White Paper for *Frontiers of Plasma Science Panel*

Date of Submission:	***June 19, 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	
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:	In situ plasma data in the inner solar corona: plasma structures and current sheets at 10 solar radii—observation and theory
Corresponding Author:	James Chen
Institution:	Naval Research Laboratory
email:	James.chen@nrl.navy.mil
Co-Authors:	

(Limit text to 3-pages including this form. Font Times Roman size 11.
1 page of references and 1 page of figures may also be included. *Submit in PDF format*.)

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

NASA's mission to the inner solar corona, Solar Probe Plus [1], which is slated to be launched in 2018, will gather, for the first time in the history of science, in situ plasma (particle and field) data down to 10 solar radii. This is a natural plasma environment that has not been explored previously. One important unsolved plasma physics question is how magnetic reconnection occurs in the solar corona. At the foundation of the question is the structure of current sheets. The in situ properties of certain structures such as coronal mass ejections (CMEs) and streamers have never been observed at this distance. As a result, it has not been possible to test various concepts and models of CMEs, solar flares, and prominence eruptions using in situ data. CMEs are, of course, the main drivers of severe geomagnetic storms affecting the Earth's ionosphere that can cause deleterious effects on various technological systems such as satellites, communications systems, and electric power grids [2]. A key concept in understanding CMEs and other solar eruptive phenomena and therefore in any effort to develop capabilities to predict geomagnetic disturbances is to understand structures of reconnecting current sheets near the source of eruptions. This is because virtually all theoretical and numerical models of CMEs and flares use magnetic reconnection [3] as an essential element of the eruptive process. No correct understanding of this process can be achieved or tested without an accurate understanding of the plasma structure of current sheets in the corona. Thus, this is one of most fundamental first steps to be taken in order to bring the physical understanding of CME [4] and flare mechanism to a qualitatively higher levels. In this regime, it is expected that the plasma parameters are in a regime such that the particle motion is collisionless on the

scale of gyroradius but is collisional on the scale of the dimensions of coronal structures. The research will take advantage of the previous work in the area of collisionless current sheets and collisionless reconnection and develop new theoretical models applicable to this hitherto unexplored plasma environment. This represents are truly new frontier in plasma physics research and new intellectual challenges as a physics research discipline.

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

Many solar and coronal structures are identified, by heuristic ideas and based on morphological features, as currents and flux ropes. Theoretically, a small number of well-known current sheet structures exist. However, tested against observations in near-Earth plasma space (e.g., the magnetosphere), these models do not necessarily agree with the data. The important point is that the current sheet structures are dependent on the internal plasma energy distribution (pressure tensor) so that the structure is directly coupled to plasma dynamics such as magnetic reconnection. Furthermore, most current sheet models use symmetric structures. This may be generally inapplicable in the near-Sun corona. The proposed research approach is to develop a new kinetic approach [5] that allows current sheets to be highly nonsymmetric with strong solar wind-like flows. Before developing numerical simulation tools, one needs to establish a good theoretical understanding in this new regime so that numerical simulation tools can be better defined. It is expected novel theoretical plasma physics techniques and results will result from such an effort.

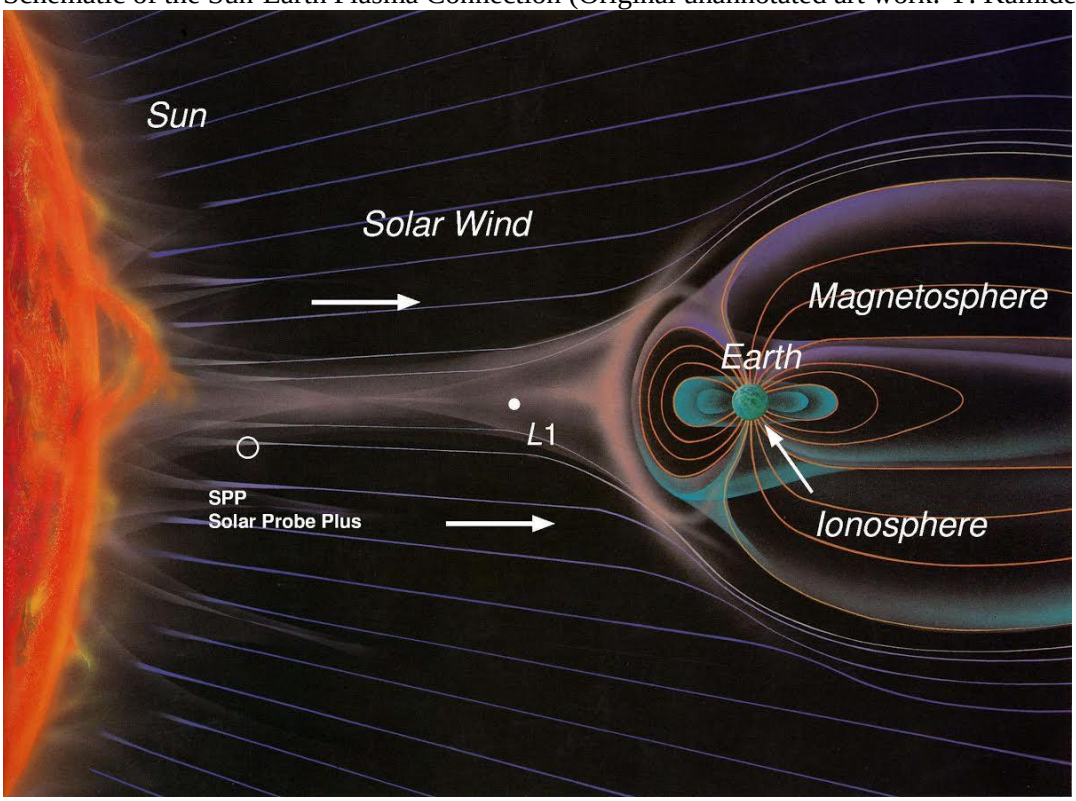
- ***Describe the impact of this research on plasma science and related disciplines and any potential for societal benefit***.

In situ plasma data at 10 solar radii have not been obtained previously. So far, all solar data have been obtained by remote sensing methods, i.e., photons, with no independent way to validate the inferred plasma properties. The true relationship between photon data from this region in the corona and the inferred plasma properties has not been tested. For the first time, studying the Solar Probe Plus plasma data can shed light on the veracity of the previous inferences. This is of fundamental importance to plasma science and solar physics. This will also improve the understanding of the plasma environment in which CMEs occur that can disrupt terrestrial systems, which will help develop predictive capabilities. Solar Probe Plus plasma data will allow one to directly study the plasma dynamics of CMEs, which provide a direct connection between geoplasma space and the Sun. Needless to say, this will allow one to document the plasma physics in a plasma regime of essential importance to human life.

References (Maximum 1 page)

1. Solar Probe Pluls, http://solarprobe.jhuapl.edu/
2. Allen, J., Sauer, H., Frank, L., and Reiff, P., EOS, Trans. Am. Geophys. Union, {\bf 70}, 1479 (1989). Also see publications of the National Space Weather Program, Office of the Federal Coordinator for Meteorology.
3. Birn, J., Drake, J. F., Shay, M. A., Rogers, B. N., Denton, R. E., Hesse, M., Kuznetsova, M., Ma, Z. W., Bhattacharjee, A., Otto, A., and Pritchett, P. L., J. Geophys. Res., {\bf 106}, 3715 (2001).
4. Chen, J., J. Geophys. Res., 101, 27499, 1996.
5. Holland, D. L., and Chen, J., Geophys. Res. Lett., 20, 1775, 1993.

Schematic of the Sun-Earth Plasma Connection (Original unannotated art work: Y. Kamide)



Figures (maximum 1 page)