Advertisement for Research Associate (RA) position

Project CODE: FT-TOKAMAK-0001/RA/2026		
1	Title of the Project	Development of a computational framework for studying tungsten emission together with experimental validation in ADITYA-U tokamak plasma
2	Domain Area	Modeling / Theory / Experiment
3	Project Category as found relevant	Plasma Diagnostics ; Tokamak devices ; Plasma-wall interaction ; Fusion Technology ; Plasma Atomic and Molecular Physics
4	Desirable Qualification/Experience required for the post:	PhD in Physics, experienced in development and computational tools for tokamak edge plasma physics, atomic/molecular physics, along with knowledge of tokamak plasma spectroscopy.
5	Brief Summary about the Project	Tungsten (W) is a key plasma-facing material for present and next-generation fusion devices because of its high melting point, low sputtering yield, and excellent resistance to extreme thermal loads. It is therefore the material of choice for plasma-facing components in ITER [1]. It is also being considered for the divertor configuration of the ADITYA-U tokamak. Very recently, tungsten pellet injection experiments have been carried out in the ADITYA-U tokamak for disruption mitigation studies. Owing to its high atomic number, tungsten undergoes multiple stages of ionization, producing emissions that span a broad spectral range from X-rays to the visible [2]. Unlike highly charged tungsten ions, which dominate radiation in hot core plasmas, neutral W I is particularly relevant near the plasma-facing surface and in the edge/divertor region, where sputtered tungsten initially enters as neutral atoms. Visible and near-UV W I emission lines are used to monitor tungsten influx, erosion, and impurity transport. Therefore, reliable W I atomic data are essential for quantitative spectroscopy. Previously, a substantial body of literature reported atomic data and spectroscopy for highly charged tungsten [3], but much less is known

		about neutral and lowly ionized tungsten. In the proposed project, tungsten emissions in fusion plasmas as well as in the ADITYA-U tokamak plasma will be investigated by analyzing the underlying atomic processes such as electron-impact excitation (EIE), ionization, and recombination through the development of a collisional-radiative model (CRM) after using an open-source code, FAC (flexible atomic code) [4]. The generated database will provide the atomic structure and EIE cross sections required for CRM calculations and spectroscopic interpretation of tungsten emission. For neutral tungsten (W I), fine-structure level energies will be calculated using a multiconfiguration Dirac-Fock (MCDF) approach with extensive configuration interaction (CI). The corresponding electron-impact excitation cross sections will then be calculated using the relativistic distorted-wave (RDW) method [5]. The MCDF+CI description will be adopted because relativistic effects and strong configuration mixing are important for accurately describing the atomic structure of W I. The resulting atomic data will be incorporated into a CRM to investigate the population dynamics of tungsten levels and to interpret the intensities and wavelengths of selected tungsten emission lines. In addition, the neutral transport (DEGAS2) [6] and plasma fluid (UEDGE) [7] codes will be coupled to investigate the transport of fuel neutrals in the ADITYA-U edge and scrape-off-layer (SOL) plasma. The coupled model will incorporate the temporal evolution of the edge plasma during a discharge, thereby providing a more realistic description of neutral transport and particle fluxes. After validation of the coupled framework for fuel neutrals, it will be extended to the transport of tungsten neutrals. This will provide a systematic framework for investigatingfuel-neutral transport in the presence of W neutrals in the ADITYA-U edge and SOL regions. The integrated atomic and plasma-transport framework will enable a more

		realisticdescription of tungsten neutral dynamics and their interaction with the evolving edge plasma References: [1] R. A. Pitts et al, “A full tungsten divertor for ITER: Physics issues and design status”, Journal of Nuclear Materials 438, (2013) S48-S56. [2] Thomas Putterich et al, “Modelling of measured tungsten spectra from ASDEX Upgrade and predictions for ITER”, Plasma Phys. Control. Fusion 50 (2008) 085016. [3] Tetsutarou Oishi et al, “Observation of tungsten emission spectra up to W46+ ions in the Large Helical Device and contribution to the study of high-Z impurity transport in fusion plasmas”, Nucl. Fusion 64, (2024) 106011. [4] M. F. Gu, “The flexible atomic code”, Can. J. Phys. 86 (2008) 675. [5] Zuo T, McEachran R and Stauffer A D, “Relativistic distorted-wave calculation of electron impact excitation of xenon”, J. Phys. B: At. Mol. Opt. Phys. 24 (1991) 2853. [6] Ritu Dey et al, “Spectroscopic estimation of radial particle flux using Hα emissivity profiles in ADITYA tokamak plasmas”, Fusion Science and Technology, 1-11. https://doi.org/10.1080/15361055.2025.2594375. [7] Ritu Dey et al, “Effect of convective transport in edge and scrape-off-layer plasmas of ADITYA-U tokamak”, Scientific Reports 16, 1450 (2026).
6	Any other information/remarks	The proposed work is closely aligned with the ongoing activities of the Institute for Plasma Research (IPR) in fusion plasma research, particularly the experimental and computational studies associated with the ADITYA-U tokamak. Tungsten is an important plasma-facing material for future fusion devices, and its transport,

		ionization, and radiation characteristics are essential for understanding plasma-wall interactions and impurity behavior. However, reliable atomic data for neutral and lowly ionized tungsten are comparatively limited in widely used databases. The proposed development of a detailed W I atomic database, including fine-structure-resolved energy levels and electron-impact excitation cross sections, together with collisional-radiative modeling (CRM), will provide the atomic data needed to predict tungsten emission-line intensities. This work will be carried out using the well-established Flexible Atomic Code (FAC), which has been successfully implemented for modeling oxygen impurity emission in ADITYA-U tokamak plasmas. The experimentally observed tungsten emission lines will then be modeled and interpreted using the developed atomic data and CRM framework. In addition, coupling the neutral transport code (DEGAS2) with the plasma fluid code (UEDGE) will further complement the ongoing efforts at IPR in edge-plasma and neutral-particle modeling. Both codes have individually demonstrated their capability to successfully predict key physics features of ADITYA/ADITYA-U plasmas in the limiter configuration. Initially validated for fuel-neutral transport, the framework will subsequently be extended to tungsten neutrals, enabling self-consistent investigation of their generation, transport, ionization, and penetration in the ADITYA-U edge and SOL. The integrated atomic and plasma-transport modeling will provide a computational link between atomic physics, neutral transport, edge-plasma evolution, and spectroscopic observations. 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.