The Need for a National Stellarator Program

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A national stellarator program should be an integral part of the U.S. magnetic fusion program. The stellarator program should be at least as large as it is at present, and preferably larger. The arguments in favor of stellarator research are easily stated, clear, and generally accepted. As a candidate fusion device stellarators are a credible alternative to tokamaks, with significant advantages, as well as difficult issues, in comparison with the leader. Outside the U.S., stellarators are on a slow, but steady, development path, complementing the main line efforts. It can be, and has been, argued that stellarator development could be deferred until any serious limitations of the tokamak line are identified. Even without consideration of the important contributions made by stellarator work in support of the tokamak line, the policy of deferring stellarator development is unwise. Even if ITER achieves all its goals, the need to maintain currents in a tokamak for extremely long pulses could render the tokamak concept difficult to translate into an economically sensible power source. Additionally, one must recognize that in any research project there is a possibility of not reaching one's goals. In either case, one should have available a credible alternative to the main line activity. One should not wait additional decades to offer an alternative. These ideas are well recognized outside the U.S., and our program should also be an active participant in furthering this part of world fusion development.

In addition to its role as a potential magnetic fusion device, the U. S. stellarator program has been a vital element in the intellectual development of fusion plasma science. The obvious property of stellarators, that they are intrinsically three dimensional, non-symmetric objects, has forced the study of non-symmetric plasma dynamic effects. These effects are now becoming manifest in tokamaks, and much stellarator analysis can be and is being transferred to tokamaks. The advantage of studying such effects in a stellarator is that they are typically larger, and thus easier to see and understand. The relative smallness of the effects in tokamaks does not in any way imply that they induce minor modifications of the dynamics. These effects in tokamaks are critical in long time tokamaks dynamics. It would be naïve to believe that one has learned enough of three-dimensional dynamics so that at this point one could rely on tokamak work alone. The study of three-dimensional effects is growing and stellarators can make vital contributions in this study. Stellarators continue to be a source for the development of stimulating intellectual activity in magnetic fusion physics.

The U.S. stellarator program presently consists of modest university-sized experiments, international collaborations on existing large facilities and on construction of new facilities, analytic theory development, and numerical modeling. The loss or reduction in size of any of these elements would result in a serious gap in the U.S. and the world programs. In the moderate to longer term, the U.S. should reinstitute a large experimental program at a government laboratory. Earlier U.S.

program reviews, TAP and ReNeW, have identified essential issues that would be addressed in such an activity and that are not examined by existing devices. The stellarator concept has an embarrassment of riches in the possibilities for differing realizations. Comparison of the advantages and limitations of various types need to be considered in preparation for new or restarted facilities. Much of this work can be done through modeling, theory, and engineering studies, but finally new experimental programs are needed. Another issue relates to the perception of the importance of the stellarator program. At present many of those working on stellarators do so as a part-time activity. This situation is particularly true at government laboratories. The positive side of this situation is that it contributes to the cross fertilization between tokamak and stellarator work. The negative side is that it significantly reduces the work done on stellarators, while in appearance adding only very modestly to the much larger body of tokamak work. This situation induces the impression that perhaps working on stellarators is not considered important enough or appreciated enough to focus one's career on. It is important to create a sense in the magnetic fusion program that stellarator work is important, it is valued, and it will have a future. Without such a sense, the program will have the feeling of always being on the edge of disappearance. These issues are far from being exclusively a matter of funding; they also depend on attitudes.

Stellarators offer the world and U.S. programs a source of fusion energy concepts, support for the main line tokamak program, and essential intellectual stimulation. Stellarator development must be seen as an integral and essential part of the U.S. program.