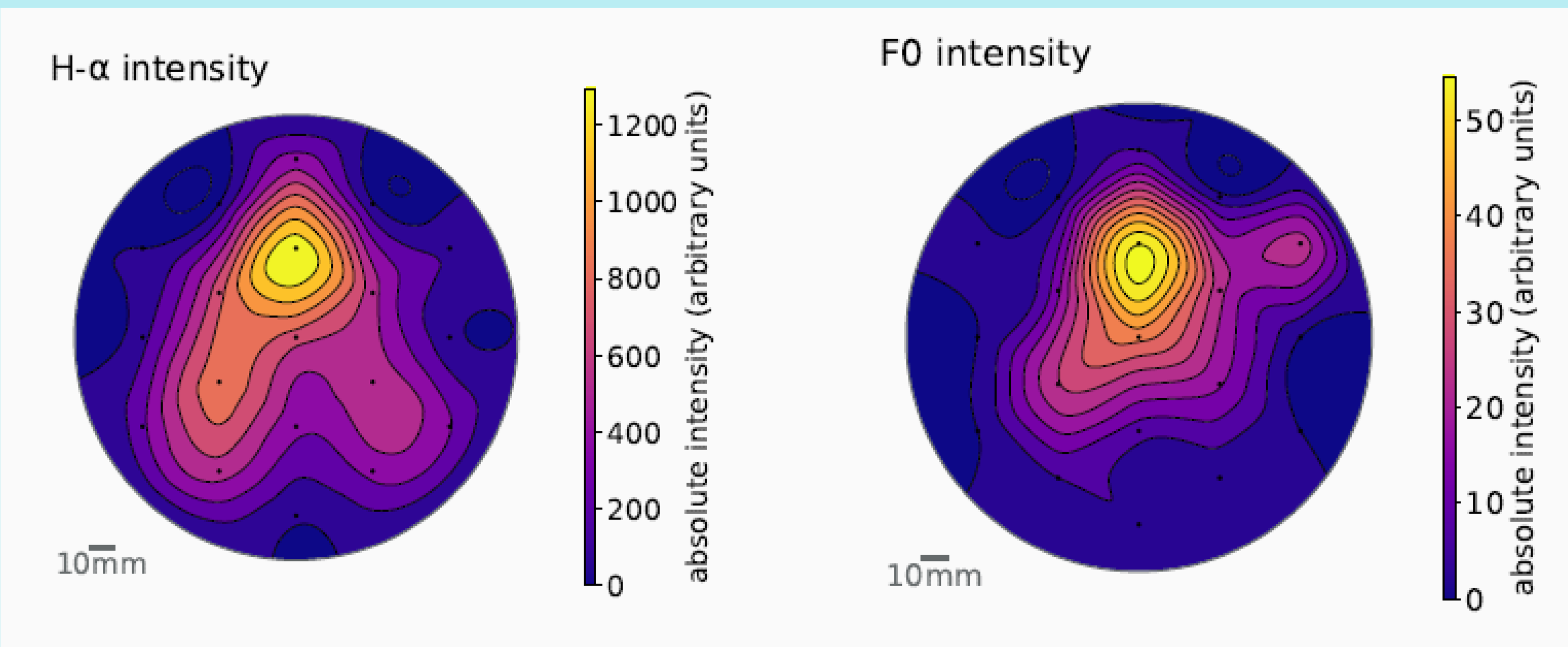
The reconstruction of the 2D pattern of emissivity in the SMT poloidal cross-section is undertaken from a 19 viewline average spectra dataset, using a tomographic approach. [see Barni et al. - *Plas. Sci. Tech.* **20**, 025102 (2018)].



Emissivity Profiles

The mean pattern of the emission profile was reconstructed for the Balmer Hα line and the first Fulcher-α diagonal band line F0. Both are maximal at the location corresponding to the filament magnetic shadow. The emissivity pattern show how the average plasma column extends asymmetrically towards edges, with the formation of protruding tails.

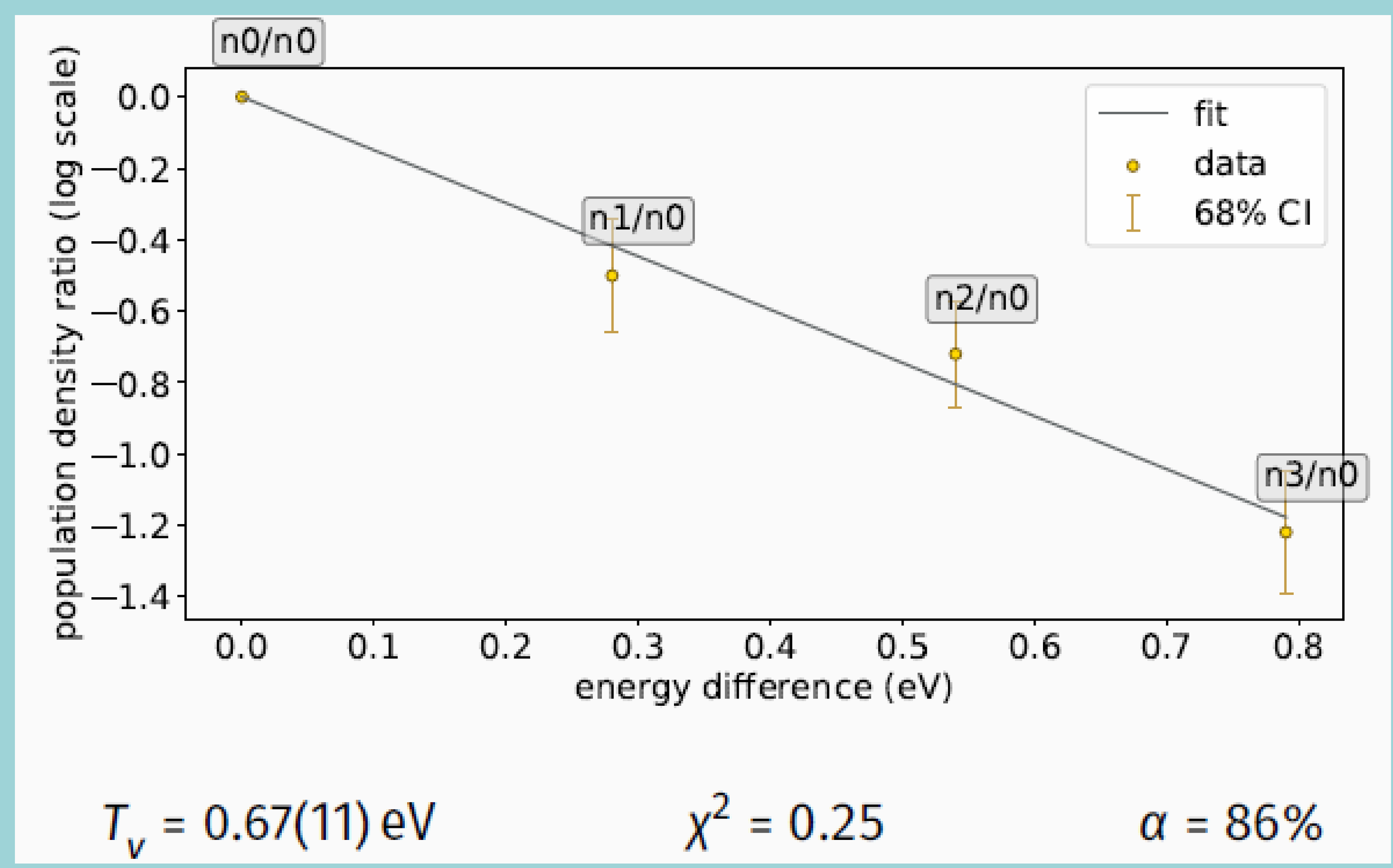
It could be noticed that, contrary to naive expectations, the molecular line pattern is more concentrated in the central region, around the filament magnetic shadow in the poloidal cross-section.



Analysis of the H2 Fulcher Band

Finally, from the reconstructed intensities of the diagonal bands, by using the relevant lifetimes and branching ratios [see Fantz et al. *Atomic Nuclear Data Table*, **92**, 853 (2006)] it is possible to estimate the relative population of the first four vibrational levels of the excited H2 3c state.

As it could be seen from figure, their distribution is roughly described by a Boltzmann factor, from which it is possible to extract an effective excitation temperature or, as it sometimes referred to, a vibrational temperature, in this case Texc=0.67±0.11 eV.
This should be compared with a central electron temperature of 4.4 eV.



Future prospects

Better spatial resolutions could be obtained by increasing the grid viewline, as well as using optimized profile extraction algorithms.

The measurement of time resolved line intensities will allow to reconstruct also the fluctuations and their spatio-temporal evolution by conditional sampling.

The development of collisional radiative models suitable for low temperature magnetised plasmas could also be considered. Such models link emissivity pattern and excitation temperatures to more plasma parameters, in particular electron temperature and density.

Conclusions:

- OES of magnetised plasmas takes advantage of the rich structure of emission spectra, even in hydrogen.
- 2D reconstruction of emissivity profiles is feasible and by using a somewhat easy to implement and cheap diagnostics.
- It allows to measure the pattern of emissivity, but also specific properties of the plasma state, such as the excitation temperature of the excited H2 3c-state.