SPiZF: A Private Fusion Initiative in India

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Topics

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Communication type

Poster

Abstract

SPiZF (Stabilized Plasma in Z-Pinch Fusion) is a `private fusion' technology initiative launched in the second half of 2025 in India; based on alternate magnetic confinement scheme aimed at achieving and demonstrating commercial `thermo-nuclear fusion' by 2032-2033. SPiZF promises a compact fusion device that would be portable that is appropriate for nano-grids, low cost and scalable. Its simple geometry, unity beta and absence of expensive technological elements such as external magnets, cryogenics, heating systems and lasers etc puts SPiZF ahead of its competitors and enhances its possibility at the earliest realization. The sheared-flow stabilization in SPiZF would enable the desired equilibrium that would sustain the compressed plasma state for durations much longer than other plasma timescales i.e. instabilities. On completion of the feasibility study that includes a 0-D adiabatic scaling and some MHD modelling, SPiZF has now embarked upon the essential technological stages of realizing an appropriate SiC MOSFET based pulsed power technology, durable electrodes materials technologies and configurations, fast diagnostics techniques and neutrons detection in stage-I till 2030-2031. In parallel, liquid metal technologies including circulation loops, hydrogen isotope separation, tritium breeding technological arrangements with ratio exceeding unity and thermos-electrical conversion systems are being studied for phase-II of SPiZF till 2032-33. SPIZF is milestone based. Milestone-1 till 3 envisaged during 2028-2030 would demonstrate plasma currents of 300-700 kA in submillimetre pinch radius with density in the range of ~ 5 X 10^24 m-3, plasma temperature in the range of 1-5 keV, energy confinement times in the range of 2-5 μs and Lawson Criterion in the range of 2 X 10^19 – 2 X 10^20 sm^-3. This would be at the threshold of `scientific breakeven'; after which the `engineering breakeven' and `prototype reactor' conditions would be realized by 2032-2033. As spin-offs, X-ray and thermonuclear neutron sources based on SPiZF topologies are likely to emerge for commercial applications. The X-ray sources will be hot (1-2 keV), intense (10 MW), long pulse (> 10 μs) and energetic (>100 J/pulse). On the other hand, the neutron sources would be 2.54 MeV neutron with a yield of ~ 1 x 10^10 neutron yield per pulse with 20 millijoule per pulse. The basic design studies from physics and engineering considerations, the technological elements along with their roadmap synced with the SPiZF milestones would be highlighted in this paper.

#13501

Boron Hydrides: A Fuel of Choice for p-B Fusion?

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Topics

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Oral

Abstract

Aneutronic proton–boron (p–B) fusion — in which a proton fuses with a boron-11 nucleus to produce three alpha particles — promises a revolutionary source of clean, radiation-free energy. Yet despite its appeal, progress towards a practical p–B fusion fuel has been limited. To date, most experimental targets have relied on boron compounds containing additional elements such as nitrogen, silicon, or carbon-rich polymers. These materials not only dilute the boron content but also introduce unwanted contaminants that divert energy away from the desired fusion reaction. In this context, boron hydrides (boranes) represent an intriguing and largely unexplored alternative. Composed solely of boron and hydrogen, boranes form a rich family of polyhedral, spherically aromatic clusters. Though absent in nature, they can be readily synthesised in laboratories like our own from abundant raw materials, with production scalable from milligrams to kilograms. In this contribution, we report the first demonstration of solid boranes as a fuel for laser-driven p–B fusion.1 Using an “in-target” geometry, the solid boron hydride anti-$B_{18}H_{22}$ (octadecaborane) produced a remarkable yield of approximately 10^9 alpha particles per steradian under sub-nanosecond, low-contrast laser irradiation (PALS, ~10^{16} W cm^{-2}). This result not only highlights the promise of boron hydrides as efficient and clean fusion fuels, but also opens a new avenue for exploring molecularly engineered targets in aneutronic fusion research.

#13503

Laser borane and plasma studies with B18H22 derivatives

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Topics

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Oral

Abstract

In our pursuit of new and improved laser systems based on B18H22, we investigated substitution reactions on the boron cluster, in which hydrogen atoms are replaced by different elements. One such modification involved the chlorination of octadecaborane (B18H22). We report the synthesis, separation, and photophysical characterization of several chlorinated derivatives of B18H22. The effect of temperature, which leads to a variety of substitution patterns on the 18-vertex boron cluster, is discussed. The photophysical properties of selected compounds were examined. These findings provide valuable insights into the influence of chlorination on the photophysics of octadecaborane and, more generally, reveal how the position of substituents on the boron cluster affects the emission wavelength, excited-state lifetimes, and quantum yield. Taken together, this information opens a promising new pathway for the design of B18-derivative molecular systems with enhanced emission properties. Furthermore, the application of compounds like these for the study of plasma properties is discussed as part of the broader Vortex 4 Fusion project, which aims to provide more information about boranes as potential fusion fuels.

#13723

The FLARE Reactor concept: Shock management and neutronics

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Abstract

In addition to the familiar functions of capturing neutron energy, breeding tritium and providing a coolant for heat extraction, inertial dt fusion reactors must typically also manage the shockwave driven by the pulsed energy delivery. In this work we show how the reactor in our FLARE concept (Fusion Via Low-Power Assembly and Rapid Excitation) uses a natural lithium blanket to perform these multiple simultaneous roles. A thick (2m), in-vessel, natural lithium blanket - made possible by ambient pressure operation - almost completely surrounds the neutron source, providing lithium first-wall, tritium breeding, energy capture, energy gain, coolant and shock mitigation functions. Transient structuring of the lithium is shown to reduce the shock intensity to manageable levels through expansion, reflection, scattering and absorption of the shock energy. The lithium is in its natural Li6/Li7 isotopic mix without neutron multipliers or Li6 enrichment. The combination of high solid-angle coverage by a thick lithium blanket and the availability to the lithium of the un-moderated native fusion neutron spectrum leads to high neutron energy capture (> 99.9%) and a Tritium Breeding Ratio (TBR) of 1.8 with low vessel neutron damage and consequently long vessel lifetimes (> 60yrs). Fusion reactor designs with an overall TBR greater than the engineering threshold for tritium self-sufficiency, expected to lie between 1.05 and 1.2, may complement break-even or simpler zero-TBR reactors in the future fusion economy.

First French fusion project based on modern open magnetic traps

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Topics

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Oral

Abstract

Plasma confinement and heating in open magnetic systems have been studied in parallel with tokamaks and stellarators since the 1950s. At that time, longitudinal plasma losses prevented the achievement of the record temperatures possible in tokamaks, and by the beginning of the 21st century most magnetic mirror–based fusion facilities had been shut down. However, results obtained at the remaining facilities at the Budker Institute of Nuclear Physics (Russia) and the University of Tsukuba (Japan), together with advances in magnetic and heating technologies as well as new theoretical findings, have revived interest in this area. Open traps have a number of fundamental advantages over closed systems. For example, open magnetic field lines allow the natural formation of a divertor of arbitrary size, reducing the heat flux on the material to an acceptable level. The linear design enables the use of simple ring magnets with very large magnetic fields, which can be effectively isolated from the neutron flux. The simplicity of the geometry makes it possible to take advantage of a modular design and achieve plasma beta values above 50%. This report presents a project aimed at the development of open magnetic traps with ultra-strong coils for fusion plasma confinement. The project is currently being launched in France by the private company Dicio Conflatio.