Molecular Deuterium Behaviour in Tungsten Divertor on JET


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**MOTIVATION**

Recycling in the divertor plays an important role for plasma fuelling in a tokamak. Neutral particles are formed on the target surface due to neutralization of the impinging plasma ions. Then the neutrals are reemitted from the surface and ionized in the plasma. Depending on the material and the surface temperature, deuterium can be reemitted as an atom or molecule. In contrast to an atom, a molecule has a longer ionization chain in the plasma due to the additional dissociation process. The source position of the charge particles inside the plasma strongly depends on the type of reemitted particles. In addition, the presence of vibrationally excited deuterium molecules can increase the recombination rate in cold plasmas and have vital impact on the divertor operation. The previously performed JET measurements with the full carbon divertor [1] have confirmed that deuterium release from the divertor walls dominates in the form of molecules as in TEXTOR [2]: molecules contribute more than 70% to the total deuterium influx.

**MOLECULAR DEUTERIUM SPECTROSCOPY**

- Fulcher-a band (\(\nu_p \rightarrow \nu_a+1\)) is brightest transition in the visible spectral range 600-660 nm
- Vibrational bands with \(\nu_a\) are visible: \(\nu_0=0 \rightarrow \nu_a=0, 1, 1, 2, 2, 3, 3, 4, 4, 5, 5\)
- Each band consists of R (\(\Delta \nu=+1\), Q (\(\Delta \nu=0\)) and P (\(\Delta \nu=-1\)) rotational branches
- At present time only Q rotational branches are suitable for data analysis

**DIVERTOR SPECTROMETER SYSTEM KT3B [3]**

- 22 viewing chords across outer divertor
- Spectrometer equipped with CCD camera grating 1200 lines/mm, slits width 20 µm, dispersion about 0.128 nm/pixel, 1024 pixels, pixel size 13 µm
- Population measurements were performed in a series of reproducible pulses #81271-
- Plasma parameter flat-top 55 s - 64 s
- 1MW NBI + 0.5 MW ICRH
- \(Te(core)\) = 50 55 60 65 70
- Ip=2.0MA, \(Bt=2.4T\)
- Covered within 3 pulses.

**EXPERIMENTAL RESULTS**

- 17 first lines of Q(0)-0 could be resolved
- \(Trot(\nu_0)\) almost factor of 2 higher \(Trot(\nu_1)\)
- Remarkably high population of \(\Delta \nu=0\) and non-Boltzmann population of ground state

**CONCLUSIONS**

- Molecular deuterium was spectroscopically observed in full tungsten JET divertor
- High rotational temperature of the excited Q(0)-0 correspond to rotational temperature of the ground state about 5000 K
- Remarkably high population of \(\Delta \nu=0\) level can indicate non-Boltzmann vibrational population of the ground state of deuterium molecules at a strike point in the attached L-mode plasma
- In detached plasma the molecular line emission is strongly suppressed due to high local electron densities and dramatic increase of DXB coefficient.
- The rotational temperature also reduces due to drop of local electron temperature at the strike point during detachment

**ACKNOWLEDGEMENTS**

This work was supported by EURATOM and carried out within the framework of the European Fusion Development Agreement. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

**REFERENCES**


**FIGURES**

- Figure 1: Viewing chords of KT3 spectrometer and gas injection positions
- Figure 2: Combined molecular deuterium Fulcher-a band spectrum
- Figure 3: Boltzmann plot for rotational sublevels
- Figure 4: Vibrational population of Q(0) state
- Figure 5: Calculated \(\Delta \nu=0\) vib. populations
- Figure 6: Measured profiles at t=55-63s, #81271
- Figure 7: Trot and molecules density evolution at strike point
- Figure 8: L-mode pulse #81271, Br=2.472(0.04A)
- Figure 9: Intensity of continuum radiation at \(\lambda=611\) nm
- Figure 10: Intensity of Q(0)-0 branch
- Figure 11: Rotational temperature of Q(0)-0 branch
- Figure 12: H-mode density limit, #81233, Br=2.372(0.04A)
- Figure 13: Intensity of continuum radiation at \(\lambda=608.4\) nm
- Figure 14: Intensity of Q(0)-0 branch
- Figure 15: Rotational temperature of Q(0)-0 branch

**DATA TABLES**

- Table 1: Summary of experimental parameters
- Table 2: Molecular deuterium population ratios
- Table 3: Rotational temperature

**ADDITIONAL INFORMATION**

- DIVERTOR SPECTROMETER SYSTEM KT3B: KT3B is a spectrometer system designed for the study of deuterium behavior in the JET divertor.
- EXPERIMENTAL RESULTS: Results from the experimental measurements are shown, including population measurements, rotational temperature, and molecular deuterium behavior.
- CONCLUSIONS: The conclusions drawn from the experimental results are presented, highlighting the significance of molecular deuterium in JET divertor conditions.

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