



Project Proposal for Ph.D.

Project Details (The research problem must clearly indicate the need for an interdisciplinary approach)	
Project Title	Characterization of fire-glows in low-temperature plasma source using nonlinear dynamical and AI/ML tools
Project Summary (Minimum 500 and maximum 2000 characters)	Plasma is a complex, highly energetic ionized gas with its quasi-neutral properties having an inherent self-organizing ability against external perturbations which, in turn, trigger nonlinear features in different types of plasma sources. This plasma feature is very useful for a wide range of applications, including fusion plasmas, plasma-based material processing and surface modifications, plasma cutting and welding, plasma scrubbers and cleaners, etc. One important feature that exemplifies self-organization in plasma sources is the space charge region, called plasma sheath, that develops between the plasma medium and any boundary confining the same. The nonlinear potential that develops across the plasma sheath is very difficult to probe using in-situ sensors without changing its characteristics significantly. However, small perturbations to this sheath triggers various interesting nonlinear responses both within the plasma medium as well as in the external circuit that drives this perturbation. Measuring these responses and undertaking a nonlinear-dynamical characterization of these excited features can identify processes that could be tuned to improve the performance of a given plasma source for a given application. Further, these estimates can be used as inputs to physics-based models in conjunction with AI/ML tools, to predict the behaviour of the non-linear sheath under different ambient conditions. Plasma Lab at IIT Delhi has observed many nonlinear features such as ion acceleration across self-consistently developed double layers in ECR based plasma thruster, rotating anode glow fireballs in dc discharges and nonlinear power coupling regimes in rf discharges. This research problem would attempt to address one such interesting feature viz., fire-drops, fire-sheets as well as rotating fireballs and fire-drops, that were triggered in dc discharges using aforementioned tools. Considering the complexity of these phenomena, the underlying physics-based models will be used in conjunction with AI/ML tools to predict the relevant conditions that lead to the rotating anode glows. Further, synchronization studies would also be carried out by coupling two such distinct rotating anode glow discharges and study the effect of different operating parameters using nonlinear tools.

Ph.D. Supervisors* (Supervisor 1 and Supervisor 2 cannot be from the same department of IITD)			
Role	Name of Faculty	Academic Unit in IITD/Institute/University	Email ID (Official)
Supervisor 1*	Ramesh Narayanan	Department of Energy Science and Engineering, Indian Institute of Technology Delhi	rams@dese.iitd.ac.in
Supervisor 2	Vikrant Saxena	Department of Physics, Indian Institute of Technology Delhi	vsaxena@physics.iitd.ac.in

*Supervisor 1 must be from IIT, Delhi.

+All cells in this table are mandatory fields that need to be filled by faculty for consideration of proposal.

\$The date of superannuation of supervisors should be at least three years from the date of registration of selected candidates.

Project requirements (Student qualifications, experience required, etc)
*The candidate will be shortlisted based on common shortlisting criteria decided by ScRC (SIRe)
M. Sc. In Physics or M. Tech. in Electronics and Instrumentation - Exposure to electronics and / or vacuum systems may be preferable? - Preferable has some knowledge of numerical techniques?

Source of fellowship/funding and project number
(CSIR/UGC/DBT/ICMR/ICAR/NEET-PG/DST-INSPIRE/IRD/FITT Project details, if any)
CSIR/UGC/DBT/ICMR/ICAR/NEET-PG/DST-INSPIRE or any other scholarship holder students can apply (preferable) If not, then Institute Fellowship (FIA) can be considered.

Role of Faculty Members involved:	
Supervisor-1	Prof. Ramesh Narayanan (DESE, IIT Delhi) will mentor the student on the development and characterization of the discharges triggered in low-temperature plasma sources for nonlinear studies.
Supervisor-2	Prof. Vikrant Saxena (Physics, IIT Delhi) will mentor the student to understand theoretical physics concepts of such discharges and use of relevant models to study the

Note :-

- 1. Approval from the respective DRC/CRC/ScRC of your Department/Centre/School will be required for using the "Full-time Institute Assistantship (Category-wise) (FIA)" for selecting the students in SIRe.**
- 2. Declaration:- Faculty members, please ensure that you have at least 3 years of service left before superannuation along with adequate sitting space & lab facilities for the SIRe student.**
- 3. PI/s are also encouraged to submit joint proposals with AIIMS, NII, JNU and institutes with which IITD has an existing MoU. If the Co-PI (Supervisor 2) is from outside IITD, kindly share his/her detailed CV.**
- 4. If a research scholar is to be considered for selection under the project fellowship, then the project should have a minimum of two-year duration remaining.**
- 5. A candidate applying with a valid JRF/INSPIRE/any national level fellowship should have at least two-year validity from the date of joining the Ph.D. program.**
- 6. The third supervisor's name (if required) can be added only after the formation of Student Research Committee (SRC) subject to a strong recommendation of SRC and subsequent approval from the competent authority.**
- 7. If Institute fellowship is being sought, then DRC approval of the parent department of Supervisor 1 is required at the time of selection.**