JET hits record for fusion confinement

by Charles B. Stevens

Scientists attending the Boston meeting of the American Physical Society's Division of Plasma Physics, held during the last week of October, report that the Joint European Torus (JET) tokamak has attained record energy confinement times for fusion plasmas in the range of seven tenths of a second—more than double that previously achieved on both the Princeton Tokamak Fusion Test Reactor (TFTR) and on JET itself. Despite the fact that this result is precisely that which is needed for fusion-power reactor operation, the U.S. magnetic confinement program continues to suffer significant funding cuts, and the plans for actually producing net energy on the Princeton TFTR have been postponed until sometime in 1988.

The excellent, early results for the JET strongly indicate that this Western European joint effort, under the auspices of the European Community, will achieve its full potential. This could mean that the European Community will not only be the first to produce net-energy-producing fusion plasmas, but could doubly leap ahead of the United States through attaining full fusion plasma ignition—a goal which is essential to realizing economical tokamak power plants, and not within the capabilities of the TFTR.

Both the JET and TFTR were conceived and designed in the mid-1970s as experiments to provide the basis for development of magnetic-fusion engineering test power plants. The Princeton TFTR design was completed first and represented a bold step forward at that time. But TFTR's coming on line was delayed until December 1982 because of the cutbacks in fusion research during the Carter administration.

The JET design was completed later than that of TFTR, and incorporated further experimental advances.

While both JET and TFTR have the capability to burn tritium fusion fuel—the heaviest isotope of hydrogen, which, in combination with the second heaviest isotope, deuterium, is the easiest fusion fuel to burn—TFTR is much smaller and has a much shorter experimental pulse length. Because of recent advances, this difference has become extremely significant. It has been found that energy confinement time—the time which it takes energy from a hot plasma to "seep" through the magnetic fields—increases with the size of a tokamak at a much faster rate than previously expected.

Furthermore, the German ASDEX tokamak has demonstrated the "H-mode," in which this increase of energy confinement time with size has been extended to high-temperature plasmas needed for fusion.

Ignition

The net result is that while TFTR will definitely attain energy breakeven (produce more fusion energy than that utilized to heat the hydrogen plasma to fusion temperatures), JET has the possibility of going beyond breakeven to fusion ignition. Fusion ignition takes place when the plasma is able to trap the fusion energy output to such an extent that the plasma temperature can be maintained at fusion temperatures without the use of external heaters. Fusion ignition is key to the realization of economic fusion electric power plants. But ignition also represents a crucial scientific frontier beyond which entirely new fusion possibilities may be attained.

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JET's larger size, experimental pulse length, and plasma current combine to give it the possibility of achieving fusion ignition. But the JET design's emphasis on radio-frequency (RF) heaters, as opposed to the neutral-beam heaters upon which TFTR primarily depends, has further extended the ignition potential of JET.

RF heaters consist of antennas which direct electromagnetic waves into the plasma. Besides increasing the plasma temperature, RF, as has been experimentally demonstrated on the MIT Alcator and Princeton PLT tokamaks, can also generate and sustain plasma electric currents. Thus the RF heaters on JET can also be utilized to further extend the pulse length of the experiment and therefore give more time for the attainment of fusion ignition.

Nasty rumors

These most recent good results on JET completely refute rumors that JET had suffered some type of experimental disaster during last summer. Indeed, JET is already exceeding original design specifications. Besides achieving record energy confinement times, JET has also been able to maintain pure hydrogen plasmas. This is crucial since non-hydrogen impurities in the JET plasma could prevent the machine from reaching the conditions needed for ignition.

JET experimentalists at Culham, England are demonstrating that they are mastering the techniques needed to keep the JET plasma clean. With the addition of RF and neutral-beam heaters over the coming years, JET may be the first magnetic fusion device to reach the conditions needed for fusion ignition.