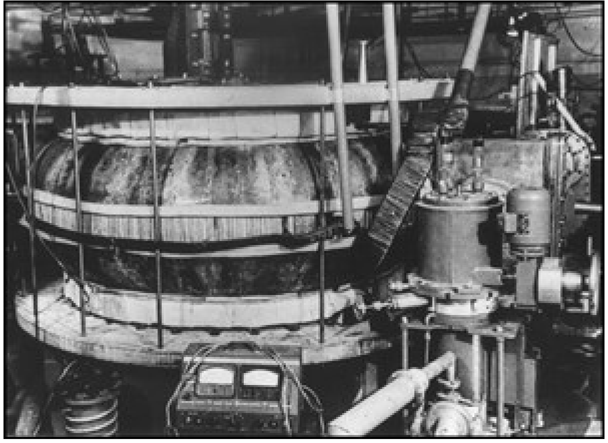
60 years of progress



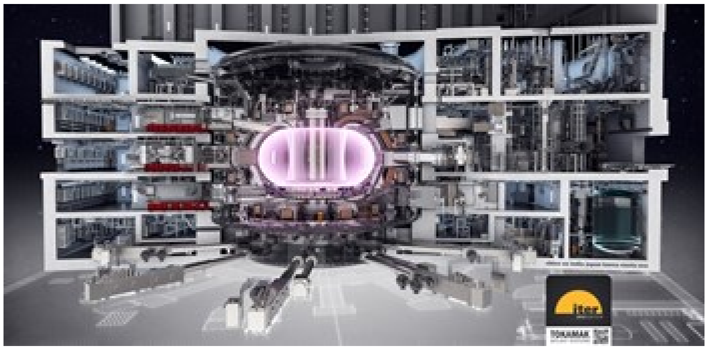
The world's first tokamak device: the Russian T1 Tokamak at the Kurchatov Institute in Moscow. Plasmas in the range of 0.4 cubic metres were produced in its copper vacuum vessel.

Following the first fusion experiments in the 1930s, fusion physics laboratories were established in nearly every industrialized nation. By the mid-1950s "fusion machines" were operating in the Soviet Union, the United Kingdom, the United States, France, Germany and Japan. Through experiments on these machines, scientists' understanding of the fusion process was gradually refined.

A major breakthrough occurred in 1968 in the Soviet Union. Researchers there were able to achieve temperature levels and plasma confinement times—two of the main criteria to achieving fusion—that had never been attained before. The Soviet machine was a doughnut-shaped magnetic confinement device called a **tokamak**.

From this time on, the tokamak was to become the dominant concept in fusion research, and tokamak devices multiplied across the globe.

Milestones around the world



ITER: writing the first chapter of 21st century fusion.

Producing fusion energy, it soon became clear, would require marshalling the creative forces, technological skills, and financial resources of the international community. The Joint European Torus (JET) in the UK, in operation since 1983, was a first step in this direction. JET, which is collectively used by more than 40 European laboratories, achieved the world's first controlled release of fusion power in 1991.

Steady progress has been made since in fusion devices around the world. The Tore Supra tokamak in France holds the record for the longest plasma duration time of any tokamak: 6 minutes and 30 seconds. The Japanese JT-60 achieved the highest value of fusion triple product—density, temperature, confinement time—of any device to date. US fusion installations have reached temperatures of several hundred million degrees Celsius.

Fusion research has increased key fusion plasma performance parameters by a factor of 10,000 over 50 years; research is now less than a factor of 10 away from producing the core of a fusion power plant.

Achievements like these have led fusion science to an exciting threshold: the long sought-after plasma **energy breakeven** point

(Q=1). Breakeven describes the moment when plasmas in a fusion device release at least as much energy as is required to heat them. Plasma energy breakeven has never been achieved: the current record for energy release is held by JET, which succeeded in generating 16 MW of fusion power, for 24 MW of power used to heat the plasma (a Q ratio of 0.67). Scientists have now designed the next-step device—ITER—as a Q≥10 device (producing 500 MW of fusion power for 50 MW consumed by the heating systems). ITER will begin writing the chapter on 21st century fusion. But it will not be striving alone in its quest—fusion machines all over the world have re-oriented their scientific programs or modified their technical characteristics to act either partially or totally in support of ITER operation. These machines are conducting R&D on advanced modes of plasma operation, plasma-wall interactions, materials testing, and optimum power extraction methods, contributing to the success of ITER and the design of the next-phase device. (Find these devices and laboratories in our **International Tokamak Research** section.)

6 RECOMMENDED ARTICLE(S)

60 years ago: the speech that changed everything

Twist and fuse

Who "invented" fusion?

20 years ago, a DT shot heard around the world

The (re)discovery of fire

"Proyecto Huemul:" the prank that started it all