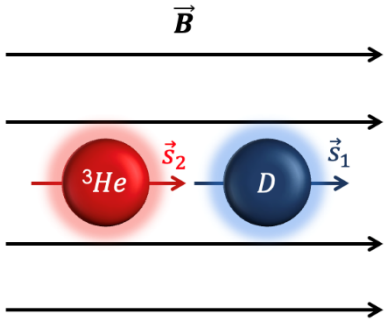
University-national laboratory collaboration receives DOE Fusion Energy Sciences award to advance spin-polarized fusion at DIII-D, aiming to increase power output by greater than 50%

Experts in plasma and nuclear physics to establish a collaboration funded by the US Department of Energy to perform research at the DIII-D National Fusion Facility developing a promising approach to advance the power output of magnetic fusion reactors.

San Diego, 5 October 2023 - Researchers at four institutions including University of California Irvine (UCI), Thomas Jefferson National Accelerator Facility (Jefferson Lab), University of Virginia (UVA), and Oak Ridge National Laboratory (ORNL) have been awarded funding from the Department of Energy (DOE) to establish a collaboration to study a fusion reaction known as "spin-polarized fusion" at the DIII-D National Fusion Facility. This multi-year collaboration aims to study the polarization lifetime of nuclei in fusion reactor fuel. The work has the potential to increase fusion power, making it easier to develop a fusion pilot plant. The award is part of the DOE Fusion Energy Sciences DIII-D program, and the associated announcement and funded projects can be viewed here and here, respectively.

All atomic nuclei spin in a specific direction, and spin-polarized fusion takes advantage of this property to create a fuel in which the orientation of individual nuclei is aligned with the magnetic field. This alignment is predicted to increase the number of reactions and thereby increase fusion power, with the fusion energy gain expected to increase by greater than 50% compared with the gain of unpolarized fuel. The increase in the reaction rate requires that this parallel spin state, called polarization, be maintained for longer than the amount of time a typical fuel ion spends in the device. A pair of published companion papers (Baylor et al. and Garcia, Heidbrink, and Sandorfi) describe the collaborators' plans for the first experimental tests of these expectations.



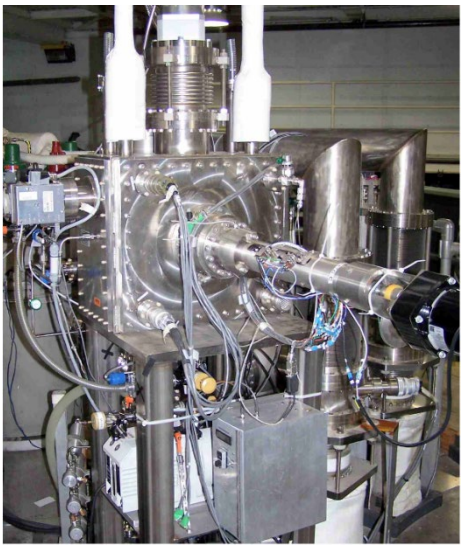
Alignment of ^{3}He and ^{2}H nuclear spins with a magnetic field.

The technology required to test these predictions has become available only recently, and scientists have finally developed the means to produce spin-polarized fuel pellets. What is not known is how long polarization can be maintained. The collaboration at DIII-D will create spin-polarized fuel and test the lifespan of the polarization to determine if polarized fuel is a viable approach for commercial fusion.

To achieve these goals, this project will bring together experts in both plasma physics and nuclear physics. According to the project lead, UC Irvine Distinguished Professor William Heidbrink, "This project brings together experts in making polarized fuel, in delivering the fuel to the tokamak, and in fusion experiments to complete this challenging, novel research. We're all learning from each other."

This award also includes funding to support students and early-career scientists as team members for this work in the DIII-D program. These young scientists will benefit from the opportunities to participate in transformative research and learn from colleagues in different fields within the collaboration as well as the larger program, building the fusion workforce of the future.

Although tritium (^{3}H)–deuterium (^{2}H) reactions are the expected approach in fusion power plants, the ^{2}H –helium (^{3}He) reaction will be used in this research to avoid the complications and expense incurred



DIII-D pellet injector system developed by Oak Ridge National Laboratory.

with tritium handling. The ^{2}H–^{3}He reaction is a mirror nuclear reaction of the ^{2}H–^{3}H reaction, having nearly identical nuclear physics without the risks associated with radioactive material. The polarized ^{2}H fuel will be produced at Jefferson Lab, while the polarized ^{3}He fuel will be made at UVA.

Additionally, ORNL will expand its ongoing work in pellet injector systems to create a unique pellet injector for spin-polarized fuel introduction. The diagnostic expertise at UCI will be utilized to create a new diagnostic that measures fusion reaction products to monitor polarization. This is an exciting advance, as nuclear polarization has never been measured in a fusion device.

Completing this project will require the development of a new plasma scenario at DIII-D, exploiting the flexibility of the machine to explore a new approach for achieving commercial fusion. As Dr. Richard Buttery, Director of the DIII-D National Fusion Facility, explains, “This project exploits a unique combination of innovative technologies, plasma flexibilities, and measurement systems at DIII-D, offering the potential of a transformational boost to fusion performance in future power plants.”

About the DIII-D National Fusion Facility. *DIII-D is the largest magnetic fusion research facility in the U.S. and has been the site of numerous pioneering contributions to the development of fusion energy science. DIII-D continues the drive toward practical fusion energy with critical research conducted in collaboration with more than 800 team members and over 600 actively contributing scientists representing 95 institutions worldwide. As a U.S. Department of Energy, Office of Science User Facility, participation in DIII-D research is open to all interested parties. For more information, visit* d3dfusion.org.