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## Investigation of the Extreme-UV background emission in WEST tokamak

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## Background & Motivations

➤ Tungsten (W) density can be determined experimentally from its spectral line brightness [1]:

$$B_{ij} = \int n_e N_W f_z C_{ij} dl$$

- Errors in line brightness determination due to background estimation.

• Low Z spectra (Tore Supra):

- Small background compared to lines.

➔ Minor role on brightness values.

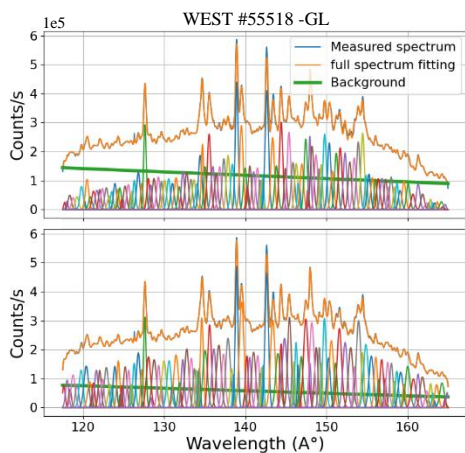
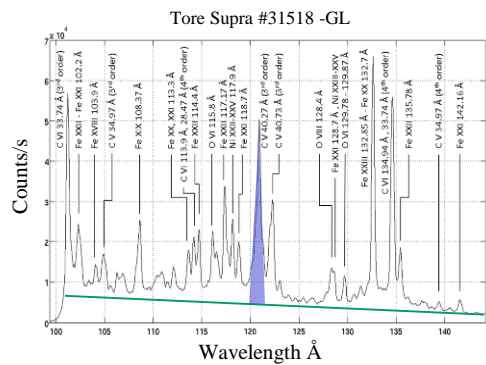
Uncertainties are small.

• High Z spectra (WEST):

- Apparent background is not small.

- Fitting procedure results depend strongly on the initial guesses.

➔ What is the background real value ?



We attempt to answer this question by assuming that the measured spectrum  $B_{tot}$  (in the wavelength region 115-165 Å) is composed of:

$$B_{tot} = B_{line} + B_{ff} + B_{fb} + B^{m>1}$$

Higher diffraction orders emission

## Higher diffraction orders emission

➤ Light propagation inside the spectrometer:

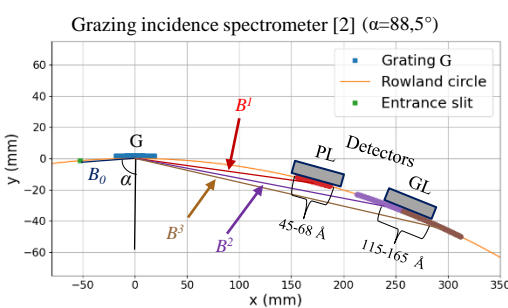
$$B^m(m\lambda) = B_0 E_G^m(\lambda) E_D(\lambda)$$

Measured brightness    Grating efficiency    Detector efficiency

$$\frac{B^{m>1}(m\lambda)}{B^1(\lambda)} = \frac{E_G^{m>1}(\lambda) E_D^{GL}(\lambda)}{E_G^1(\lambda) E_D^{PL}(\lambda)} = K^{m>1}(\lambda)$$

$$B^{m>1}(m\lambda) = B^1(\lambda) K^{m>1}(\lambda)$$

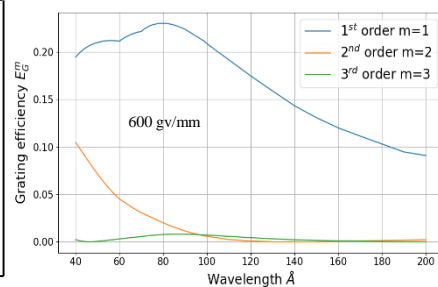
Higher orders    First order



Grating efficiency simulation

- Differential method [3]
- Wavelength region :  $\lambda = 40 - 200 \text{ \AA}$
- Grating parameters:

Grating length	Grating radius	Incidence angle $\alpha$	Blaze angle	Coating
35 mm	1999.5mm	88.50°	1.5°	Gold



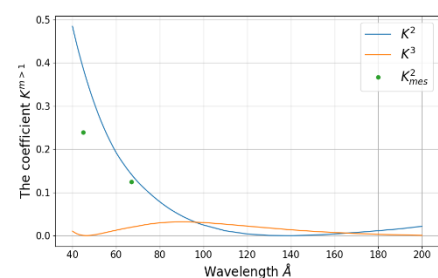
➤  $K^{m>1}(\lambda)$  coefficient :

relates the spectrum brightness of a particular order  $m$   $B^{m>1}$  to the first order spectrum  $B^1$ .

- Identical detectors (their efficiency ratio  $\sim 1$ )

- Good agreement: 2<sup>nd</sup> order  $K^2$  calculations and measurements.

- Errors : concave grating aberrations (5-15 %).



## Bremsstrahlung & recombination radiation

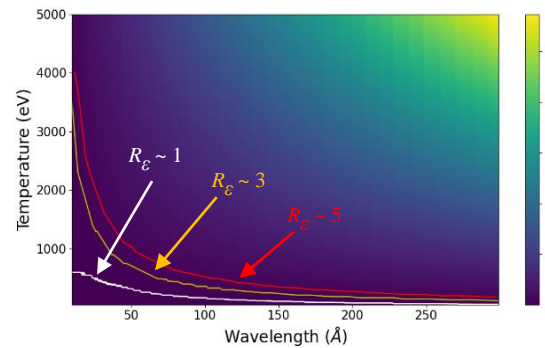
Continuum emission calculations (ff, fb)

- Maxwellian emission coefficients ( $C_{ff}$ ,  $C_{fb}$ ) [4].
- Impurity : tungsten ( $Z=74$ ).
- Wavelength range :  $\lambda = 10 - 300 \text{ \AA}$ .
- Temperature range :  $T_e = 50 - 5000 \text{ eV}$ .

Reasonable and fast estimation of the two processes

➤ The comparison of Bremsstrahlung (ff) and radiative recombination (fb) is done by calculating the local emissivity ratio  $R_e$  of the two processes:

$$R_e = \frac{\epsilon_{ff}}{\epsilon_{fb}} = \frac{\sum_z f_z C_{ff}^z}{\sum_z f_z C_{fb}^z}$$



- $\lambda < 50 \text{ \AA}$ : fb is not negligible and can be dominant below 500 eV.
- $\lambda > 50 \text{ \AA}$ : fb is negligible with respect to ff for almost all temperatures ( $\lambda=115-165 \text{ \AA}$  in particular).

➤ Total Bremsstrahlung [5] :  $\epsilon_{ff}(\lambda) = 9.584 \cdot 10^{-14} \frac{n_e^2}{\lambda \sqrt{T_e}} Z_{eff}^2 \bar{G}_{ff} \exp(-\frac{hc}{\lambda T_e})$

## Analysis of a low temperature spectrum ( $T_e \sim 1 \text{ keV}$ )

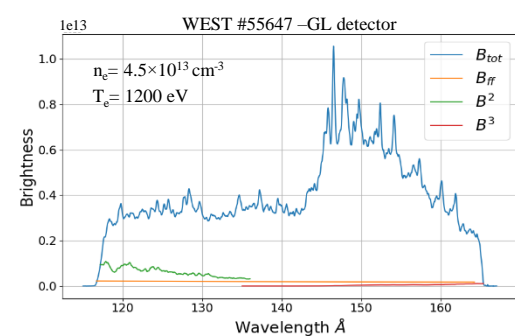
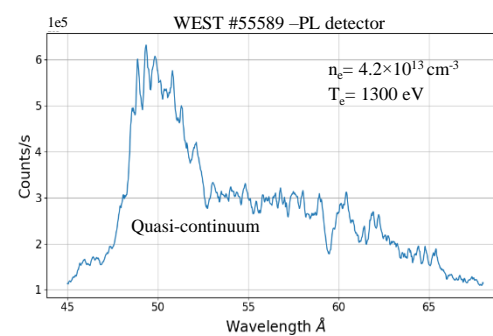
➤ Application to spectrum measured by GL (115-165 Å) during the discharge #55647:

Higher diffraction orders  $B^2$  and  $B^3$

- Estimated using a spectrum measured by PL (45-68 Å) during the discharge #55589.

Bremsstrahlung  $B_{ff}$

- Evaluated using #55647 plasma parameters and  $Z_{eff}=2.5$ .



- Bremsstrahlung ( $B_{ff}$ ) is negligible.
- 2<sup>nd</sup> order  $B^2$  may contribute to the spectrum.
- spectral lines dominate the emission (merge into an apparent background ?).
- Individual lines wavelengths above 145 Å correspond very well with those of 47-53 Å quasi-continuum, which casts some doubt on the 3rd order calculation.

➔ Uncertainties in line brightness (therefore W density) determination may not be small.

## Conclusion & Perspectives

- In the wavelength region 115-165 Å at low temperatures ( $T_e \approx 1 \text{ keV}$ ) :
  - Continuum emission (Bremsstrahlung and recombination) is very weak.
  - Higher diffraction order emission may contribute to the spectra.
  - Spectral lines dominate the emission.

$$B_{tot} = B_{line} + B_{ff} + B_{fb} + B^2 + B^3$$

➤ What about spectra measured in different wavelength and temperature ?

## References:

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