1. Introduction

We present results of a study of the negative ion population in a helicon plasma device, measuring H densities of over $1 \times 10^{18}$ m$^{-3}$.

2. Motivation

Negative ion sources are required for neutral beam injection (NBI) systems for tokamaks (e.g. [1, 2]). Negative ions are produced, accelerated and neutralised to form high-energy neutral beams for heating and fuelling the plasma. Neutralisation process is more efficient for negative ions than for positive ions.

However, formation of negative ions currently needs a caesium catalyst.

3. Experimental equipment

MAGPIE is a linear machine with a helicon plasma source (shown in Figure 2) [5].

- Separate source and target magnetic field coils produce a tailored mirror field profile.
- 20 kW of pulsed power at 13.56 MHz.

Diagnostic techniques:

- Laser photodetachment [6]: negative ion density.
- B-dot probe: magnetic field strength.

<table>
<thead>
<tr>
<th>Pulse parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Pulse duration</td>
<td>40 ms</td>
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<tr>
<td>Gas pressure</td>
<td>10 mTorr</td>
</tr>
<tr>
<td>Source field current</td>
<td>50 A (~10 mT)</td>
</tr>
<tr>
<td>Mirror field current</td>
<td>800 A (~170 mT) peak</td>
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</tbody>
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4. Results

The electron temperature ($T_e$) and density ($n_e$) profiles throughout a pulse are shown in Figures 3 and 4. The negative ion density ($n_i$) evolution is shown in Figure 5.

Figure 6 shows the time evolution of each parameter for an axial position of 500 mm.

- Obtained $n_i > 1 \times 10^{18}$ m$^{-3}$.
- Profiles evolve throughout the pulse, resulting in a transient peak in $n_i$ lasting a few ms.
- $n_i$ peak corresponds to the region of low temperature.
- Peak position is around the peak magnetic field (~500 mm).
- As the electron heating region propagates forward, $n_i$ decreases in front of it.

5. Conclusions

Promising results for the future of negative ion sources for NBI systems:

- Observed negative ion densities of above $1 \times 10^{18}$ m$^{-3}$ (factor of ten higher than the estimated level required).
- Negative ion evolution throughout the pulse correlates well with the rate coefficients expected from the electron temperature measurements.
- Possible Alfvénic wave modes identified after $n_i$ has peaked.

Further work:

- Develop an operation regime with aims to maintain high negative ion densities.
- Investigate $n_i$ production in deuterium [3].

6. References