Cumulative List of INFUSE Awards

INFUSE 2022b, January 17, 2023

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: A modern neutronics-modeling uncertainty methodology towards a future fusion neutronics handbook

Abstract:

This program proposes to take the first step towards developing a handbook-grade documentation of fusion neutronics workflows for the fusion powerplant era. We propose to update the SINBAD database with modern tools and datasets, simulate the SINBAD experiment with those tools, gather the data necessary to perform a comprehensive uncertainty analysis of that simulation output, and, apply these modern workflows and uncertainty analyses to a prototypical ARC neutronics simulation. This work will benefit both CFS and the broader fusion community by providing a modernized neutronics modeling guide that includes a comprehensive uncertainty treatment.

Company PI: Ms. Corinne Mitchell

Company e-mail: cmitchell@cfs.energy

Institution: ORNL

Institution PI: Michael Loughlin, loughlinmj@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2022b, January 17, 2023

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: Oxide Dispersion Strengthened Ferritic Steel Wire Feedstock Development for Large-Format Additive Manufacturing

Abstract:

This INFUSE project seeks to demonstrate the viability of fabricating large, complex-parts from oxide dispersion strengthened (ODS) steel with advanced manufacturing. Exhibiting excellent radiation tolerance and high mechanical performance at elevated temperatures, ODS steel is a promising structural material candidate for near-plasma components in fusion energy systems. Its use, however, has been limited by a lack of manufacturability. This project will seek to produce ODS steel wire through a solid-state shear assisted extrusion process and then demonstrate that the wire can undergo controlled local melting while being welded with the final part sufficiently retaining the beneficial properties of ODS steel. This would allow the use of wire-arc additive manufacturing (WAAM) to manufacture large-scale ODS parts, even though ODS is currently only available as a powder. WAAM is a promising technique for producing components like the replaceable ARC vacuum vessel.

Company PI: Dr. Cody Dennett

Company e-mail: cdennett@cfs.energy

Institution: PNNL

Institution PI: Dalong Zhang, dalong.zhang@pnnl.gov

Cumulative List of INFUSE Awards

INFUSE 2022b, January 17, 2023

Company: Energy Driven Technologies LLC, DUNS: 080060913

Title Retention of Fusion Plasma Species in PFC Candidate Fine-Grain Dispersion-Strengthened Tungsten Materials

Abstract:

This project is a collaboration between Energy Driven Technologies and Sandia National Laboratories in Livermore, CA. This work will expose PFM candidate fine-grain dispersion-strengthened tungsten to high fluence, low energy deuterium, and helium plasmas to evaluate retention behavior and resilience of the microstructure and surface morphology compared to ITER-grade tungsten.

Company PI: Mr. Zachariah Koyn

Company e-mail: zkoyn@editekk.com

Institution: SNL

Institution PI: Jonathan Coburn, jdcobur@sandia.gov

Cumulative List of INFUSE Awards

INFUSE 2022b, January 17, 2023

Company: Focused Energy Inc., DUNS: 118411704

Title: Simulation study for risk assessment of laser-plasma instabilities in proton fast ignition

Abstract:

Focused Energy is pursuing a laser-driven inertial fusion energy (IFE) scheme for commercial fusion based on proton fast ignition (PFI), an advanced inertial confinement fusion scheme. Proton fast ignition has the potential to reach the high target gains needed for IFE in a robustly performing platform. A key scientific risk in laser driven fusion is the potential for laser-plasma instabilities (LPI), which can reduce energy coupling efficiency and drive uniformity.

In this INFUSE project Focused Energy will partner with Los Alamos National Laboratory (LANL) to apply state-of-the-art simulation tools developed at LANL, and high-performance computing resources, to evaluate the LPI physics risks for fast ignition target designs and assess mitigation techniques.

Company PI: Dr. Pravesh Patel

Company e-mail: pravesh.patel@focused-energy.world

Institution: LANL

Institution PI: Dr. Brian Albright, balbright@lanl.gov

INFUSE 2022b, January 17, 2023

Company: Focused Energy Inc., DUNS: 118411704

Title: Model validation of low-density foams wetted with liquid deuterium and tritium for inertial fusion target optimization

Abstract:

In the proton fast ignitor inertial fusion scheme, the assembly of a high-density inertial fusion target and the subsequent heating of a small “ignition spark” region are separated. The former being driven by a spherically distributed configuration of nanosecond-scale laser beams while the latter derives from a high-intensity, picosecond-scale laser which accelerates protons that subsequently deposit their energy into the ignition spark region temporally near peak compression. With the compression and heating phases separated, the symmetry and thermodynamic requirements associated with producing an isobaric central hot spot are eliminated, allowing for more robust and higher gain designs. Traditional inertial fusion targets are created using a multi-day manufacturing process called beta-layering which relies on the slow nuclear decay of tritium into ^{3}He. In order to create an inertial fusion power plant on par with existing electrical power plants, a new target manufacturing process must be used that can scale with the necessary shot rate of an inertial fusion reactor. One such manufacturing process uses low-density foams wetted with deuterium and tritium. This process greatly reduces manufacturing times and minimizes fabrication oversight. For this process to become viable, high-resolution, three-dimensional model validation must be done using state-of-the-art radiation-hydrodynamics codes to characterize the compressive behavior of this heterogeneous material, which could then be used in the computational design of inertial fusion reactor targets.

Company PI: Dr. Leonard Jarrott

Company e-mail: charlie.jarrott@focused-energy.world

Institution: LLNL

Institution PI: Dr. Elijah Kemp, kemp10@llnl.gov

Cumulative List of INFUSE Awards

INFUSE 2022b, January 17, 2023

Company: General Atomics, DUNS: 067638957

Title: Machine learning-accelerated predictions of power and particle exhaust in a fusion pilot plant

Abstract:

This project will utilize LLNL expertise in the development of machine learning-based surrogate models for predicting plasma detachment in a fusion pilot plant (FPP) under conceptual design at General Atomics. Built upon a latent space representation, the surrogate models will be used to identify promising regimes for handling the extreme heat and particle loads that will occur in the FPP. The results will be used to guide higher fidelity physics and engineering design activities.

Company PI: Dr. Jonathan Yu

Company e-mail: yujh@fusion.gat.com

Institution: LLNL

Institution PI: Ben Zhu, zhu12@llnl.gov

Cumulative List of INFUSE Awards

INFUSE 2022b, January 17, 2023

Company: Princeton Stellarators Inc, DUNS: 118736608

Title: Determining fast particle behavior in a reactor-relevant Quasi-Axisymmetric stellarator equilibrium

Abstract:

Princeton Stellarators, Inc. (PSI) will collaborate with Princeton Plasma Physics Laboratory (PPPL) to analyze fast particle behavior in candidate stellarator equilibria. Particles of very high energy are introduced into fusion reactors in several ways, notably as the product of fusion reactions and injected via Neutral Beam Injectors. Historically, the stellarator concept of plasma confinement has had difficulty confining these fast particles. Recently, stellarator equilibria have been developed that so precisely exhibit a property known as quasi-symmetry that they are expected to confine the large majority of fast particles. PSI has identified such an equilibrium as the starting point of its reactor design. In this project, PPPL will analyze the behavior of fast particles in this equilibrium and subsequent versions. This will allow PSI to develop better equilibria, and allow PSI's reactor design to proceed to a much higher fidelity in several important ways.

Company PI: Dr. Charles Swanson

Company e-mail: charles.swanson@princetonstellarators.energy

Institution: PPPL

Institution PI: Phillip Bonofiglo, pbonofig@pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2022b, January 17, 2023

Company: Princeton Stellarators Inc, DUNS: 118736608

Title: Stellarator evolution modelling

Abstract:

We are proposing to work with PPPL to use new tools, which is expected to be available in early 2023, to understand the effect of bootstrap current on island growth in stellarator geometry. The tools are modifications to the PPPL flagship code M3D-C1 which is a time dependent resistive MHD code. The two planned changes are to add a "Sauter-like" model (valid only in quasi-symmetric configurations) and also interface to the SFINCS code by Landreman (U. Maryland) to M3D-C1. these tools will be benchmarked against each other and used to understand neoclassical island healing in stellarator-like magnetic shear.

Company PI: Dr. Mike Martin

Company e-mail: mike.martin@princetonstellarators.energy

Institution: PPPL

Institution PI: Adelle Wright, awright@pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2022b, January 17, 2023

Company: Tokamak Energy Inc, DUNS: 117135313

Title: Evaluation of the effect of coolant purity on the corrosion resistance of Castable Nanostructured Alloys for structural application in tokamak reactor blankets

Abstract:

TE will use Castable Nanostructured Alloy (CNA) steels in future reactors because of their higher operation temperature and superior neutron resistance compared with current generation reduced activation ferritic-martensitic (RAFM) steels but needs to understand the likely lifetime of such materials under operating conditions, particularly as a result of their chemical compatibility with potential coolants, such as lithium, and to understand how the coolant purity might impact that lifetime.

Stage 1: Static testing -- In year 1, a series of capsule tests using a range of temperatures and C, O and N impurities will be evaluated. The capsule experiments will yield (1) mass change, (2) effects on room temperature tensile properties and (3) changes in microstructure or surface composition as revealed by specimen characterization including metallographic cross-sections and electron microscopy including energy dispersive spectroscopy to measure composition profiles.

Stage 2: Flowing testing -- In year 2, a thermal convection loop (TCL) will be built from CNA and operated twice for 500-1000 h. The baseline would operate with a peak temperature of 600 C and use a Li composition selected from Stage 1. The selection of experimental conditions (flow and temperature) will be guided by the blanket design study that is being conducted by Tokamak Energy. If this project is successful, it will address one of the main concerns regarding such blanket concepts by either determining whether corrosion is a concern, or at least delineating safe operating conditions in terms of temperature and coolant purity.

Tokamak Energy intends to employ a Li-based blanket to breed tritium and extract heat and has an aggressive deployment strategy. In order to meet that timeline, it is essential that basic materials science issues, such as Li compatibility with structural materials, are quickly addressed so that more complex aspects, like the effect of irradiation can then be investigated. While RAFM steels like CNAs are expected to have reasonably good compatibility with Li, no data currently exist and the results suggest that Li purity standards are needed. Furthermore, the data was not generated in a thermal gradient where mass transfer can occur. Previous research in flowing Li in a thermal gradient was last conducted in the 1980s.

Company PI: Naomi Mburu

Company e-mail: naomi.mburu@tokamakenergy.com

Institution: ORNL

Institution PI: Bruce Pint, pintba@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2022b, January 17, 2023

Company: Type One Energy Group Inc., DUNS: 117343133

Title: High-temperature superconducting CORC® conductors for stellarator magnet applications

Abstract:

BCMT and TOE will collaborate through the INFUSE program, sponsored by DOE Office of Fusion Energy Sciences, to validate the technical feasibility of HTS conductors, especially the CORC® conductors, making and testing small bend radius coils for 3D non-planar high field stellarator magnet designs.

Company PI: Mr. Paul Harris

Company e-mail: pharris@typeoneenergy.com

Institution: LBNL

Institution PI: Xiaorong Wang, xrwang@lbl.gov

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: Characterization of Turbulent Transport and Confinement in ARC with STEP and CGYRO

Abstract:

This project is a collaboration between CFS and the University of California, San Diego (UCSD) to develop a more detailed characterization of microturbulence dynamics expected in a future ARC power plant and determine the extent to which these same dynamics will be observed in SPARC. The work will entail three main activities:

1. Translating 0D empirical predictions of ARC design points into first-principles 1.5D transport solutions using the OMFIT STEP workflow.
2. Benchmarking TGLF and CGYRO predictions of core turbulent transport in ARC.
3. Comparing expected ARC and SPARC turbulence characteristics.

Company PI: Dr. Alex Creely

Company e-mail: alex@cfs.energy

Institution: UCSD

Institution PI: Dr. Chris Holland, chholland@ucsd.edu

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: Assessing ELM mitigation by pellet triggering in SPARC low-collisionality discharges

Abstract:

The main deliverable of this project is to answer the question if pellet ELM triggering is feasible in SPARC, which scenarios are likely/unlikely to allow pellet ELM triggering, and which poloidal injection location is the most promising in SPARC.

Company PI: Dr. Chris Chroback

Company e-mail: cchrobak@cfs.energy

Institution: ORNL

Institution PI: Dr. Andreas Wingen, wingen@fusion.gat.com

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: Machine learning assisted prediction of tungsten heavy alloy plasma facing component performance for fusion energy applications

Abstract:

This project aims to leverage existing deep learning models expertise and tools developed at MIT to study thermal and mechanical material properties in high heat flux environments and apply them to the application of tungsten heavy alloy plasma-facing components in the SPARC tokamak. The key deliverable will be a tool to predict remaining component lifetime.

Company PI: Dr. Dina Yuryev

Company e-mail: dyuryev@cfs.energy

Institution: MIT

Institution PI: Dr. Markus Buehler, mbuehler@mit.edu

INFUSE 2022a, June 15, 2022

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: Agile design workflow for plasma-facing fusion components with coupled thermofluidic and structural optimization

Abstract:

This project will build a design optimization workflow for plasma-facing components in fusion devices that couples thermofluid and structural analysis, and incorporates the constraints and requirements of advanced manufacturing. The workflow builds on an existing one designed for the Transformational Challenge Reactor program at ORNL.

Company PI: Dr. Caroline Sorensen

Company e-mail: caroline@cfs.energy, line@mit.edu

Institution: ORNL

Institution PI: Dr. Justin Weinmeister, weinmeistejr@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: General Atomics, DUNS: 067638957

Title: Fuel Cycle and Tritium Plant Model for Fusion Pilot Plant

Abstract:

General Atomics (GA) is developing a modeling workflow for fusion pilot plant (FPP) integrated design and optimization and is in need of verified and validated models for the tritium fuel cycle. Savannah River National Laboratory (SRNL) will develop two models for GA's use: a reduced model for tritium processing which will be integrated into GA's proprietary FPP systems code, as well as comprehensive Aspen fuel cycle simulations to assess the significance of particular design decisions. GA and SRNL will perform FPP optimizations with these tools and SRNL will provide a relative, initial cost analysis for the tritium processing facilities.

Company PI: Dr. David Weisberg

Company e-mail: weisbergd@fusion.gat.com

Institution: SRNL

Institution PI: Dr. Holly Flynn, Holly.Flynn@srnl.doe.gov

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: General Fusion Corp., DUNS: 117111477

Title: Tritium Fuel Cycle Modelling and Optimization to Enable Fusion Pilot Plant Development

Abstract:

General Fusion will partner with Savannah River National Laboratory (SRNL) to model the total inventory of tritium in General Fusion's future Commercial Pilot Plant (CPP) -- the first General Fusion machine that will use tritium as a fuel. Understanding tritium inventory is a necessary step to design, license, construct, and operate larger and increasingly integrated fusion machines. SRNL, the leading DOE laboratory for tritium process research, development, and demonstration, will apply its expertise to quantify and streamline tritium processing in the CPP to enable fusion pilot plant development to deliver clean, safe, and on-demand fusion power at industrial scale.

Company PI: Dr. Ryan Guerrero

Company e-mail: ryan.guerrero@generalfusion.com

Institution: SRNL

Institution PI: Dr. George Larsen, George.Larsen@srnl.doe.gov

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: General Fusion Corp., DUNS: 117111477

Title: Beyond Neoclassical Closures for MHD Simulation of General Fusion Devices via Kinetic Monte Carlo Calculations

Abstract:

General Fusion and Oak Ridge National Laboratory will cooperatively enhance open plasma modelling tools to enable large scale calculations of kinetic electron orbits in fusion plasmas. These tools will enable a powerful approach to efficient modelling of General Fusion's Magnetized Target Fusion (MTF) devices. This modelling will enable high fidelity study of General Fusion's Fusion Demonstration Plant, a first-of-a-kind MTF demonstration facility that the company is building at the Culham Centre for Fusion Energy and will accelerate the design and construction of a commercial fusion plant to deliver clean, safe, and on-demand fusion power at industrial scale.

Company PI: Dr. Colin McNally

Company e-mail: colin.mcnally@generalfusion.com

Institution: ORNL

Institution PI: Dr. Mark Berrill, berrillma@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: HelicitySpace, DUNS: 117087016

Title: Observing Density Evolution During Merging of Plectonemic Taylor states

Abstract:

The project requests the assistance of Swarthmore College's expertise to build a set of diagnostics to measure plasma density at several locations simultaneously in the company's new fusion proof-of-concept experiment called ECLAIR. The new fusion concept relies on the merging of plectonemic Taylor states first observed at Swarthmore on the SSX experiment and later on the MOCHI experiment at the University of Washington. The diagnostic will be tested on SSX first before shipping them and implementing them on ECLAIR. The results will be compared to existing theory and numerical simulations to help determine the viability of the new fusion concept.

Company PI: Dr. Setthivoine You

Company e-mail: setthivoine.you@helicityspace.com

Institution: Swarthmore University

Institution PI: Dr. Mike Brown, mbrown3@swarthmore.edu

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: Magneto-Inertial Fusion Technologies, Inc. (MIFTI), DUNS: 078640171

Title: 3D modeling of the Staged Z-pinch with the FLASH code

Abstract:

The Staged Z-pinch (SZP) fusion concept is a magneto-inertial compression scheme in which small amounts of fusion fuel are brought to fusion-relevant conditions by passing multi-million amperes strong current through a cylindrical shell of high atomic number material. One- and two-dimensional modeling with the MACH2 code suggests that net fusion energy gain can be achieved when currents in the 10 million amperes range compress a 50%-50% mixture of deuterium and tritium gas. In this project we will use the FLASH code to execute high-fidelity, three-dimensional simulations of various SZP configurations, in collaboration with the Flash Center for Computational Science at the University of Rochester and the Laboratory for Laser Energetics. FLASH is a high-performance computing, multi-physics, radiation-magnetohydrodynamic (MHD) code with extended physics capabilities, which is developed at the Flash Center. The goal of this project is to assess the shell/fuel stability of the pinch to three-dimensional MHD instabilities and to utilize FLASH's extended physics capabilities to understand how extended-MHD effects impact implosion dynamics and plasma conditions at stagnation. The project is a natural extension of our ongoing collaboration with the Flash Center through the ARPA-E BETHE program and will provide us with simulation capabilities that are currently beyond our reach with MACH2. Ultimately, we want FLASH to become one of our simulation workhorses for reliable, high-fidelity SZP platform design.

Company PI: Dr. Emil Ruskov

Company e-mail: emil@miftec.com

Institution: Univ. Rochester

Institution PI: Dr. Petros Tzeferacos, p.tzeferacos@rochester.edu

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: Magneto-Inertial Fusion Technologies, Inc. (MIFTI), DUNS: 078640171

Title: Hard x-ray imaging and characterization of staged z-pinch plasmas in order to exclude ion beams as cause of fusion

Abstract:

When deuterium and tritium nuclei collide with enough energy to overcome their mutual repulsion they can fuse and release many times more energy than was invested. While this fusion process offers bountiful energy production, it is extremely challenging because of the difficulty in confining the reacting nuclei long enough to obtain a return on the energy that was invested. Confined nuclei develop random thermal motion, so this energy-producing process is called thermonuclear fusion. The Staged Z Pinch is a promising fusion concept that has already indicated significant fusion yields as evidenced by substantial neutron production. However, there is a possibility that these neutrons were produced by local particle beam instabilities rather than from well-confined nuclei. It is thus important to determine whether the neutrons are thermonuclear in origin or from beam instabilities as the former process leads to scalable energy production while the latter does not. The presence or lack thereof of spurious fusion from particle beam instabilities will be established by measuring the X-rays produced at the Magneto-Inertial Fusion Technologies Inc. (MIFTI) Staged Z-pinch experiment in operation at the University of California San Diego. This will be done by a Caltech team that has developed a 128-channel X-ray detector that has been designed to image X-ray instabilities and additionally measure X-ray energies. These measurements are capable of distinguishing X-rays produced by beam-target instabilities from X-rays produced by thermonuclear processes as the former are more localized, more directed, and more energetic than the latter. The X-ray diagnostic now operates in a linear one-dimensional mode with 128 channels and will be upgraded to have 256 channels arranged in a 16x16 pixel array so at to provide a two-dimensional imaging capability. The scintillator material will be upgraded to enable faster (8 nanosecond) time resolution than the existing time resolution (20 nanoseconds). The system will resolve X-ray energies as low as 4 keV and as high as 80 keV, where energies in the range of 4-10 keV indicate thermonuclear fusion whereas energies above 20 keV indicate beam-target fusion. This partnership between MIFTI and Caltech will provide a significant step forward in developing the staged Z pinch as a viable fusion energy concept.

Company PI: Dr. Hafiz Rahman

Company e-mail: hafiz@miftec.com

Institution: CalTech

Institution PI: Dr. Paul Bellan, pbellan@caltech.edu

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: Princeton Fusion Systems, Inc., DUNS: 805686870

Title: Electron density profiles on PFRC with USPR

Abstract:

UC Davis has, under prior ARPA-E funding, updated their diagnostic and prepared hardware to attach it to the PFRC-2 experiment at PPPL; however, in no small part due to COVID, funds will now only allow the diagnostic to visit the HIT-SIU device in Seattle, WA.

INFUSE funds will cover the cost of transporting the ARPA-E USPR system to Princeton, NJ, to install and commission the system on the PFRC device, and to operate the system and collect/analyze time-resolved density profile data.

Company PI: Dr. Chris Galea

Company e-mail: cgalea@psatellite.com

Institution: UC-Davis

Institution PI: Dr. Neville C. Luhmann, Jr., cwdomier@ucdavis.edu

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: Princeton Fusion Systems, LLC, DUNS: 805686870

Title: Evaluating RF antenna designs for PFRC plasma heating and sustainment

Abstract:

We will perform numerical modeling of new antenna concepts and designs that improve power coupling to the plasma ions, allow easier installation and maintenance, provide greater flexibility in containment-vessel and axial-magnet-array design, and expand the power range of PFRC-type fusion reactors. This project will inform design decisions for next-generation devices as well as for power-producing reactors.

Company PI: Mr. Michael Paluszek

Company e-mail: map@psatellite.com

Institution: PPPL

Institution PI: Dr. Samuel Cohen, scohen@pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: Princeton Fusion Systems, LLC, DUNS: 805686870

Title: Stabilizing PFRC plasmas against macroscopic low-frequency modes

Abstract:

Numerous approaches have been implemented in or proposed for FRC devices to slow the rate-of-growth of and stabilize these modes. Examples of successful experimental methods are: Ioffe bars, biased rings, energetic beam injection, gas puffing, and RF fields. Gas-dynamic-trap conditions and other flow and flow-shear methods may also provide stability. With this INFUSE assistance we will perform numerical studies to benchmark the TriForce code against the existing PFRC-2 experiment and analyze any discovered instabilities. We will then simulate several stabilizing mechanisms, such as gas puffing and loop biasing.

Company PI: Ms. Stephanie Thomas

Company e-mail: sjthomas@psatellite.com

Institution: PPPL

Institution PI: Dr. Samuel Cohen, scohen@pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: SuperPower, Inc. DUNS: 832548338

Title: Performance-structure characterization to improve REBCO Fusion conductor production at SuperPower

Abstract:

The central goal of this project is to generate testing and characterization data that support SuperPower's coated conductors that will be used by the fusion industry. SuperPower anticipates difficulty meeting upcoming specifications with high yield without changes to present production methods. This work aims to understand root causes responsible for property variations. Since capability to measure the performance at 20 T and 20 K exist only in national user facilities in Japan and at the NHMFL in the USA, there is insufficient routine testing to understand the critical properties of the product that is coming off the production line. This work taps into the extensive characterization database at NHMFL and augments it with new measurements to provide rapid feedback to new conductors being made at SuperPower with properties of highest relevance to the fusion industry. Micro- and nano-structural analyses will also be made at NHMFL to connect structure-property relationships and refer them to processing. Prior long collaborations between the two PIs are formally extended to immediate challenges of fusion by this project.

Company PI: Dr. Yifei Zhang

Company e-mail: yzhang@superpower-inc.com

Institution: FSU

Institution PI: Dr. Dmytro Abraimov, abraimov@asc.magnet.fsu.edu

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: TAE Technologies, Inc, DUNS: 065262557

Title: Development of a High-Flux Inductive Spheromak Gun for FRC Formation via Counter-Helicity Merging

Abstract:

We ultimately aim to combine TAE's high-power NBI technology with PPPL's well-studied and fully developed spheromak-merging FRC formation technique. TAE and PPPL have already begun a collaboration under the INFUSE program (2020b award) whose objective is to investigate the feasibility of high-magnetic-flux FRC formation via counter-helicity spheromak merging for C-2W. In this ongoing collaboration, we have constructed a relatively small spheromak injector that fits well to the MRX device at PPPL to demonstrate the proof-of-principle and a preliminary experiment has already commenced. Meanwhile, in this new INFUSE project, in order to scale-up the spheromak injector to C-2W-relevant level and achieve a high-magnetic-flux FRC (up to ~30 mWb), we aim to develop a new spheromak gun that enables a novel high-flux spheromak formation scheme via inductive flux injection at a size still compatible to C-2W. Initial high-flux spheromak formation and merging experiments with the upgraded gun will be conducted on MRX, after which the spheromak guns can eventually be installed in C-2W to produce a high-magnetic-flux FRC via spheromak merging. It would allow more effective capture of injected fast NBI particles, thus enhancing the effect of NB heating and current drive to achieve C-2W FRC plasmas of higher energy density in the future.

Company PI: Dr. Hiroshi Gota

Company e-mail: hgota@tae.com

Institution: PPPL

Institution PI: Dr Masaaki Yamada, myamada@pppl.gov

INFUSE 2022a, June 15, 2022

Company: TAE Technologies, Inc, DUNS: 065262557

Title: THz Radiation Generation to Enable Internal Magnetic Field Measurement of Burning Plasmas

Abstract:

Over the last 20 years, TAE Technologies (TAE) has developed an advanced beam-driven Field-Reversed Configuration (FRC) for superior plasma confinement limited by power supply and not by physics. In collaboration with Google, TAE has developed an equilibrium reconstruction tool to better understand plasma stability, transport and confinement; however, the tool is only as good as the supplied data. TAE utilizes a state-of-the-art plasma diagnostic to measure internal density, electron and ion temperature with the magnetic field measured outside the plasma only. The reconstructed equilibria are well validated with simulation; however, the internal magnetic field heavily relies on models since a direct measurement in missing. TAE has embarked on the first-ever direct and non-perturbative measurement of the internal magnetic field topology of an FRC. To that end we are developing a pulsed polarimetry diagnostic. Pulsed polarimetry is a Lidar technique that combines two well-known diagnostic techniques of Thomson scattering and polarimetry to provide profiles of $n_e(s)$, $T_e(s)$ and $B_{||}(s)$ along the laser sightline. The rate of change of Faraday angle with distance, $\Delta\alpha/\Delta s$, is directly proportional to the local $[n_e B_{||}(s)]$ product. To achieve a large progressive Faraday rotation and maintain Thompson scattering incoherent, a pulse of THz light (<100 ps) is required; however, there are no commercially available THz sources powerful (>1 mJ) enough. Such powerful sources are under laboratory and simulation investigation in a process whereas relativistic laser irradiates a target achieving 1% efficiency and 10's mJ THz pulse. TAE has partnered with the Laboratory for Laser Energetics at the University of Rochester to develop a THz source for the pulsed polarimetry. In this public-private partnership, scientific contributions from the Department of Energy will directly accelerate progress toward the development of fusion energy in the private sector and beyond as we believe the pulsed polarimetry can be applied to any magnetized fusion device. Pulsed polarimetry improves with density and machine size, and thus is compatible with burning plasmas.

Company PI: Dr. Ales Necas

Company e-mail: anecas@tae.com

Institution: Univ. Rochester

Institution PI: Dr Gerrit Bruhaug, gbru@lle.rochester.edu

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: Tokamak Energy, Inc., DUNS: 117135313

Title: FLARED -- Flowing Lithium's Adsorption and Release Experiment for Deuterium

Abstract:

The Center for Plasma Material Interactions (CPMI) at U. Illinois at Urbana Champaign is the premier academic lithium technology lab in the U.S. Other molten metals have been studied as well. CPMI is a strong proponent of the low-recycling divertor concept which utilizes a flowing-liquid-lithium divertor plate. The low-recycling concept achieves higher confinement times, higher core-electron temperatures and a more stable plasma. Existing work with TE, described in a recent paper showing that the low-recycling concept can lead to a much more affordable fusion-energy device [De Castro, Moynihan, Stemmley, Szott, and Ruzic, "Lithium, a path to make fusion energy affordable", Phys. Plasmas 28 (2021) 050901], seeks to create a reactor-compatible flowing-lithium-divertor plate for testing in ST40. Specifically, the existing contract calls for the creation of a lithium loop and testing of all loop components and for high-heat-flux testing of the divertor plate using an electron beam, whereas, this proposal asks if the hydrogen can be extracted from the lithium in a complete and timely manner [Allain, Nieto, Coventry, Neumann, Vargas-Lopes, Ruzic, "FLIRE—Flowing Liquid Surface Retention Experiment, Design and Testing" Fusion Engineering and Design 61-62 (2002)245-250].

Adding a plasma source to the lithium loop and testing the distillation column will help address the most serious objection to the low-recycling paradigm. There are several concepts for liquid lithium divertors / first walls in overcoming challenges of using liquid metals in this way: Capillary Pore System (CPS); slow-flowing thin films (FLiLi); medium-speed self-flowing thermoelectric MHD (TEMHD) driven flows; and fast flowing lithium. As previously mentioned, TE has been directly sponsoring work with CPMI for 3 years to develop a reactor-compatible TEMHD self-flowing liquid-lithium-divertor that can be tested in the ST40 spherical tokamak.

Liquid lithium's ability to pump (adsorb and retain) deuterium and tritium has pros and cons. The advantage arises because alternate methods of deuterium and tritium pumping during a transient plasma (and continuously in a reactor) are more technically challenging and because present best-practices, e.g., cryo-pumps, do not scale to continuous operation. The disadvantage arises because the retention of tritium in liquid lithium depends on (1) how quickly liquid lithium pumps tritium, and (2) how quickly the tritium can be separated from the liquid lithium and neither of these adsorption and extraction properties are understood theoretically and technologically, at this time. Quantifying both properties is the purpose of this project having the long-range goal of enabling an advance towards the use of liquid lithium in a reactor design. Previous experiments using deuterium plasma have measured the pumping rate with stationary liquid lithium. However, deuterium is only absorbed in a thin layer of the liquid lithium surface which quickly becomes saturated. Therefore, we expect the pumping rate of flowing liquid to be higher, where the surface is constantly being replenished. The significance of the project is the anticipated

fundamental measurement of lithium's ability to pump deuterium while flowing which, perhaps surprisingly, has yet to be made. Our methodology is designed to overcome the technical challenges of working with large quantities of liquid lithium, perhaps the constraint in other labs that now can be overcome at UIUC CPMI. In the past, CPMI constructed a complete flowing liquid lithium loop and measured the pumping of hydrogen gas in the FLIRE experiment. However, we expect the pumping rate of (ionized) plasma to be different to that of neutral gas. The CPMI team is presently constructing a new and improved liquid lithium loop under the TEMHD-ST40 project that TE is already sponsoring. We plan to use this new loop within this INFUSE project.
Deuterium absorbs into lithium by dissolving, known as 'alpha-phase', and by chemically reacting to form lithium hydride, known as 'beta-phase'. Separating the alpha-phase is comparatively simpler and involves heating the liquid lithium and exposing a free surface to vacuum, whereas separating the beta-phase requires thermal decomposition. CPMI has developed and tested a distillation column which was supplied with lithium hydride and has shown it does perform the more challenging task of separating the beta-phase. During experiments, the liquid lithium will be contained within the lab, away from water, and will not be under pressure. When the experiment is not running, the lithium will be frozen.
To our knowledge, CPMI is the only institution that has tested a distillation column. We will incorporate a plasma source into a closed-loop liquid lithium system, test the distillation column, and quantify the distillation-column efficiency for a representative distribution of alpha and beta phases. CPMI has an excellent safety record of working with liquid lithium. We emphasize that the fundamental measurements and results from this project will be applicable to any flowing liquid-lithium concept, and that this project is aligned to both TE's and CPMI's long-term goals.

Company PI: Dr. Mark Koepke

Company e-mail: Mark.Koepke@tokamakenergy.com

Institution: UIUC

Institution PI: Dr. David Ruzic, druzic@illinois.edu

Cumulative List of INFUSE Awards

INFUSE 2022a, June 15, 2022

Company: VWG, Inc. dba Xcimer Energy, DUNS: 118546777

Title: Simulation of Direct-Drive Hybrid Using Two Opposed Beams for Inertial Fusion Energy

Abstract:

Xcimer Energy plans to construct a novel facility to deliver high-energy laser light at low cost, with many of the characteristics needed for inertial fusion energy (IFE). Details of this architecture naturally support a target that is illuminated by two opposed beams. Several preliminary designs have been developed to exploit this space, including a novel Direct-Drive Hybrid target design, termed the DDH, which seeks to benefit from recent advances in the field. Physics-based modeling would inform Xcimer of the tradeoffs in this approach, identify risks and options for improvement, and lead to an integrated system with reduced cost and complexity. This program would leverage the unique tools and expertise available at the University of Rochester's (UR's) Laboratory for Laser Energetics (LLE). The codes LILAC and DRACO have been developed and validated against an extensive set of experimental data, and include the necessary aspects of laser absorption, x-ray production, and hydrodynamics. Xcimer Energy and LLE will work to implement a version of the hybrid design in both codes, and LLE will evaluate aspects of the DDH in 1-D and 2-D. Outputs will reduce uncertainty with respect to hybrid drive, the techniques used to obtain good implosion symmetry with two-sided illumination, and the potential for high gain. Findings could apply broadly to many types of drivers, increase the parameter space available to IFE, and motivate more extensive partnerships in the broader community.

Company PI: Dr. Conner Galloway

Company e-mail: cgalloway@xcimer.net

Institution: Univ. Rochester

Institution PI: Dr. Cliff Thomas, ctho@lle.rochester.edu

Cumulative List of INFUSE Awards

INFUSE 2021b, November 22, 2021

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: Magnetic Pumps for Molten Salt Fusion Devices

Abstract:

Commonwealth Fusion Systems (CFS) plans to complete construction of ARC, an affordable compact fusion power plant in the early 2030's. ARC will employ a novel liquid immersion blanket design that uses a molten lithium salt as both the tritium breeding material and the vacuum vessel coolant. FLiBe is currently the leading salt candidate due to its favorable heat transfer, neutronic, and tritium breeding properties. ARC will also require a FLiBe-compatible molten salt pump that can handle high temperatures and high pumping powers.

This program leverages Oak Ridge National Laboratory's (ORNL's) expertise in high-temperature, canned-rotor magnetic bearing pumps. This category of pump is well suited for service in ARC because it does not expose any internal seals or bearings to the molten salt. The ORNL and CFS team will identify modifications needed to adapt an existing ORNL salt pump design to meet ARC's requirements. The team will also experimentally test and evaluate the dielectric strength of insulation materials needed to reach ARC's power requirements. If successful, the program will accelerate CFS' molten salt pump roadmap for ARC.

Co. PI: Dr. Brandon Sorbom

Co. e-mail: brandon@cfs.energy

Laboratory: ORNL

Lab PI: Dr Alex Melin, melina@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2021b, November 22, 2021

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: Neutron Ion Handshake for Fusion Materials

Abstract:

Commonwealth Fusion Systems plans to complete construction of ARC, an affordable compact fusion power plant in the early 2030's. ARC's vacuum vessel needs to withstand high temperatures, mechanical loadings, and intense neutron radiation fields. A testing program is required to enable the judicious selection of structural materials that can withstand radiation-induced degradation. However, such programs have been hampered by the lack of appropriate neutron sources, long program timelines and high costs.

This program leverages the unique *in situ* ion irradiation transient grating spectroscopy facility at Sandia National Laboratories and its state-of-the-art shared materials analytical facilities to establish an equivalency between ion irradiation and neutron irradiation testing of candidate materials. If successful, the program will simplify and accelerate ARC materials testing, enabling testing of fusion-relevant materials at speeds three orders of magnitude faster than is possible with neutron irradiation test reactors.

Co. PI: Dr. Brandon Sorbom

Co. e-mail: brandon@cfs.energy

Laboratory: SNL

Lab PI: Dr. Khalid Hattar, khattar@sandia.gov

Cumulative List of INFUSE Awards

INFUSE 2021b, November 22, 2021

Company: Energy Driven Technologies LLC., DUNS: 080060913

Title: High Heat Flux Exposure of PFC Candidate Fine-Grain Dispersion-Strengthened Tungsten Materials

Abstract:

Energy Driven Technologies (a.k.a. Editekk) is developing a plasma facing material for future burning-plasma magnetic thermonuclear fusion reactors. While tungsten is an attractive option due to its high melting temperature, good thermal conductivity, and high sputtering threshold, current monolithic tungsten suffers from brittleness and grain growth under heavy thermal loads. Editekk' s approach is to use advanced manufacturing to create fine-grain dispersion-strengthened tungsten to improve thermo-mechanical properties. To achieve this goal and offer a material solution, this project will subject candidate samples to prototypical high heat fluxes using an electron beam facility. These tests will demonstrate material performance under extreme thermal loading and check for damage, such as melting and crack formation, as well as microstructural changes, such as grain growth. Results of these tests will guide development of the manufacturing process and demonstrate feasibility of Editekk' s material design approach.

Co. PI: Mr. Zachariah Koyn

Co. e-mail: zkoyn@editekk.com

Laboratory: ORNL

Lab PI: Dr. Travis Gray, graytk@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2021b, November 22, 2021

Company: Energy Driven Technologies LLC., DUNS: 080060913

Title: Mechanical Characterization of PFC Candidate Fine-Grain Dispersion-Strengthened Tungsten Materials

Abstract:

Energy Driven Technologies (a.k.a. Editekk) is developing a plasma facing material for future burning-plasma magnetic thermonuclear fusion reactors. While tungsten is an attractive option due to its high melting temperature, good thermal conductivity, and high sputtering threshold. Current monolithic tungsten suffers from brittleness and grain growth under heavy thermal loads. Editekk's approach is to use advanced manufacturing to create fine-grain dispersion-strengthened tungsten to improve thermo-mechanical properties. To achieve this goal and offer a material solution, this project will test the high temperature mechanical properties of candidate materials including tensile strength, ductile-to-brittle transition temperature, flexural strength, thermal diffusivity, the ability to inhibit grain growth after prolonged exposure to high temperatures and how this exposure affects properties, such as hardness. Results of these tests will define mechanical properties, guide the development of the manufacturing process, and demonstrate feasibility of Editekk's material design approach.

Co. PI: Mr. Zachariah Koyn

Co. e-mail: zkoyn@editekk.com

Laboratory: ORNL

Lab PI: Dr. Lauren Garrison, garrisonlm@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2021b, November 22, 2021

Company: General Atomics, DUNS: 067638957

Title: In-Field Performance Testing of a Novel HTS CICC for Practical and Cost-Effective Fusion Magnet Systems

Abstract:

High temperature superconducting (HTS) magnets could significantly enhance the performance of fusion devices and are recognized as one of the four first-tier transformative enabling capabilities to efficiently advance fusion technology. General Atomics (GA) is actively evaluating the technical feasibility of large-scale HTS fusion magnets. One of the focus areas at GA is the demonstration of an HTS-based segmented toroidal field (STF) coil at a scale typical of a compact tokamak fusion device. GA's design of the STF coil uses a unique configuration of Conductor-on-Round-Core (CORC®) HTS cables in a Cable-In-Conduit-Conductor (CICC). The CICC concept is novel approach to have an internally cooled conductor with large current capacity. The use of CORC® compared to the stacked and/or twisted tape cables enable a round geometry and isotropic properties which are favorable attributes in terms of fabrication as well as tokamak operation. Thus, the CORC-based CICC design offers a simplified and cost-effective solution to large-scale HTS magnets. Under this project, GA is fabricating a 4 m long test article of the CORC®-based CICC that will be tested under high-applied currents and high magnetic field conditions at the DCC017 dipole system at Brookhaven National Laboratory. The parametric evaluation of the test article that includes the tight radius bend will retire key manufacturing risks by demonstrating the integrity of CORC® cable inside the copper stabilizer and welded SS conduit. If successful, the project will demonstrate the technical feasibility of full-scale HTS fusion magnets and provide a path towards compact high-density plasma fusion machines.

Co. PI: Dr. Zbigniew Piec

Co. e-mail: Zbigniew.piec@ga.com

Laboratory: BNL

Lab PI: Dr. Ramesh Gupta, gupta@bnl.gov

Cumulative List of INFUSE Awards

INFUSE 2021b, November 22, 2021

Company: Magneto-Inertial Fusion Technologies, Inc. (MIFTI), DUNS: 078640171

Title: Thermonuclear fusion verification of Staged Z-pinch fusion on a 0.5 MA LTD pulsed power generator

Abstract:

Magneto-Inertial Fusion Technologies, Inc. (MIFTI) is developing a fusion concept based on the oldest fusion idea, the Z-pinch, and refines it by surrounding the fusion fuel with a high atomic number cylindrical plasma shell. This so-called Staged Z-Pinch concept was recently successfully tested on the one million ampere pulsed power generator Zebra where krypton plasma shell compressed a deuterium target producing ten billion thermonuclear neutrons. MIFTI is about to start experiments on a five hundred thousand ampere pulsed power generator utilizing Linear Transformer Driver (LTD) technology which has more efficient energy coupling to the plasma load. We propose to use neutron diagnostics developed by the Lawrence Livermore National Laboratory to accurately measure the neutron yield on this machine. Monte-Carlo code simulations will clarify the neutron scattering properties of the LTD device and facility and will inform the interpretation of the neutron time of flight measurements along multiple sightlines, which are essential for establishing the thermonuclear neutron origin.

Co. PI: Dr. Emil Ruskov

Co. e-mail: emil@miftec.com

Laboratory: LLNL

Lab PI: Dr. Drew Higginson, higginson2@llnl.gov

Cumulative List of INFUSE Awards

INFUSE 2021b, November 22, 2021

Company: Renaissance Americas Inc., DUNS: 117506666

Title: Artificially intelligent optimization of alpha particle transport in stellarators

Abstract:

Stellarator optimization requires rapid evaluation of physical properties associated with the magnetic equilibrium. However, certain optimization targets such as alpha losses are computationally costly to evaluate. With experts in machine learning from the Princeton Plasma Physics Laboratory (PPPL) we will:
1) generate an open-source dataset of burning stellarator equilibria,
2) efficiently evaluate alpha losses from such equilibria, and
3) generate machine-learned proxies for those metrics.
These proxies will aid Renaissance and the whole stellarator community in designing future reactors.

Co. PI: Dr. Christopher Berg Smiet

Co. e-mail: chris.smiet@renfusion.eu

Laboratory: PPPL

Lab PI: Dr R. Michael Churchill, rchurchi@pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2021b, November 22, 2021

Company: Silver-Fir Software, Inc, DUNS: 117147222

Title: Extension of MCNP® Mesh Based Weight Windows to Support Unstructured Mesh Topologies

Abstract:

In this project, the capabilities of the MCNP Monte Carlo code will be extended by Los Alamos National Laboratory to support weight windows defined on unstructured mesh topologies. As a cost-share contribution, Silver Fir Software will extend the capabilities of Attila4MC to support the new MCNP unstructured mesh weight window format.

Co. PI: Dr. Eugeny Sosnovsky

Co. e-mail: gene.sosnovsky@silverfirsoftware.com

Laboratory: LANL

Lab PI: Dr. Joel A. Kulesza, jkulesza@lanl.gov

Cumulative List of INFUSE Awards

INFUSE 2021a, June 14, 2021

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: Informing Layout and Performance Requirements for SPARC Massive Gas Injection

Abstract:

Commonwealth Fusion Systems (CFS) is designing a compact tokamak called SPARC and is evaluating massive gas injection (MGI) as its primary means of plasma disruption mitigation technique. Present conservative scoping has enabled a preliminary design of the MGI system. However, physics-based modeling can help CFS inform an optimized layout, which can either reduce the cost of MGI system by reducing the number of gas injectors or provide supporting evidence that present scoping estimates are correct.

This program leverages the 3D magneto-hydrodynamic modeling expertise at Princeton Plasma Physics Laboratory (PPPL), which is maintained through the development and use of the M3D-C1 code. CFS and PPPL will develop a gas source model representative of SPARC MGI's system. PPPL would then use M3D-C1 to simulate unmitigated SPARC disruptions, to develop a baseline response, and then simulate mitigated disruptions representing a variety of MGI system configurations. The specific output of this program will reduce risks associated with disruptions on SPARC, make SPARC's disruption mitigation system more cost-effective, a benefit that will carry to commercial fusion devices. The methodology developed by this program is expected to have wide benefits, independent of the design details, and have potential applications to other future power-producing fusion device concepts.

Co. PI: Dr. Matthew Reinke

Co. e-mail: mreinke@cfs.energy

Laboratory: PPPL

Lab PI: Dr Nathaniel Ferraro, nferraro@pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2021a, June 14, 2021

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: Active Redox Control of Molten Salts for Fusion Blankets

Abstract:

Commonwealth Fusion Systems is investigating FLiBe molten salt as a novel blanket material for its fusion tokamak. However, FLiBe is known to cause significant degradation to structural materials via impurity-driven corrosion. The use of FLiBe for commercial fusion applications will require the application of corrosion mitigation strategies, including monitoring impurities and salt chemistry, controlling impurity levels, and ensuring protection of salt-facing structural materials.

This program leverages the expertise in electrochemical and corrosion engineering at Savannah River National Laboratory to monitor corrosion caused by FLiBe in real time, and to enable local control of corrosion rates by adjusting impurity concentrations in the FLiBe. Electrochemical reference electrodes will be used to detect the presence of hydrogen isotopes and of corrosion products. An active redox control system that maintains stable redox conditions in response to real-time sensor output will be demonstrated.

Co. PI: Dr. Brandon Sorbom

Co. e-mail: brandon@cfs.energy

Laboratory: SRNL

Lab PI: Dr. Brenda Garcia-Diaz, Brenda.Garcia-Diaz@srnl.doe.gov

Cumulative List of INFUSE Awards

INFUSE 2021a, June 14, 2021

Company: General Atomics, DUNS: 067638957

Title: Performance Testing of Low-Resistance Demountable HTS Joints for Large Segmented Magnets

Abstract:

High temperature superconducting (HTS) magnets could significantly enhance the performance characteristics of fusion devices and are recognized as one of the four first-tier transformative enabling capabilities to efficiently advance fusion technology. General Atomics (GA) is actively evaluating the technical feasibility of large-scale HTS fusion magnets. One of the focus areas at GA is the demonstration of an HTS-based segmented toroidal field (TF) coil at a scale representative of a compact tokamak fusion device. Practical configurations of magnet coils for future fusion devices, such as TF coils, will require demountable, high current, low-resistance joints. A method for reliably constructing such joints is essential for the application of HTS to fusion magnet systems, as the ability to remove a quadrant of the TF coils permits access to the machine's internals and simpler exchange of components. The goal of the present project is to significantly advance the current state-of-the-art HTS conductor and joint technology beyond tabletop experimentation. Under this project, GA will design and fabricate test articles of the HTS joints and perform basic testing for superconductivity at a temperature of 77 Kelvin. The detailed testing at a temperature of 4.5 Kelvin will be conducted at Lawrence Berkeley National Laboratory's (LBNL) unique facilities ideally suited to the testing of superconducting joints under high magnetic fields and high transport currents. LBNL also has expertise in the instrumentation of such test samples, which is crucial to ensure the viability of the results. The project will provide important joint performance data for the development and demonstration of the HTS demountable joint technology that is novel, generic, scalable, and parallelizable, thus promising dramatic simplification and cost reduction for any fusion concept benefiting from demountable HTS coils. The program will demonstrate the technical feasibility of demountable HTS magnets and provide a path towards compact high-density plasma fusion machines.

Co. PI: Dr. Zbigniew Piec

Co. e-mail: Zbigniew.piec@ga.com

Laboratory: LBNL

Lab PI: Dr. Xiaorong Wang, xrwang@lbl.gov

Cumulative List of INFUSE Awards

INFUSE 2021a, June 14, 2021

Company: HelicitySpace., DUNS: 117087016

Title: Simulation of the Helicity Drive Magneto-Inertial Fusion Concept

Abstract:

The Helicity Drive is a new, compact magneto-inertial fusion concept with a unique fusion output scalability that could simplify the challenge of achieving net fusion gain in short pulses. The concept exploits magnetic reconnection-heating of merging plectonemic plasmas with peristaltic magnetic compression to increase the fusion triple product. The project proposes to perform magnetohydrodynamic simulations with select kinetic simulations to investigate the plasma physics behind the concept. Our Request for Assistance is therefore complementary to our existing, separately funded, experimental effort to build a new proof-of-concept device in collaboration with academia and national laboratories. Together, the proposed simulation effort is critical to the company's ambition of building a robust development program for our new magneto-inertial fusion concept.

Co. PI: Dr. Setthivoine You

Co. e-mail: setthivoine.you@helicityspace.com

Laboratory: LANL

Lab PI: Dr. Hui Li, hli@lanl.gov

Cumulative List of INFUSE Awards

INFUSE 2021a, June 14, 2021

Company: Microsoft Corporation, DUNS: 081466849

Title: Improving Plasma Control Capabilities in Magnetically-Confined Tokamak Systems with Transformer Neural Networks

Abstract:

The ongoing AI revolution in fundamental science offers multifarious new opportunities for application and further development of cutting-edge machine learning algorithms used in Microsoft products. In particular, the advanced AI-enabled deep learning disruption prediction capability developed at PPPL is being actively targeted in current R&D efforts at DOE's Princeton Plasma Physics Laboratory (PPPL) for implementation into plasma control capabilities in magnetically-confined tokamak experiments. This objective represents a great candidate for the proposed implementation of Microsoft's approach based on transformer neural networks to improve forward temporal projection algorithms that accurately predict dangerous disruption events encountered in thermonuclear tokamak plasmas which can in turn lead to important beneficial advances in real-time plasma control in advanced tokamak systems, including ITER.

Co. PI: Dr. Alexey Svyatkovskiy

Co. e-mail: alsvyatk@microsoft.com

Laboratory: PPPL

Lab PI: Dr. William Tang, tang@pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2021a, June 14, 2021

Company: Renaissance Americas Inc., DUNS: 117506666

Title: Phase Diagram of Li-LiH,D,(T) Mixtures and Implications for Tritium Retention and Extraction

Abstract:

Solutions of Lithium and its hydrides are expected to exhibit isotopic effects that could facilitate the extraction of LiT (alone or lumped with LiD) from liquid walls and blankets. As a preliminary test of this new concept, we propose to measure the phase-diagram of Li-LiH,D and analytically infer from it the behavior of Li-LiD,T.

Co. PI: Dr. Francesco Volpe

Co. e-mail: fv@renaissancefusion.eu

Laboratory: SRNL

Lab PI: Dr James Klein, james.klein@srnl.doe.gov

Cumulative List of INFUSE Awards

INFUSE 2021a, June 14, 2021

Company: TAE Technologies, Inc, DUNS: 065262557

Title: Extending Operational Boundaries in the Advanced FRC

Abstract:

The 3D hybrid Particle-In-Cell code HYM will be used at PPPL to simulate the stability properties of realistic plasma equilibrium states in Advanced Field Reversed Configuration (FRC) plasmas. The study will include the effects of the large fast ion population that is present in Advanced FRC plasmas due to the use of neutral beam injection (NBI). On the C-2W experiment at TAE Technologies, Inc, it is found empirically that the fast ion contribution has a strong stabilizing effect, allowing a high temperature FRC plasma to be confined with parameters that would not be accessible to conventional FRCs, which are lacking NBI. Using the HYM code, initial value simulations will be performed to identify the mechanism behind the stabilization effects of the NBI. In particular, the effect of the fast ion population on mode growth rate, non-linear saturation, and possible mode coupling will be studied. Simulation results will be used to interpret C-2W results by detailed comparison of numerical and experimental phenomena. Simulations will also be used to explore the use of other external actuators for mitigation of instabilities. The resulting improved theoretical understanding of operational boundaries will be later used to make critical decisions in the conceptual design of a next-step Advanced FRC device that is currently being planned at TAE. In this public-private partnership, scientific contributions from the Department of Energy will directly accelerate progress toward the development of fusion energy in the private sector.

Co. PI: Dr. Sean Dettrick

Co. e-mail: sean@tae.com

Laboratory: PPPL

Lab PI: Dr Elena Belova, ebelova@ pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2021a, June 14, 2021

Company: TAE Technologies, Inc., DUNS: 065262557

Title: X-ray Diagnostic for C-2W FRC Plasma

Abstract:

TAE Technologies (TAE) is committed to develop and distribute safe, cost-effective commercial fusion energy with the cleanest environmental profile. TAE's fusion approach relies on the advanced beam-driven Field-Reversed Configuration (FRC) plasma. One of the critical advantages of the advanced beam-driven FRC is its capability to suppress MHD modes and extend the stability boundary. To investigate the impact of fast ions on these phenomena, TAE recognizes the need to augment its diagnostic capability that can quantify MHD mode activities in the FRC core with sufficient time and spatial resolution. Understanding and extension of stability boundary will have a direct impact on the design and operation of TAE's next milestone device, Copernicus.

To measure the MHD mode activities in TAE's FRC core plasma, Los Alamos National Laboratory (LANL) will provide two 7-detector high-frequency x-ray diagnostic systems. TAE will work with LANL to install the diagnostics on the C-2W (aka Norman) FRC plasma device. After validating an adequate signal-to-noise ratio and frequency response in the x-ray signal for the MHD study, dedicated experiments and data analysis campaigns will be conducted to understand and extend the stability boundaries for beam-driven FRC plasmas. The data with two 7-detector (five filters, one open, and one blind) system will also help determine a rough energy spectrum of the x-ray emission. In addition, the physics and technical requirements for a 2D solid-state x-ray imaging diagnostic for TAE's FRC plasma devices will be identified and specified to further extend the capabilities for measuring the core MHD activities.

Co. PI: Dr. Deepak Gupta

Co. e-mail: dgupta@tae.com

Laboratory: LANL

Lab PI: Dr. Glen Wurden, wurden@lanl.gov

Cumulative List of INFUSE Awards

INFUSE 2020b, November 25, 2020

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: Time-Dependent Boundary Modeling to Inform Design of SPARC Diagnostic and Actuators

Abstract:

In order to inform near-term design and enable future advanced control, CFS is looking to obtain modeling of the time-dependent boundary plasma behavior it can expect in SPARC. This will be used to test plasma response to various actuator designs provided by CFS and as inputs to synthetic diagnostic modeling to inform design decisions. This activity requires laboratory assistance because of the complexity of performing boundary plasma simulation that can accurately capture plasma, neutrals and their dynamic, self-consistent behavior. This is not a present capability of CFS or a capability that is commercially available, but is one that DOE maintains and improves as part of its Fusion Energy Sciences mission.

Co. PI: Dr. Alex Creely

Co. e-mail: alex@cfs.energy

Laboratory: ORNL

Lab PI: Dr. Jeremy Lore, lorejd@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2020b, November 25, 2020

Company: General Fusion Corp., DUNS: 117111477

Title: Ion Temperature Diagnostic Improvement

Abstract:

This project is to improve General Fusion's ion temperature diagnostic for fusion plasmas. An accurate, time- and spatially-resolved measurement of ion temperature will enable experimental confirmation of fusion reaction rates.

Co. PI: Dr. Akbar Rohollahi

Co. e-mail: Akbar.Rohollahi@generalfusion.com

Laboratory: ORNL

Lab PI: Dr. Theodore Biewer, biewertm@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2020b, November 25, 2020

Company: Princeton Fusion Systems, LLC, DUNS: 0020074970

Title: Magnetic Field Vector Measurements Using Doppler-Free Saturation Spectroscopy

Abstract:

A non-perturbative diagnostic will be deployed to measure the topology of the equilibrium magnetic field in the PFRC-2 device at PPPL. The diagnostic implements Doppler-free saturation spectroscopy to obtain a 2D high-resolution, spatially resolved, measurement of the H_α spectral line profile.

Co. PI: Dr. Charles Swanson

Co. e-mail: charles.swanson@psatellite.com

Laboratory: PPPL

Lab PI: Dr. Samuel Cohen, scohen@pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2020b, November 25, 2020

Company: Magneto Inertial Fusion Technologies, Inc, DUNS: 065262557

Title: Staged Z-pinch modeling with HYDRA and CHICAGO codes

Abstract:

The Staged Z-pinch (SZP) fusion concept is a magneto-inertial compression scheme where small amounts of fusion fuel (pure deuterium gas, or a mixture of deuterium and tritium gas) are brought to fusion relevant conditions by passing multi-million amperes strong current through a cylindrical shell of high atomic number material. Modeling with the MACH2 code suggests that net fusion energy gain can be achieved when currents in the 10 million amperes range compress a 50%-50% mixture of deuterium and tritium gas. In this project various SZP configurations will be explored with the HYDRA and CHICAGO codes through collaboration with the Lawrence Livermore National Laboratory. HYDRA is a radiation-magnetohydrodynamic code, similar to MACH2, while CHICAGO is a particle-in-cell code which is suitable for a more realistic treatment of the alpha particle heating. Of particular interest are models for high current machines. The ultimate project goal is to provide independent confirmation of net fusion energy gain from the Staged Z-pinch.

Co. PI: Dr. Hafiz Rahman

Co. e-mail: hafiz@miftec.com

Laboratory: LLNL

Lab PI: Dr. Drew Higginson, higginson2@llnl.gov

Cumulative List of INFUSE Awards

INFUSE 2020b, November 25, 2020

Company: Renaissance Americas, Inc, DUNS: 065262557

Title: Innovative Joints for High-Temperature Superconducting Tapes

Abstract:

The ability to segment HTS coils for tokamaks and stellarators is very attractive but requires joints of ultra-low resistance, well below 1 nOhm. These could be enabled by ultra-thin In-Ag solder (at BNL) between ad-hoc HTS splices (from U. Houston).

Co. PI: Dr. Francesco Volpe

Co. e-mail: fv@renaissancefusion.eu

Laboratory: BNL

Lab PI: Dr. Bill Sampson, wsampson@bnl.gov

Cumulative List of INFUSE Awards

INFUSE 2020b, November 25, 2020

Company: TAE Technologies, DUNS: 065262557

Title: Measurement of Magnetic Field using Doppler-Free Saturation Spectroscopy (DFSS) in C-2W FRC plasma

Abstract:

In TAE Technologies' fusion approach, which requires high population of confined fast ions, Field Reversed Configuration (FRC) plasma provides an advantage due its unique magnetic field profile. In the experiment, measurement of internal magnetic field profile is important to verify the presence of the FRC and to estimate/simulate the orbit of confined fast ions. Doppler-Free Saturation Spectroscopy (DFSS) is capable of measuring Zeeman and Stark splitting with a resolution nearly three orders of magnitude when compared to conventional OES capabilities, and hence serve as excellent non-perturbative diagnostic to measure a low magnetic field.

A feasibility study conducted by ORNL in collaboration with TAE Technologies has shown that measurements of magnetic fields with an error of ± 5 Gauss may be possible to obtain in C-2W FRC plasma. In this proposal, ORNL will temporarily deploy their mobile Doppler Free Saturation Spectroscopy (DFSS) diagnostic system on TAE's C-2W FRC plasma device. ORNL will also help with the operation and data analysis of DFSS system on C-2W. The main goals of this collaboration are:

1) Validate that adequate signal-to-noise ratio (SNR) as well as temporal and spatial resolution can be achieved with DFSS in C-2W plasma.
2) Demonstrate the capability of DFSS to non-intrusively measure low magnetic fields and its direction in the core of the FRC plasma.
3) Experimentally assess the presence of a reversed magnetic field configuration inside the C-2W plasma.

Co. PI: Dr. Deepak Gupta

Co. e-mail: dgupta@tae.com

Laboratory: ORNL

Lab PI: Dr. Elijah Martin, martineh@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2020b, November 25, 2020

Company: TAE Technologies, DUNS: 065262557

Title: Feasibility Study of High-Flux FRC Formation via Spheromak Merging for C-2W Experiments

Abstract:

This project on MRX at PPPL will allow us to assess the feasibility of new spheromak-merging high magnetic-flux FRC formation technique for C-2W NBI experiment at TAE that could further advance C-2W performance to achieve higher energy density regime.

Co. PI: Dr. Hiroshi Gota

Co. e-mail: hgota@tae.com

Laboratory: PPPL

Lab PI: Dr. Masaaki Yamada, myamada@pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2020b, November 25, 2020

Company: Tokamak Energy, Inc., DUNS: 117135313

Title: XGC1 predictions of Scrape of Layer width in present and future high field spherical tokamaks

Abstract:

This project aims to calculate the Scrape-Off-Layer width and the heat power deposition of present and future high field spherical tokamak reactors using the global gyrokinetic code XGC1 developed at PPPL.

Co. PI: Dr. Michelle Romanelli

Co. e-mail: Michele.Romanelli@tokamakenergy.co.uk

Laboratory: PPPL

Lab PI: Dr. Choonseok Chang, cschang@pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2020b, November 25, 2020

Company: Tokamak Energy, Inc., DUNS: 117135313

Title: Fabrication and characterization of transition metal hydrides for radiation shielding in tokamak devices

Abstract:

Metal hydrides are identified as key radiation shielding materials to protect components in tokamak reactors. This project will investigate the fabrication and characterization of metal hydrides manufactured by the powder metallurgy process.

Co. PI: Dr. Thomas Davis

Co. e-mail: tom.davis@tokamakenergy.co.uk

Laboratory: LANL

Lab PI: Dr. Caitlin Taylor, caitlin@lanl.gov

Cumulative List of INFUSE Awards

INFUSE 2020b, November 25, 2020

Company: Type One Energy Group, Inc., DUNS: 117135313

Title: Characterization and Qualification of JK2LB Alloy for Additive Manufacturing of Fusion Components

Abstract:

JK2LB is a nuclear alloy providing fast clearance for fusion components. The project provides initial characterization & qualification of JK2LB for additive manufacturing (AM). The ORNL High Flux Isotope Reactor will irradiate AM-JK2LB specimens followed by tensile & microstructural analysis.

Co. PI: Mr. Randall Volberg

Co. e-mail: rvolberg@typeoneenergy.com

Laboratory: ORNL

Lab PI: Dr Yutai Katoh, katohy@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2020a, August 14, 2020

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: Baselining a Tritium Accountancy and Safety Case for a Molten Salt Liquid Immersion Fusion Blanket

Abstract:

The ARC reactor concept is a leading commercial fusion plant concept, featuring a simplified reactor design and decreased costs

The switch to high temperature superconducting (HTS) magnets further enables innovation in the reactor's blanket. Since the power density may be too high for solid ceramic breeders, and the high magnetic field may create unacceptably large pressure drops in liquid metal breeders, the molten salt FLiBe (2LiF+BeF2) has been proposed as a tritium breeder, multiplier, and coolant for ARC.

Any economically and environmentally viable fusion reactor must minimize onsite tritium inventories and environmental releases (to $\lesssim$ 0.1 g tritium released annually) and successfully mitigate release of tritium and activation products during off-normal events or accidents. While tritium transport and accident analyses are routinely performed by Idaho National Laboratory for Fusion Energy Systems Studies (FESS) designs such as ARIES and FNSF, no comparable analyses have ever been performed for ARC or another design using FLiBe. We propose to leverage the expertise of INL researchers and the MELCOR/TMAP code developed there to perform these analyses for ARC, in order to characterize its tritium transport and safety behavior.

Co. PI: Dr. Brandon Sorbom

Co. POC: brandon@cfs.energy

Laboratory: INL

Lab PI: Dr. Paul Humrickhouse, Paul.Humrickhouse@inl.gov

Cumulative List of INFUSE Awards

INFUSE 2020a, August 14, 2020

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: SPARC 3D Field Physics and Support of the Non-Axisymmetric Coil Assessment

Abstract:

The Ideal Perturbed Equilibrium Code (IPEC) code developed and maintained by Princeton Plasma Physics Laboratory Scientists Jong-Kyu Park and Nikolas Logan has revolutionized the physical understanding of plasma sensitivity to error fields and is the centerstone of this proposal. IPEC will be used to assess the types of error fields that the plasma is most susceptible to in the various plasma conditions expected during SPARC plasma current ramp-up, the steady equilibrium phase, and the plasma current ramp-down. Knowledge of the dominant error fields then allows the evaluation of a set of error field correction coils where the metric is the overlap of the applied correction field with the dominant spectrum.

Co. PI: Dr. Alex Creely

Co. POC: alex@cfs.energy

Laboratory: PPPL transferred to LLNL

Lab PI: Dr. Nikolas Logan, logan35@llnl.gov

Cumulative List of INFUSE Awards

INFUSE 2020a, August 14, 2020

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: Advanced Manufacturing Workflows for Tokamak Internal Components

Abstract:

CFS is currently designing a commercial fusion reactor called ARC, whose key innovation is the use of high-field HTS magnets. These allow for reduced plant size and cost. In addition, they allow for resistive, demountable superconducting joints that give ready access to interior components, dramatically improving RAMI. In order to fully realize benefits of demountability, the following challenges must be addressed:

- A rapid/inexpensive fabrication method must be developed to keep costs down of replacing the internal components
- The fabrication method must be able to support the construction of large (several meter scale) components

In addition, early fusion energy devices will have a learning curve and there will likely be design changes to internal components. This may require expensive re-tooling unless we have an adaptable/reconfigurable fabrication method. Additive manufacturing (AM) is a potential solution to the above challenges and opens up the rapid, low cost fabrication of large components with novel materials. The metal Big Area Additive Manufacturing team developed GMAW-based (gas-metal-arc-welding) capability at ORNL from the ground up. Our overall objective is to design a workflow for the design and manufacture of an AM internal component in a fusion device. This workflow will be tested and driven by the production of an actual subscale divertor module of an ARC vacuum vessel

Co. PI: Dr. Brandon Sorbom

Co. POC: brandon@cfs.energy

Laboratory: ORNL

Lab PI: Dr. Andrzej Nycz, nycza@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2020a, August 14, 2020 [RESCINDED]

Company: Gamma Alloys, Inc., DUNS: 830224049

Title: Tungsten Engineered Feed Stock for PFCs

Abstract:

Gamma would seek to work with Oak Ridge National Lab for reasons as follows. ORNL has extensive knowledge in process modeling, process control, in-situ and ex-situ characterization of a wide range of high temperature materials fabricated via additively manufacturing. This includes fabrication of refractory materials such as Tungsten and Molybdenum. While ORNL has exhibited success in printing these systems, the process window range is relatively small. Besides porosity, which can largely be controlled via the energy density, the major technical challenge is in suppressing the formation of intergranular cracks along columnar grains generating during printing. Prior research has shown that powders decorated with small particles can induce the nucleation of equiaxed grains during solidification. By manipulating the solidification dynamics, it may be possible to eliminate columnar grains and therefore minimize cracking. Furthermore, as traditional processing of refractory materials is incredibly difficult, processing via additive manufacturing offers a novel opportunity to surpass the current manufacturing bottleneck and deploy these materials into industrial use. Currently, Gamma is in the early stages of a, AM Aluminum CRADA with ORNL focusing on similar development for Aluminum engineered feedstock. Lastly ORNL is our ideal choice as there is an internal need for Tungsten & Tungsten alloy parts & printing.

Co. PI: Mr. Micah Peabody

Co. POC: micah.peabody@gammaalloys.com

Laboratory: ORNL

Lab PI: Dr. Peeyush Nandwana, nandwanap@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2020a, August 14, 2020

Company: General Fusion Corp., DUNS: 117111477

Title: Advanced Stability Analysis for Magnetized Target Fusion

Abstract:

This project seeks to apply advanced computational stability analyses to model equilibrium states representing the Fusion Demonstration Plant (FDP) device General Fusion is designing. The FDP is a Magnetized Target Fusion concept that strongly compresses a toroidal plasma inside of a liquid Lithium blanket. In particular, building on encouraging initial analyses, the effect of plasma rotation on the stability will be studied using the Resistive DCON and MARS-F codes under development at Princeton Plasma Physics Laboratory. The results will help to inform General Fusion on the stable operation of their design, and the project will pave the way for more advanced analyses such as the influence the energetic particles driven from fusion reactions would have on the stability.

Co. PI: Dr. Aaron Froese

Co. POC: aaron.froese@generalfusion.com

Laboratory: PPPL

Lab PI: Dr. Zhirui Wang, zwang@ pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2020a, August 14, 2020

Company: Solid Material Solutions, LLC, DUNS: 0020074970

Title: Low Temperature Testing of New Lower Cost Magnum-NX HTS Cable for Fusion

Abstract:

This program will directly measure the electrical current carrying properties of a new type of lower cost, more robust and quench resistant high temperature superconducting tape cable, thereby providing vital information for designing and developing fusion reactor coils and assessing their utility. The test cables will be produced by Solid Material Solutions, LLC and testing will be completed by staff at Brookhaven National Laboratory.

Co. PI: Dr. Alexander Otto

Co. POC: alex.otto@solidmaterialsolutions.com

Laboratory: BNL

Lab PI: Dr. Ramesh Gupta, gupta@ bnl.gov

INFUSE Innovation Network for Fusion Energy

Cumulative List of INFUSE Awards

INFUSE 2020a, August 14, 2020

Company: TAE Technologies, DUNS: 065262557

Title: Development of phased-array HHFW antenna and load-resilient matching network for the C-2W FRC plasma device

Abstract:

This proposal is to develop the optimized design of a high power capable phased-array HHFW antenna and a load-resilient matching network for the C-2W FRC plasma device. The antenna will be designed to allow arbitrary phasing of currents on the radiating elements in order to maximize heating efficiency. It will be necessary to minimize RF/edge plasma interactions with design features to be considered including low-Z insulating limiters and the reduction to the greatest possible extent of surface currents on the antenna enclosure. The matching network design will incorporate a passive load-resilience feature, which will allow the antenna to operate with arbitrary current phasing between elements, even for low levels of antenna coupling for which impedance matching of all elements would otherwise not be possible.

Co. PI: Dr. Xiaokang Yang

Co. POC: xyang@tae.com

Laboratory: ORNL

Lab PI: Dr. Richard Goulding, gouldingrh@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2020a, August 14, 2020

Company: Tokamak Energy, Inc., DUNS: 117135313

Title: Investigating microstability characteristics of next step tokamaks across a range of aspect ratios

Abstract:

This project will investigate the microstability characteristics of next step tokamaks across arrange of aspect ratios. A systems code followed by a 1.5D transport code will be used to produce plasma equilibria and kinetic profiles that satisfy a set of high-level criteria across a range of aspect ratios. Linear gyrokinetic simulations will then be used to characterise the strength and thresholds of micro-instabilities to identify which configurations are most likely to project to high confinement. The results from this project are expected to provide assistance to Tokamak Energy by providing valuable insight to the design of the Company's next step device, ST-F1, and by informing the research programme on Tokamak Energy's high field spherical tokamak, ST40.

Co. PI: Dr. Steven McNamara

Co. POC: Steven.Mcnamara@tokamakenergy.co.uk

Laboratory: PPPL

Lab PI: Dr. Walter Guttenfelder, wgutten@pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2020a, August 14, 2020

Company: Tokamak Energy, Inc., DUNS: 117135313

Title: Development of an RF Antenna to start-up and sustain a fusion plasma in a spherical tokamak

Abstract:

The central solenoid is an intrinsic part of all present-day tokamaks and most spherical tokamaks (ST). The use of a conventional solenoid in an ST-based fusion reactor may be impossible. Solenoid-free plasma start-up and steady state operation is therefore an area of extensive worldwide research activity.

Tokamak Energy's ST40 has a toroidal magnetic field of 3T which allows testing of reactor relevant RF based plasma start-up, current ramp-up and sustainment methods with commercially available MW range RF power sources. Electron Bernstein wave (EBW) based plasma start-up and plasma current drive are in the research programme of ST40. Efficient EBW excitation in the plasma requires RF power to be launched as an X-mode from the high field side (HFS) of the machine. HFS RF launching was always technically difficult in tokamaks but it is even more challenging in STs because of very limited space at the centre of the torus. However, it is strategically important to develop a technology for HFS RF launching in the STs.

Oak Ridge National Laboratory (ORNL) will perform a conceptual design of an ST compatible HFS launching system to enable investigation of a reactor scale plasma start-up, current ramp-up and sustainment of spherical tokamak plasms, The ultimate aim will be to demonstrate steady-state EBW operation and eventually to use EBW as a main method of plasma current generation in an ST reactor.

Co. PI: Dr. Vladimir Shevchenko

Co. POC: vladimir.shevchenko@tokamakenergy.co.uk

Laboratory: ORNL

Lab PI: Dr. Tim Bigelow, bigelowts@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2020a, August 14, 2020

Company: Tokamak Energy, Inc., DUNS: 117135313

Title: Conceptual design of a tritium pellet injector for the ST40 spherical tokamak

Abstract:

ORNL has a long track record of pellet injection technology development. For the application of pellet fueling on ST40, a previous design by ORNL of a flexible pipe-gun type injector named "pellet injector in a suitcase" would likely be an ideal technology to use as it has already been proven on several fusion devices and can be built and integrated into ST40 for relatively modest cost. The application of this system for ST40 would require some changes to make it tritium compatible and provide the necessary isolation of tritium containing components. The implementation of the injector for tritium use is of research interest to ORNL who have yet to deploy an injection system for use with tritium. The present proposal is to determine the pellet sizes to be utilized on ST40 and to modify the design for these sizes and for tritium compatibility.

Co. PI: Mr. David Wilson

Co. POC: david.wilson@tokamakenergy.co.uk

Laboratory: ORNL

Lab PI: Dr Larry Baylor, baylorlr@ ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2019b, September 23, 2019

Company: Advanced Conductor Technologies, DUNS: 969353734

Title: Development of a modeling toolbox for CORC® cable performance evaluation

Abstract:

Advanced Conductor Technologies and SuperPower Inc. request Lawrence Berkeley National Laboratory (LBNL) to develop a simulative tool that would create a deeper understanding of current distribution between tapes in CORC® cables for fusion magnet in the presence of common performance variations within REBCO tapes when operating at high magnetic fields. Such tool, which would be developed under the "Enabling technologies including new and improved magnets" topic area, would allow tailoring the design of CORC® cables for fusion magnets based on actual REBCO tape performance variations to ensure their optimum operation and prevent conductor burnout during a magnet quench. The model should be based on actual REBCO tape performance, with emphasis on variations in high-field REBCO tape performance due to variations in chemistry and processing conditions, and other key parameters such as contact resistance between REBCO tapes in CORC® cables.

Co. PI: Dr. Danko Van der Laan

Co. POC: danko@advancedconductor.com

Laboratory: LBNL

Lab PI: Dr. Steven Gourlay, sagourlay@lbl.gov

Cumulative List of INFUSE Awards

INFUSE 2019b, September 23, 2019

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: Superconducting Cable Quench Detection

Abstract:

This proposal will enable Commonwealth Fusion Systems (CFS) to pursue its cable development program by using the 10-T Brookhaven National Laboratory (BNL) dipole magnet, DCC017. CFS and BNL will work together on cable design and construction, cable instrumentation, design and construction of a cable test fixture, quench testing at 4 K temperatures, and quench data analysis.

Co. PI: Dr. Brandon Sorbom

Co. POC: brandon@cfs.energy

Laboratory: BNL

Lab PI: Dr. Ramesh Gupta, gupta@bnl.gov

Cumulative List of INFUSE Awards

INFUSE 2019b, September 23, 2019

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: Divertor Component Testing

Abstract:

Power exhaust is an immense challenge in tokamaks. Commonwealth Fusion Systems (CFS), in collaboration with MIT and others, is designing and building a compact, high-field tokamak for the demonstration of net fusion energy, called SPARC. A successful SPARC divertor will require very carefully engineered and qualified divertor tiles and cassettes to handle the cyclic thermal loading. Testing of materials and components under relevant heat flux conditions is a necessary step for developing a robust and reliable power exhaust system. Here we propose to use the high-heat flux testing expertise maintained by ORNL, used in support of NSTX-U, to demonstrate the thermal performance of tungsten-coated graphitic foam targets, to help CFS and its collaborators assess the performance of base materials and divertor mockups under SPARC-like divertor heat flux conditions.

Co. PI: Dr. Dan Brunner

Co. POC: dan@cfs.energy

Laboratory: ORNL

Lab PI: Dr. Travis Gray, tkgray@pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2019b, September 23, 2019

Company: Commonwealth Fusion Systems, DUNS: 117005109

Title: Divertor Plasma Simulations

Abstract:

Power exhaust is an immense and unsolved challenge in tokamaks. The intensity of the boundary plasma in present experiments falls far short of the conditions expected in net-energy tokamaks. This proposal will allow CFS to use the unique UEDGE plasma neutral simulation code to simulate boundary plasmas under conditions relevant to its net-energy tokamak device, called SPARC.

Co. PI: Dr. Dan Brunner

Co. POC: dan@cfs.energy

Laboratory: LLNL

Lab PI: Dr. Maxim Umansky, umansky1@llnl.gov

Cumulative List of INFUSE Awards

INFUSE 2019b, September 23, 2019

Company: Commonwealth Fusion Systems., DUNS: 117005109

Title: Alpha Particle Diagnostics Simulation

Abstract:

Measuring and understanding the physics of transport of fast ions is an important part of the missions of TFTR, JET, ITER and SPARC, because it affects both plasma performance (MHD stability and plasma heating) and survival of the first wall. A well-designed diagnostic set will be required to study the transport and loss of energetic ions from both classical (ripple) and MHD-driven mechanisms. Careful simulations of the expected properties of the energetic ion populations must first be carried out to optimally design, and position the diagnostics that are required to adequately test the transport models. The work proposed here aims to lay out the requirements for alpha-particle diagnostics, especially lost alphas, by predicting how these particles are expected to behave under conditions relevant to SPARC, CFS' break-even tokamak. We propose to use two sets of code developed and maintained by the Princeton Plasma Physics Laboratory to perform calculations of fast-ion losses in SPARC arising from toroidal field (TF) ripple and magnetohydrodynamic effects.

Co. PI: Dr. Steve Scott

Co. POC: sscott@psfc.mit.edu

Laboratory: PPPL

Lab PI: Dr. Gerrit Kramer and Dr. Mario Podesta, mpodesta@ pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2019b, September 23, 2019 [RESCINDED]

Company: HelicitySpace, DUNS: 117087016

Title: Development of a High-Current Solid-State Switch for Magneto-Inertial Fusion

Abstract:

Magneto-inertial fusion attempts to satisfy the Lawson criterion in short pulses of the order of plasma energy confinement times. The power systems for this class of fusion concepts generally require large (> 1 MA) level currents delivered very rapidly. Delivering electricity to the grid will then require high frequency pulses (~ 1 Hz). There is therefore a strong need for switches capable of satisfying these requirements. The project proposes to develop power stacks capable of scaling up to these requirements based on light-activated thyristors that promise to provide more compact, robust and scalable switches for magneto-inertial fusion concepts.

Co. PI: Dr. Setthivoine You

Co. POC: setthivoine.you@helicityspace.com

Laboratory: PPPL

Lab PI: Mr. Clement Bovet, cbovet@ pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2019b, September 23, 2019

Company: HelicitySpace, DUNS: 117087016

Title: Simulation of Plectoneme Formation

Abstract:

Plectonemes are non-axisymmetric Taylor states recently discovered in the SSX and MOCHI experiments. These experiments have observed remarkable stability and long lifetimes, without close-fitting walls in some cases, despite their non-axisymmetric nature. The Helicity Drive is an innovative fusion energy concept that exploits these properties together with magnetic reconnection heating and passive magnetic compression to achieve triple products sufficient for net energy gain. The company has detailed physics calculations that estimate the scaling of plasma parameters and triple product with input parameters based on prior laboratory experience. This project proposes to perform high-performance 3D MHD numerical simulations of the formation process of plectonemes to improve the understanding of the SSX and MOCHI results, and help enable predictive capabilities for the Helicity Drive concept.

Co. PI: Dr. Setthivoine You

Co. POC: setthivoine.you@helicityspace.com

Laboratory: LANL

Lab PI: Dr. Hui Li, hli@lanl.gov

Cumulative List of INFUSE Awards

INFUSE 2019b, September 23, 2019

Company: Hyperjet Fusion Corp., DUNS: 080736078

Title: 3D MHD Simulations Support for PJMIF

Abstract:

We are looking for help from the national labs in conducting credible 3D MHD simulations of our proposed target formation approach, assessing relevant merging conditions of the compact toroids that can be created in the near term and to assess the magnetic topology and plasma properties that can be obtained. These simulations are challenging because they require the study of a complicated magnetic topology in 3D, varying over a wide range of physical length scales as the compact toroids converge and stagnate, and have proved well beyond the capabilities of codes we have been able to access in the commercial space.

Co. PI: Dr. Franklin Witherspoon

Co. POC: witherspoon@hyperjetfusion.com

Laboratory: LANL

Lab PI: Dr. Glen Wurden and/or Dr. Samuel Langendorf, samuel.langendorf@lanl.gov

Cumulative List of INFUSE Awards

INFUSE 2019b, September 23, 2019

Company: TAE Technologies, Inc., DUNS: 065262557

Title: Simulations of Global Stability in the C-2W Device

Abstract:

TAE Technologies, Inc, proposes to use the HYM 3D particle-in-cell code developed at PPPL to study the synergistic effects of neutral beam injection and end biasing on the global stability of FRC plasmas in conditions relevant to the C-2W experimental device and the planned next-step device, Copernicus.

Co. PI: Dr. Sean Dettrick

Co. POC: sean@tae.com

Laboratory: PPPL

Lab PI: Dr Elena Belova, ebelova@ pppl.gov

Cumulative List of INFUSE Awards

INFUSE 2019b, September 23, 2019

Company: TAE Technologies, Inc., DUNS: 065262557

Title: Doppler-Free Saturation Spectroscopy (DFSS) for Magnetic and Electric Field Measurements in an FRC plasma

Abstract:

The proposal will examine the feasibility of implementing Doppler Free Saturation Spectroscopy (DFSS) to measure the magnetic and electric fields profiles in the Field Reversed Configuration (FRC) plasma of TAE's C-2W device. There are two primary objectives,

1) An error analysis will be conducted to determine the minimum magnetic and electric field that can be determined by DFSS, and measurement uncertainty as a function of magnetic and electric field magnitude and direction. Potential sources of systematic error will be identified using C-2W plasma parameters.
2) Recommend preliminary design for the DFSS system based on C-2W machine parameters, accessibility, and the desired spatial and temporal resolution.

Co. PI: Dr. Deepak Gupta

Co. POC: dgupta@tae.com

Laboratory: ORNL

Lab PI: Dr. Elijah Martin, martineh@ornl.gov

Cumulative List of INFUSE Awards

INFUSE 2019b, September 23, 2019

Company: TAE Technologies, Inc., DUNS: 065262557

Title: Developing high harmonic fast wave (HHFW) as an enabling electron heating actuator for an FRC plasma

Abstract:

The main task of this project is to perform HHFW simulations in FRC plasma by using Petra-M code and the 4-strap antenna geometry implemented in LArge Plasma Device (LAPD) under different plasma conditions, for example, at (1) the different phasing between straps, (2) the different external magnetic field (thus different RF frequency), and (3) the different antenna radial position. Furthermore, due to compact and limited space near the midplane of C-2W, the impact of the different number of antenna straps will be also explored in order to improve the antenna design and its performance. A study of high power enabling HHFW antenna design will be considered using the HHFW engineering and simulation tools developed at PPPL.

A possible verification activity with the experimental data (RF wave magnetic fields at both the near and far field measured by B-dot magnetic probes) for the HHFW phased-array (4-strap) antenna in LAPD will be also considered.

Co. PI: Dr. Xiaokang Yang

Co. POC: xyang@tae.com

Laboratory: PPPL

Lab PI: Dr. Nicola Bertelli, nbertell@ pppl.gov