- IFSA2025 –

Multi-state Fusion Reactor for Diverse Applications

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Conventionally, neutron sources utilizing gas fusion fuel such as deuterium (D) and tritium (T) exhibit low efficiency (less than 10%) and limited neutron output (less than 5E8 n/s for DD fusions and less than 1E9 n/s for DT fusions), hampering their high-duty applications such as medical radionuclide generation for cancer diagnosis and treatment, boron neutron capture therapy (BNCT), and fission-fusion driven systems. In contrast, Astral Systems' innovative reactor architecture incorporating multi-state and lattice confinement fusion principles effectively addresses these limitations by transitioning the dominant fusion environment to the material phase [1-3]. This approach results in enhanced efficiency and increased neutron flux. More specifically, architecture allows for unparalleled neutron fluence performance in a compact, modular, and scalable form factor which is highly attractive for hybrid fusion driven fission applications. Astral Mark I neutron reactor has successfully reached a target neutron output of 1E9 n/s using DD fusions. Moreover, the fabrication of the Astral Mark II reactor is currently underway, with the objective of achieving over 5E9 n/s for DD and exceeding 5E10 n/s for DT, enabling applications such as production of medical radionuclides, BNCT, neutron activation analysis (NAA), materials analysis, nuclear security, fission-fusion driven system and nuclear waste treatments. In this contribution, design principles, architecture, and comprehensive characterization of the reactor will be discussed, including examples of applications using the existing Astral Systems’ irradiation facility. In addition, proof of principle experiments for radiography and NAA using the reactor will also be discussed.

References

1. Fusion Science and Technology, 75(6), 479–486.
2. PHYSICAL REVIEW C 101, 044609 (2020)
3. NASA/TM—2015-218491/REV1