White Paper for *Frontiers of Plasma Science Panel*

Date of Submission:	19 June 2015

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	
• Turbulence and transport	
• Interactions of plasmas and waves	S
• Plasma self-organization	P
• Statistical mechanics of plasmas	

Indicate type of presentation desired at Town Hall Meeting.

	"X"
Oral	X
Poster	
Either Oral or Poster	
Will not attend	

Title:	Creating and diagnosing high *Re* and Re_m plasmas in the laboratory
Corresponding Author:	Carolyn Kuranz
• Institution:	University of Michigan
• email:	ckuranz@umich.edu
Co-Authors:	

1.Describe the research frontier and importance of the scientific challenge.

Creating a high *Re* and Re_m plasma is challenging, as is the related theory and computational simulations. The *Re* number is the ratio of inertial forces to viscous forces and the Re_m is the ratio of magnetic advection to magnetic diffusion. Plasmas in the high *Re* regime (> 10000) can become turbulent in which fluctuations are present on a wide range of scales, and energy is transferred from the largest scales (eddies or vortices) to the smallest (Kolmogorov). In magnetized plasmas with high the Re_m, the magnetic field is advected with the fluid flow and the field lines are "frozen in" to the flow. Plasma with high *Re* and Re_m are extremely complex due to the interplay of the velocity and magnetic field vectors and the dissipative parameters, viscosity and resistivity. There are many unanswered questions as to the behavior of these systems, such as, what is the structure and spectrum of spatial scales in these systems? And how are they affected by the magnetic field? The related theory is complex, and computational studies require significant computational resources, however, experiments can help the advancement in these areas.

2. Describe the approach to advancing the frontier and indicate if new research tools or capabilities are required.

Plasmas with high *Re* have been created at high-energy laser facilities [1] and recent experiments have reported a Re_m of 10 [2]. However, in many astrophysical systems, such as dynamos, $Re_m \sim 1000$. In order to create even higher Re_m flows, high temperature, high flow velocity plasmas must also be created. This will yield a unique and novel plasma experiment. A high magnetic field is also a key part of these experiments. Pulsed magnetic fields have been created 10 – 50 T, but there exist limitations to the diagnostic and laser beam access [3].

3. Describe the impact of this research on plasma science and related disciplines and any potential for societal benefit.

Magnetic fields are found throughout our universe. They can be found in planets, stars, galaxies, accretion and protoplanetary disks, and magnetic dynamics. The Earth's magnetic field yields the magnetospheric structure that protects us from the Sun's highly energetic particles. Magnetic fields play a key role in accreting systems that is the basis for star formation. The Report of the 2009 Workshop on Basic Research Needs for High-Energy-Density Laboratory Physics posed the question, "Are long established astrophysical models for such phenomena correct?" [4] To answer this question regarding complex magnetohydrodynamic flows we must be able to create and diagnose high *Re* and Re_m plasmas in the laboratory.

References

1. H.F. Robey, *Physics of Plasmas*, 2004.
2.G. Gregori et al., *Nature*, 2012.
3. O.V. Gotchev et al., Physical Review Letters, 2009.
4. R. Rosner and D. Hammer, "Basic Research Needs for High-Energy-Density Laboratory Physics, Report of the Workshop on HEDLP Research Needs," (2009).