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Until 8 a.m. EDT, Monday, November 17, 2025
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First Plasma in Revolutionary "Junior" Levitated Dipole Fusion Experiment

New Zealand based OpenStar Technologies achieved a key milestone for under $10 million USD in less than two years with the levitated dipole approach to plasma confinement.

LONG BEACH, Calif. — Early observations of dipole-like planetary magnetospheres, like the magnetic poles on both Earth and Jupiter, revealed a naturally stable phenomena that has been confining plasma for billions of years. The late Professor Akira Hasegawa proposed that the recreation of these magnetospheric conditions in a lab would provide scientists with ideal conditions for plasma confinement.

OpenStar's prototype device, "Junior," proved the viability of the levitated dipole method for plasma confinement with the achievement of their first supported plasmas in 2024 (Figure 1). Unlike conventional fusion reactors that require multiple interlocking magnetic coils, Junior uses a single superconducting magnet made up of 14 non-insulated High-Temperature Superconducting (HTS) coils to confine plasma.

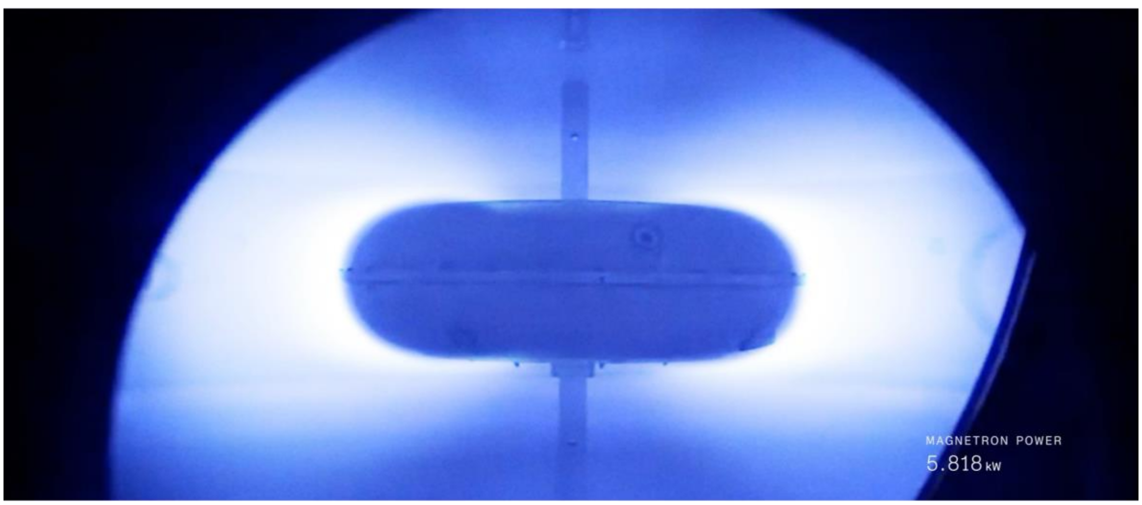

Figure 1: First plasmas in Junior, Oct. 31, 2024. "Junior" sits in the center of the chamber with dipole shaped field lines confining a white-blue glow, the plasma, around it. A shaft passes through the center which is used to move the magnet from its docked position to the center of the chamber.

Junior is designed to reach a peak field of 5.6 Tesla and operates inside a 5.2-meter vacuum chamber. Plasma heating is achieved using electron cyclotron resonance heating, the same power as your household microwave. OpenStar's first plasmas reached around 300,000 C which, although modest for a fusion device, demonstrated the key systems working together for the first time.

A vital component of the levitated dipole reactor is that its core magnet must levitate while in operation, confining the plasma around it. Because of this, the device must contain an onboard power supply, a requirement which has shelved the dipole approach for years. OpenStar's key innovation is a solution to this dilemma: a novel power supply known as a "flux pump." For their 2024 plasmas, the flux pump stored 87 kilojoules of magnetic stored energy, the largest ever delivered to an HTS magnet. In 2025, OpenStar broke this record again, reaching 170 kilojoules.

Previous experiments on the Levitated Dipole Experiment (LDX) at MIT between 1998 and 2014 demonstrated that the dipole configuration produces a turbulent inward "pinch" effect that naturally confines plasma and drives peaked pressure and temperature profiles. Dr. Darren Garnier worked as the chief experimentalist on these seminal experiments before becoming OpenStar's Chief Science Officer.

"I've been fortunate to witness first plasmas on Alcator C-Mod and LDX at MIT, but first plasma on Junior is special," Garnier said. "OpenStar went from concept to plasma in just two years, and demonstrated a functioning flux pump onboard power supply — an enabling technology that has revived the concept of the levitated dipole reactors and unlocked its scalability."

During OpenStar's first experimental campaign in late 2024, they conducted seventeen plasma shots over two days of operation using helium gas, all of which displayed their predicted stability. These experiments demonstrated the potential of maintaining strong magnetic fields without physical connections to external power sources — a critical requirement for levitated operation.

OpenStar has since engineered another vital component for their approach: the levitation system. This consists of a second superconducting magnet that sits on top of the vacuum chamber to hold the core magnet in its levitated position. Experiments with the fully levitated system are currently underway, which will enable investigation of the unique properties that make levitated dipoles promising for fusion energy production.

Junior will continue as a valuable research device for plasma physics, space physics, magnet technology and astrophysical magnetospheres. The device will receive upgrades in parallel to the development of future reactors, such as to the magnet systems, plasma heating, and plasma diagnostics. OpenStar's next machine, "Tahi," will be designed to achieve sufficient magnetic fields and heating power for fusion-relevant plasmas.

Based in Wellington, New Zealand, OpenStar invites external researchers to use the Junior experiment as part of their commitment to advancing science through collaboration. The modular design decouples the magnet and vacuum vessel engineering, allowing the core magnet to be easily removed, upgraded or swapped for different designs with relatively little downtime as well as easy diagnostic access.

The rapid construction timeline and low cost of the Junior experiment can be attributed to the relative simplicity of the levitated dipole concept. Requirements for each machine OpenStar develops will be informed by its predecessors and the dipole's elegance and modularity make it an inherently scalable and economically viable device. Junior has achieved world-firsts in magnet technology and places OpenStar at the forefront of dipole development. They're now poised to contribute substantially to the global effort toward fusion power while providing a unique research platform for additional technologies.

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Abstract

JO05.9	OpenStar Technologies: Progress towards Levitated Dipole Reactors
Session	JO05: MFE: Self-Organised Plasmas and Magnetic Mirrors 2:00 PM–5:00 PM, Tuesday, November 18, 2025 Room: 104C