Physics of negative ions and helicon waves in a resonant antenna plasma source for neutral beams


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1. In short

- Helicon sources for NIBs: Helicon plasma as negative ion sources could have advantages over traditional ICPs:
  - 1) reduced RF power
  - 2) stable operation at low pressure (~0.3 Pa) resulting in low electron stripping losses
  - 3) higher efficiency of negative ion production in volume-production mode, and a high degree of molecular dissociation, which would be favorable in a caesiated source
  - 4) by producing a magnetized plasma column, they are well-adapted to a blade-shape geometry, such as those required for photo-neutralization devices.

- RAID [1] is a high-power (up to 20kW) helicon source equipped with resonant antennas [2]
  - Helicon plasma in hydrogen and deuterium can be produced and sustained in steady-state
  - RAID plasma exhibits a negative ion-rich shell
  - The maximum negative ion density increases with injected RF power
  - A 1.5 D fluid model coupled to experimental Tin and n in profiles reproduces many observed features
    - Negative ions are generated by dissociative attachment on re-vibrationally excited H2 molecules
    - In the plasma column center, hot electrons destroy H by electron detachment and mutual neutralization. At the edge of the plasma column, atomic detachment destroys H
  - Extraction of negative ions
    - A radial extractor has been developed
    - First experiments demonstrated negative ion extraction

2. The Resonant Antenna Ion Device (RAID) [1]

3. Physics of helicon waves [3,4]

4. The physics of negative ions [10,12]

5. 1.5D fluid model and complex H/Deutchy [5,6,9]

6. Negative ion extractor design and first experiments

References
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