(TG3) Spectroscopy Topical Group Report

Nov. 2, 2022 (M. Yoshinuma)

Date: Nov. 1, 2022
Time: 13:05-16:45
Shot#: 182099 – 182157 (59 shots)

Prior wall conditioning: D2 glow
Divertor pump: ON (w/o 2I)
Gas puff: D2, Ar
Pellet: TESPEL(Fe, Ni, Cu, Ti, V, Mn)

NBI#(1, 2, 3, 4, 5)=gas(D, D, H, D, D)=P(2.1, 2.1, 3.9, 6.3, 8.4)MW

ECH(77GHz)=ant(5.5-Uout (and 1.5U), 2-OUR)=P(703, 792)kW
ECH(154GHz)=ant(2-OLL, 2-OUL , 2-OLR)=P(723, 799, 825)kW
ECH(56GHz)=ant(1.5U)=P(-)kW
ICH(3.5U, 3.5L, 4.5U, 4.5L)=P(-)MW
Neutron yield integrated over the experiment = 4.5×10^{16}

Topics

1. Impurity transport study in LHD D/H plasmas using VUV spectroscopy in experiment with TESPEL injection (T. Fornal, N. Tamura)
2. Impurity transport study in LHD D/H plasmas using VUV spectroscopy in experiment with TESPEL injections (M. Kubkowska, N. Tamura)

Impurity transport study in EC- and NBI-heated plasmas using VUV spectroscopy in experiment with TESPEL injections (T. Fornal, N. Tamura et al.)

Magnetic configuration: (R_{ax}, Polarity, B_t, γ, B_q) = (3.60 m, CCW, 2.75 T, 1.2538, 100.0%)
Shots: #182099 - #182127

Goal of this experiment

- To obtain the data in the **deuterium** plasmas by using **TESPELs containing triple tracers** for comparisons with the future results in W7-X
  - ✓ We have obtained the data in the hydrogen plasmas on Oct. 18.

Background & Motivation

- Investigation of impurity decay times in dependence of atomic number (Z) under given plasma conditions
  - ✓ Estimate an impurity decay time on the line intensity evolution for injected elements (**Ti, V, Mn, Fe, Ni, Cu**) and various density levels of plasma using EUV/VUV spectrometer SOXMOS (its wavelength range from 15 to 33 nm with a 133.6 g/mm grating)
- Comparison of experimental results obtained in EC and NBI heated plasmas with a considered electron density range of (1 – 5)E19
  - ✓ Data in EC-heated plasmas is obtained in the experiments proposed by M. Kubkowska
- Comparison of the experimental results in H and D plasmas is important

Impurity transport study in EC- and NBI-heated plasmas using VUV spectroscopy in experiment with TESPEL injections (T. Fornal, N. Tamura et al.)

Results

- **(Ti/V/Mn, Fe/Ni/Cu)-TESPELs are successfully injected** into the NBI-heated LHD D plasmas with n_e up to 3E19 m^{-3}

  3 heating patterns are applied

  A) NBI#1+NBI#2

  B) NBI#5+NBI#4(20ms on + 180ms off)

  C) NBI#5+NBI#4(180ms on + 20ms off)

Ti/V/Mn

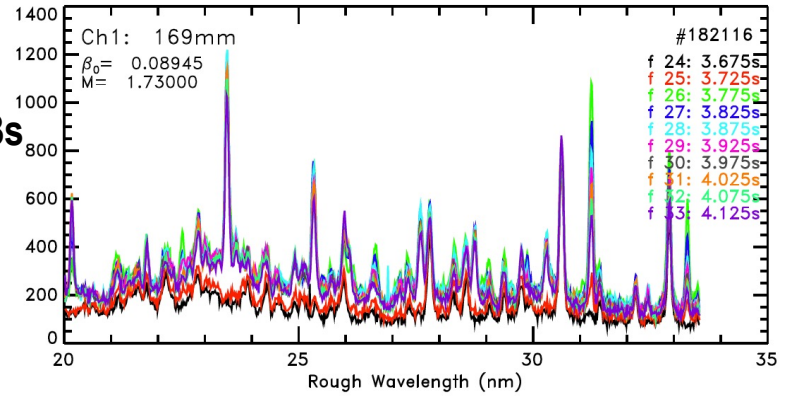
	Pattern A	Pattern B	Pattern C
1e19	✓	✓	✓
3e19	✓	✓	✓

Fe/Ni/Cu

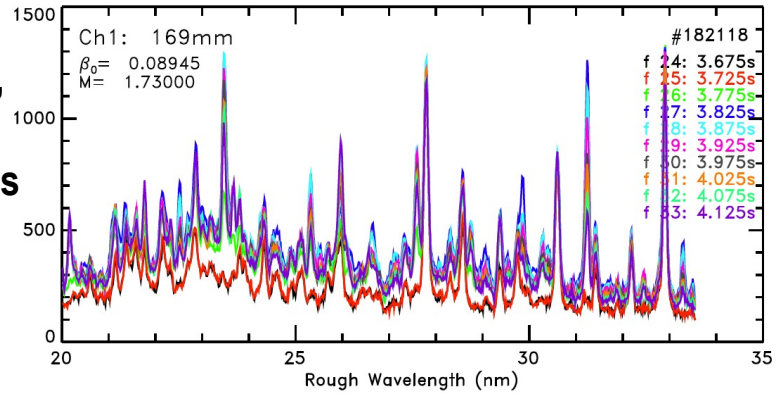
	Pattern A	Pattern B	Pattern C
1e19	✓	✓	✓
3e19	✓	✓	✓

- We obtained data in all the heating patterns
- Emission lines from Ti(22), V(23), Mn(25), Fe(26), Ni(28), Cu(29) have been observed clearly (see right figs.) → To be analyzed

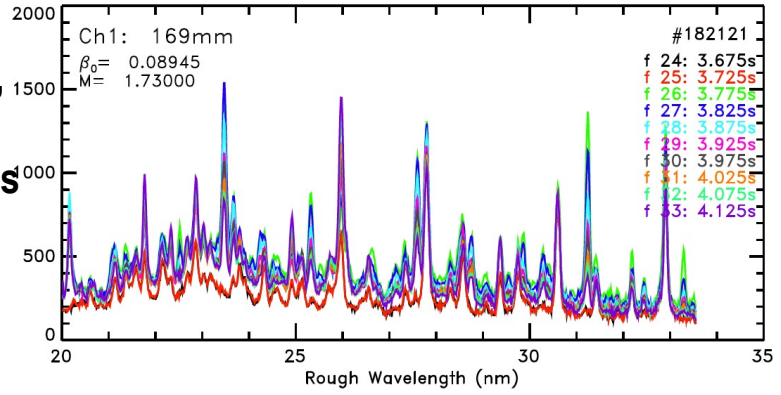
A) NBI#2+NBI#3, #182116@n_e~3e19 m^{-3} Ti/V/Mn-TESPEL@3.73s



B) NBI#5+NBI#4 (20ms on + 180ms off), #182118@n_e~3e19 m^{-3} Ti/V/Mn-TESPEL@3.73s



C) NBI#5+NBI#4 (180ms on + 20ms off), #182121@n_e~3e19 m^{-3} Ti/V/Mn-TESPEL@3.73s



Impurity transport study in LHD D/H plasmas using VUV spectroscopy in experiment with TESPEL injection (M. Kubkowska, N. Tamura et al.)

Magnetic configuration: (R_{ax}, Polarity, B_t, γ, B_q) = (3.60 m, CCW, 2.75 T, 1.2538, 100.0%)
Shots: #182128 - #182157

Background

- In the recent LHD experiment, a successful TESPEL injection was obtained for an electron density of $1 – 2 \times 10^{19}$ m^{-3}. For higher density experiment was not conducted or the plasma collapsed. The main aim of this experiment is to obtain the data by using TESPELs containing triple-tracers (Ti/V/Mn and Fe/Ni/Cu) to complete the data in the **deuterium** plasmas obtained in the last experimental campaign and for comparison with the future results in W7-X.

Objectives

- Estimate the impurity decay time based on the line intensity evolution for injected elements
- Estimate the impurity decay time based on the line intensity evolution for various electron densities of plasma (1-5E19).
- Calculation of turbulent and neoclassical radial transport of the impurities, as well as their diffusion and convection coefficients (in collaboration with CIEMAT).
- Preliminary calculation of the TESPEL shell ablation and deposition (in collaboration with CIEMAT)

Impurity transport study in LHD D/H plasmas using VUV spectroscopy in experiment with TESPEL injection (M. Kubkowska, N. Tamura et al.)

Results

- **(Ti/V/Mn, Fe/Ni/Cu)-TESPELs are successfully injected** into the ECR-heated LHD D plasmas with n_e up to 3E19 m^{-3}
  - ✓ The combination of tracers is different from the previous campaign (quadruple: **V/Mn/Ni/Fe** or **V/Mn/Ni/Cu**) ← **Too much!**

Ti/V/Mn

	1e19	(Opt: 2e19)	3e19	(Opt: 4e19)
3 x 154 GHz (2.35 MW)	✓	Not conducted	✓	Not conducted
2 x 154 GHz (1.53 MW)	✓	Not conducted	✓	Not conducted

Fe/Ni/Cu

	1e19	(Opt: 2e19)	3e19	(Opt: 4e19)
3 x 154 GHz (2.35 MW)	✓	Not conducted	✓	Not conducted
2 x 154 GHz (1.53 MW)	✓	Not conducted	✓	Not conducted

- In n_e of 3E19 m^{-3} with a lower P_{ECH}, the plasma collapsed a short time after the TESPEL injection → a good imp. confinement in D plasma
- Emission lines from Ti(22), V(23), Mn(25), Fe(26), Ni(28), Cu(29) have been observed clearly (see right figs.) → To be analyzed