Fusion Science

Objective:
To be able to predict, control, and optimize the behavior of plasma for a fusion power reactor.

For more than 30 years, the improvement in experimental capabilities and physical understanding of fusion plasmas has been remarkably steady. The results are now evident. In each crucial area of plasma behavior, scientists have achieved the performance levels they need in order to attain the program objective. What remains, however, is to achieve them all in a single experiment. The advances of the last decade have brought the research program to a point where such an experiment is now being undertaken, based on the solid foundations of plasma science developed in the research program.

The scientific achievements of the program are shown by improved plasma behavior, development of theoretical understanding, and construction of experimental devices.

Improvement of Plasma Behavior

The MFE Program seeks to produce a fusion reaction which produces more energy than is required to bring it about. The program has already succeeded in producing a limited amount of energy in experimental fusion devices, but to establish the ultimate scientific feasibility of fusion power, it is necessary to get at least as much energy out as is put in. Improvements in plasma behavior are measured chiefly in terms of the relationship between energy in and energy out and in how efficiently the magnetic field can confine the plasma fuel while fusion occurs (Beta).

Energy Gain – In the fusion community, the relationship between energy out and energy in is called energy gain. It is expressed as the ratio of the output energy produced by the plasma to the input energy needed to produce and maintain the plasma. An energy gain of 1.0 describes break-even, the condition under which equal amounts of energy are put into the system as are produced by the system. The higher the energy gain the more attractive the energy source. Proximity to an energy gain equal of 1.0 (break-even) serves as a benchmark of progress towards the experimental goal of scientific feasibility.

In 1985 the Tokamak Fusion Test Reactor (TFTR) achieved an energy gain equivalent to 0.12, or approximately one-eighth of break-even. (Since experimental fusion devices are powered by deuterium fuel rather than a deuterium/tritium mixture, an energy gain attained experimentally is somewhat less than an "equivalent" energy gain that would have resulted had radioactive tritium been added to the fuel mixture.) This represents a six-fold increase over the peak energy gain attained on TFTR's predecessor, the Princeton Large Torus (PLT).

The main plasma parameters which fusion researchers manipulate as they strive to increase energy gain are temperature, density, and confinement time. Since energy gain increases rapidly with increases in these plasma parameters, they commonly serve as interim measures of the experimental progress toward achieving a higher energy gain.