White Paper for *Frontiers of Plasma Science Panel*

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Indicate the primary area this white paper addresses by placing "P" in right column.
Indicate secondary area or areas by placing "S" in right column

	"P", "S"
• Plasma Atomic physics and the interface with chemistry and biology	P
• Turbulence and transport	S
• Interactions of plasmas and waves	
• Plasma self-organization	
• Statistical mechanics of plasmas	

Indicate type of presentation desired at Town Hall Meeting.

	"X"
Oral	X
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Title:	Study of Dust Transport in Fusion Plasmas
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Study of Dust Transport in Magnetic Fusion Plasmas

White paper for Panel 1 – Plasma atomic Physics and the interface with Chemistry and Biology – Kushner & Beiersdorfer Pannel

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Introduction

This white paper presents a key area that needs to be addressed in the fusion plasma community to help solve some of the key plasma material issues. One of the frontiers in fusion plasma science and technology is the development of material solutions (first wall, divertors, plasma-facing components) for the harsh environment of the plasma boundary, such as in fusion.[1,2] This is a challenge that requires interdisciplinary collaborations between materials research and magnetic fusion research. This means that plasma-material interactions (PMI) studies are critically needed since there still exists a significant gap between the experimental observations and quantitative understanding. Controlled experiments, materials characterization, and computer simulations that capture multi-physics and multi-scale processes in PMI will not only allow better understanding of PMI physics, but also supply necessary information for materials development.

Dust production at the PMI Boundary

As an example, the erosion of plasma facing components and the divertor will result in significant dust production in burning plasmas like ITER [3] and will have a direct impact on tritium retention. Much of the technological development based on this dust production is derived from empirical evidence rather than from a quantitative understanding of dust-plasma interaction physics. Using controlled dust injection methods that have been pioneered at LANL[4,5] and experiments on machines such as NSTX-U (PPPL) and the Hybrid Illinois Device for Research and Application (HIDRA) at UIUC could be used to gain a quantitative knowledge of dust transport physics near the plasma boundary.

HIDRA[6], formerly known as WEGA, is a multi-faceted stellarator-tokamak system that will be dedicated to testing plasma surface interactions and capable of up to 1 hour “steady state” plasma operations. The ability for HIDRA to also be run as a tokamak by ramping the central solenoid, allows for investigations

of dust behavior in high power pulsed conditions. The use of HIDRA as a testing facility provides a wide range of experimental conditions allowing better characterization of dust interactions in fusion plasmas.

Recent success in condensed matter injection for magnetic fusion

Lithium granule injector experiments in EAST and DIII-D successfully demonstrated the usefulness of granule injection for ELM triggering.[7] Other promising methods for disruption mitigation in ITER involve injecting shattered cryogenic pellets.[8] Better understanding of dust transport and dust-plasma interaction is crucial in fusion. An understanding of the way dust interacts with the edge plasma will therefore provide the necessary experimental foundation to develop effective technologies and tools to correlate wall erosion to dust production, predict modeling of dust transport and its effects on the impurity content in a plasma, describe material migration/redeposition and characterize plasma instability mitigation and particle control. Dust/granule injector technology development will also become useful to diagnose PMI in-situ and provide valuable information for materials development[9] as well develop a better understanding of tritium retention and distribution in future machines like ITER, FNSF and DEMO.

References

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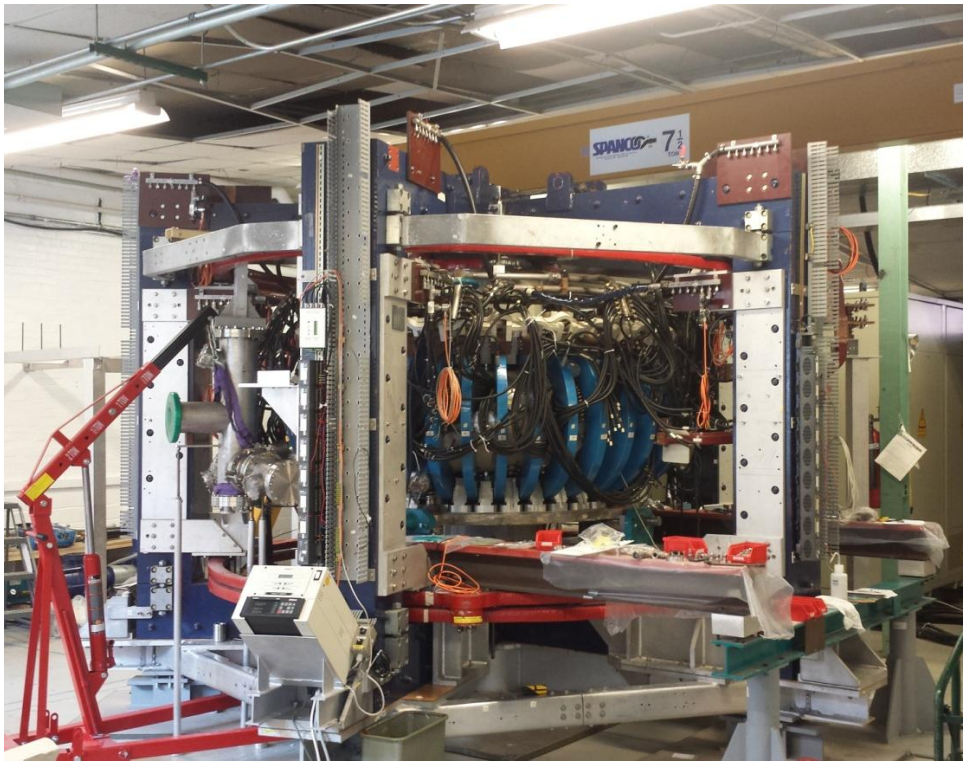
Figures



HIDRA being currently assembled at UIUC.