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Design of a Permanent Magnet System for the Production of Closed Resonance Surfaces in Microwave Discharge Ion Sources

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The production of high current beams of multiply charged ions has many applications, such as accelerator-based medical isotope production and optimisation of the atomic to molecular ion ratio in high-current proton sources relevant for major accelerator facilities. Microwave discharge ion sources are one option for production of ion beams. These sources require a system to generate a magnetic field which is resonant with a coupled microwave input to generate the plasma.
In simple designs using solenoid magnet coils, the resonant field surface that is produced is open ended and leads to poor plasma confinement and these ion sources producing only singly charged ions. Other designs require complex magnet arrays which combine solenoid and multipole fields to form a closed resonant surface, at the expense of lower beam currents but can achieve multiple charge states.
We present here the design of a novel method for generating a closed resonant field surface from a simplified permanent magnet array without a solenoid. The magnet system consists of an array of permanent magnets rods and steel pole pieces whose arrangement can produce the closed surface without the requirements for any electrical power. A mechanical tuning system allows adjustment of the shape and size of the closed resonant surface.
A prototype proof of principle device has been designed for application to a 2.45 GHz microwave source. The prototype has been built to measure the magnetic field distribution created by this magnetic array and to test the generation and tuning of the closed resonant field surface.
Future work will aim to test this magnet device on an operational plasma chamber to measure how the plasma density can be adjusted through tuning of the closed resonant field surface.

Primary authors: HINTON, Alex (STFC); SHEPHERD, Ben (STFC); FAIRCLOTH, Dan (STFC); ELAHEE DOOMUN, Kareem (STFC); TARVAINEN, Olli (STFC)

Presenter: HINTON, Alex (STFC)

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