UFA Sponsors Workshop Series on Burning Plasma Science

Stimulated by the growing interest in the science of burning plasmas coming out of discussions at the 1999 Fusion Summer Study at Snowmass and the charge [5 Oct. 2000] to FESAC by the DOE Office of Science to "...address the scientific issues of burning plasma physics," the University Fusion Association (UFA) sponsored two workshops on Burning Plasma Science. The first was held on 11-13 December 2000, in Austin, TX, to provide a forum for in-depth community discussion of the critical scientific issues connected with burning plasmas. This was followed by a second workshop focusing on burning plasma technology and specific burning plasma experiment concepts held 1-3 May 2001 at General Atomics in San Diego, CA. Each was attended by close to 100 participants. The results of these two workshops provided important input to the FESAC Burning Plasma Science Sub-panel which attended and met in parallel with each workshop.

BPS Workshop I

Discussions at the first workshop were focused around five questions: (1) What are the compelling scientific issues which could be addressed by a burning plasma experimental facility? (2) Identify those burning plasma scientific issues which are inaccessible for study in existing or near-term non-burning plasma experiments. (3) What is the present physics basis and confidence level in achieving burning plasma conditions? In particular, how have recent developments in theory and experiment affected our confidence in achieving burning plasma conditions? (4) How comprehensively can these burning plasma science issues be addressed establishing a firm basis for extrapolation in scale and magnetic configuration? (5) Are there compelling scientific issues outside of fusion energy which can be addressed by a burning plasma experimental facility?

The first workshop focused attention on the strong, non-linear coupling that will occur in a self-heated fusion plasma between the plasma pressure profile driven bootstrap current, confinement improvement due to turbulence suppression, MHD stability, fusion alpha-particles, and boundary plasma behavior. While each of these phenomena has been discovered and/or significantly advanced in the past 10 years in our present experimental facilities, the combination of these in the environment of a burning plasma presents a qualitatively new plasma physics regime. An outstanding challenge to the field is to more clearly identify the new phenomena we can expect in this strong coupling regime, and to sharpen our picture of the behavior expected in such a system.

In discussing the third question posed to the workshop, attention was focused on how recent advances in experiment and theory have affected our confidence in achieving burning plasma conditions. Summary presentation from the confinement working group said thatb ased on our present level of plasma confinement understanding, there are no known show-stoppers for achieving the generic burning plasma regime in a tokamak. Numerical simulations are rapidly improving and experimental tests on existing devices continues to improve our confidence. Ideal MHD provides an upper limit to plasma stability, and forms a credible foundation for the design of next-step devices. We have a high degree of confidence in the stability boundaries predicted by ideal MHD theory. However, advanced tokamak scenarios (self-consistent stable, steady-state, bootstrap current sustained equilibria) have not yet been clearly demonstrated on existing experiments. Important further work on internal transport barriers and the edge temperature pedestal remains to be done. In particular, the low edge density required in an advanced tokamak may be incompatible with high density divertor operation.

It is important that advances made in fusion science with a burning plasma experiment based on the tokamak configuration, provide a firm basis for extrapolation not only for the tokamak configuration but more generally across the broad family of toroidal magnetic concepts. Historically, virtually all of the theory, modeling tools, diagnostic advances, experimental techniques, and experimental discoveries made using the tokamak configuration have found application in research on other fusion configurations. Those toroidal magnetic configurations closest to the tokamak like the spherical torus, stellarator, spheromak and reversed field pinch, have been best able to build on advances made in the tokamak. Advances made in collective alpha particle effects, transport, stability, plasma control, and boundary science through the study of a burning plasma in a tokamak configuration would also be quite relevant to these configurations.

Finally, the was discussion at the workshop on how a burning plasma experimental facility could also make a contribution to advances important to the broader scientific community. Several possible areas of study which are inaccessible for study in existing non-burning experiments were discussed including alpha physics in the solar wind, collisionless reconnection in magnetospheric and solar plasmas, plasma effects on nuclear cross-sections important for nuclear astrophysics, and thermonuclear deflagration flame phenomena important for supernovae dynamics.

The complete report from the UFA BPS Workshop I along with copies of most of the plenary presentations can be found at http://w3fusion.ph.utexas.edu/bpsworkshop. In addition Nuclear Fusion has indicated it will publish the workshop report.

BPS Workshop II

The purpose of the second BPS workshop was to identify possible experimental approaches that would permit exploration of the science of burning plasmas to begin near the end of this decade. The workshop explored various experimental opportunities for pursing the science of burning plasmas and, for each approach, its capability to explore the scientific issues of burning plasmas identified in the first Burning Plasma Workshop. The workshop also sought to identify technological opportunities which could measurably improve the performance, reliability or operational flexibility of burning plasma experiments. A boundary condition was imposed limiting approaches to those that could be put into operation within about ten years.

The attention of this workshop was primarily on the developed approaches IGNITOR, FIRE, and ITER-FEAT, all of which were well represented at the workshop. While there is still clearly a range of views in the community about the best approach to take towards the study of burning plasmas, there was a strong consensus at this workshop that the community should move expeditiously to choose a preferred approach and attempt to take advantage of the improved political situation regarding energy nationally. Discussion of possible follow-on activities included suggestions to organize a “Snowmass” type meeting next year which would be focused specifically on developing a community consensus around a preferred approach to a burning plasma experiment.

The report from the second BPS workshop is still being prepared by the organizing committee, but copies of most of the presentations can be found at http://fusion.gat.com/bps2.