Advertisement for Research Associate (RA) position

Project CODE: FT-TOKAMAK-0002/RA/2026		
1	Title of the Project	Time-resolved impurity (natural and seeded) transport in ADITYA-U tokamak: An experimental and computational study
2	Domain Area	Modeling / Theory / Experiment
3	Project Category as found relevant	Plasma Diagnostics; Tokamak devices; Fusion Technology; Tokamak Core Impurity Accumulation
4	Desirable Qualification/Experience required for the post:	PhD in Physics, experienced in development and usage of computational tools for impurity (natural and seeded) transport in tokamaks, along with knowledge of handling tokamak plasma spectroscopy data.
5	Brief Summary about the Project	Impurities are an unavoidable and, in many cases, essential component of magnetically confined fusion plasmas. They strongly influence plasma performance by affecting energy confinement, radiation losses, plasma stability, and overall reactor operation. Excessive impurity accumulation can increase radiative cooling, degrade confinement, and even trigger plasma disruptions [1]. Conversely, controlled impurity seeding has been shown to improve plasma performance by enhancing edge radiation, reducing divertor heat loads, and enabling stable high-performance operation [2]. Therefore, understanding and accurately predicting impurity transport is fundamental to realizing practical fusion reactors [3]. Significant progress has been made in understanding impurity transport during the main plasma phase through both experimental and theoretical studies. For example, gyrokinetic simulations of JET plasmas have demonstrated good qualitative agreement with experimental observations for injected impurities such as argon (Ar), nickel (Ni), and neon (Ne), although discrepancies remain for intrinsic carbon (C) impurities, indicating that several aspects of

		impurity transport physics are still not fully understood [4]. Compared with the main discharge phase, impurity transport during plasma start-up and breakdown has received considerably less attention. The success of tokamak start-up critically depends on the characteristics of the initial plasma formed during electrical breakdown. While impurity effects have been extensively studied in the context of plasma-wall interactions, their role during plasma breakdown remains poorly understood. Recently, a one-dimensional particle-in-cell/Monte Carlo collision model was developed to investigate the influence of beryllium impurities on ohmic plasma start-up. The simulations demonstrated that beryllium impurities suppress plasma density growth, delay breakdown, and increase the electric field required for successful discharge initiation, particularly under low electric field conditions [5]. These findings highlight the need for comprehensive investigations of impurity transport during the start-up phase in present-day tokamaks. The proposed project aims to develop a time-dependent impurity transport model and validate it through dedicated experimental measurements during the plasma breakdown, start-up, plasma current ramp-up, and ramp-down phases of the ADITYA-U tokamak. A computational framework for plasma-material interaction (PMI) studies will be developed by incorporating modern binary collision approximation (BCA) codes such as RUSTBCA (OPEN-SOURCE) under ADITYA-U operating conditions. The developed impurity transport code will be optimized for faster results (through implementation of parallelization techniques) so it can estimate impurity transport coefficients for real-time discharges in the future. The optimized code will be coupled with RUSTBCA (OPEN-SOURCE) to incorporate impurity source terms arising from wall erosion, physical sputtering, and recycling into the transport simulations. This coupled framework will enable self-consistent investigation of impurity generation, migration,

		redeposition, and recycling, together with their effects on plasma behavior. Furthermore, the model will be extended to estimate impurity source rates originating from wall erosion, sputtering, and pellet injection experiments in ADITYA-U. The coupled simulations will predict impurity density distributions, transport characteristics, and radiative losses under a range of plasma operating conditions, providing valuable insight into impurity control strategies for ADITYA-U and future fusion devices. The experimental validation of these code outcomes will be carried out through dedicated experiments using in-situ characterization of surfaces introduced in ADITYA-U plasma using Laser-induced breakdown spectroscopy (LIBS) diagnostics. [1] P. C. de Vries et al, The influence of an ITER-like wall on disruptions at JET, Phys. Plasmas 21, 056101 (2014). [2] C. Giroud et al, Impact of nitrogen seeding onconfinement and power load control of a high-triangularity JET ELMy H-mode plasma with ametal wall, Nucl. Fusion 53 113025 (2013). [3] C. Angioni, Impurity transport in tokamak plasmas, theory, modelling and comparison with experiments, Plasma Phys. Control. Fusion 63 073001 (2021). [4] H Nordman et al, Fluid and gyrokinetic simulations of impurity transport at JET, Plasma Phys. Control. Fusion 53 (2011) 105005. [5] Yanli Peng et al, Simulation study of the influences of beryllium on the tokamak start-up process, Jornal of Plasma Physics, 89 (2023) 905890517
6	Any other information/remarks	The proposed work aligns closely with ongoing research at the Institute for Plasma Research (IPR) on the ADITYA-U tokamak and will strengthen its experimental and modeling capabilities in impurity transport. To study the transport of various impurities, an in-house-

		developed time-independent SITA (Study of Impurity Transport in ADITYA-U tokamak) code is readily available. The code solves the radial impurity transport equation using a semi-implicit numerical scheme to estimate impurity-ion transport coefficients. Building on this framework, the proposed work aims to develop a time-dependent impurity transport model, validated using dedicated measurements from ADITYA-U, to provide predictive capability for interpreting impurity behavior during the plasma breakdown, start-up, current ramp-up, and ramp-down phases, which remain relatively unexplored. Furthermore, coupling the impurity transport model with a binary-collision approximation code,such as RUSTBCA (OPEN-SOURCE), will establish an integrated plasma-material interaction modeling capability at IPR. This framework will enable quantitative assessment of impurity source rates arising from wall erosion, sputtering, recycling, and pellet injection under realistic ADITYA-U operating conditions. The validated model will support the design and optimization of plasma-facing components, impurity control strategies, and future experimental campaigns. Furthermore, the computational tools, simulations, and experimental database developed through this work will complement IPR's ongoing edge plasma and plasma-surface interaction studies, while providing valuable expertise and modeling capability relevant to developing next-generation fusion devices, including ADITYA-MA and SST-Bharat.