2002 Fusion Summer Study
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For Immediate Release

Fusion energy shows great promise to contribute to securing the energy future of humanity. The science that underlies this quest is at the frontier of the physics of complex systems and provides the basis for understanding the behavior of high temperature plasma.

Today 280 leading scientists from the U.S. and international fusion community concluded a two-week forum assessing the major next steps in fusion energy science research. The development of practical fusion power is one of the greatest scientific and technical challenges ever attempted. The 2002 Fusion Summer Study, held in the Rocky Mountain's Snowmass Village, offered opportunities for lively debate and careful scientific analysis of proposed experiments that would accelerate scientific understanding of fusion plasmas and technologies. The conclusions reported today provide critical input to the long range planning activities undertaken by the U.S. Department of Energy and called for by energy legislation recently passed by the U.S. House of Representatives and the Senate. The results of the 2002 Fusion Summer Study will be used by the DOE Fusion Energy Sciences Advisory Committee to formulate a strategy to go forward with burning plasmas for the United States which will then be reviewed by the National Academy of Science.

Two approaches to fusion energy were discussed: magnetic fusion energy in which hydrogen fuel is heated to more than 100 million degrees and held in place by powerful magnets, and inertial fusion energy, in which small fuel capsules are heated and compressed rapidly by intense energy pulses, and held together briefly by their own inertia.

Preparation for the forum started over eight months ago when teams of experts began to assemble the technical data needed to evaluate proposed "burning plasma" experiments for magnetic fusion energy and plans for integrated research experiments in inertial fusion energy. The study of "burning plasma" is at the frontier of magnetic fusion energy research and can occur only when the hydrogen fuel, or plasma, is strongly self-heated by fusion energy as in the sun and stars. An integrated research experiment would demonstrate the science and technology needed to deliver repetitive pulses of focused energy to a stream of fuel capsules.

World fusion scientists have designed several magnetic fusion burning plasma experiments based on rapid scientific progress in the last decade. Fusion experiments in the U.S. and Europe have produced over 10 million watts of fusion power and have given scientists confidence to propose next step, burning plasma, experiments.

One proposal, the International Thermonuclear Experimental Reactor (ITER), is the result of many years of collaborative design and R&D effort (including the U.S. through 1998) between Russia, Europe and Japan. Canada, Europe, and Japan have offered to host the device and negotiations are under way. This device is planned to incorporate large superconducting magnets, allowing near steady-state operation at the scale of a future fusion power station. The U.S., as a founding member, has been invited to join the ITER negotiations and is considering whether to do so. Results from the meeting at Snowmass will provide the basis for a policy decision by the United States to pursue a role in the ITER project.

A second burning plasma experimental option makes use of compact, high-field copper magnets. An experiment with copper magnets would be smaller and less costly than ITER, but it would also result in shorter pulses during which burning plasmas could be studied. Two experimental proposals, FIRE (developed in the U.S.) and IGNITOR (developed in Italy), are of this type.

The National Ignition Facility (NIF), a machine designed to demonstrate ignition and burn of inertial fusion plasma is currently under construction as part of the US Department of Energy Defense Programs. NIF will be able to test a wide variety of target concepts for inertial fusion but it is not designed to have the pulse repetition rate, shot lifetime, or efficiency needed for commercial power production. Research separate from NIF is developing devices with these capabilities.

Gas and solid-state lasers, as well as intense ion beams, are under consideration for an integrated research experiment. Most recently ideas using an intense pulsed electrical current have been proposed. A new technology, using very fast lasers to ignite the fusion fuel (called “fast ignition”) has also caught the interest of researchers.

The 2002 Fusion Summer Study resulted in six major conclusions for both magnetic and inertial fusion energy.

For magnetic fusion energy, the forum concluded:

1. The study of burning plasmas, in which self-heating from fusion reactions dominates plasma behavior, is at the frontier of magnetic fusion energy science. The next major step in magnetic fusion research should be a burning plasma program, which is essential to the science focus and energy goal of fusion research.
2. The three experiments proposed to achieve burning plasma operation range from compact, high field, copper magnet devices to a power-plant-scale superconducting-magnet device. These approaches address a spectrum of

both physics and fusion technology, and vary widely in overall mission, schedule and cost.

3. IGNITOR, FIRE, and ITER would enable studies of the physics of burning plasma, advance fusion technology, and contribute to the development of fusion energy. The contributions of the three approaches would differ considerably.
    (i) IGNITOR offers an opportunity for the early study of non-stationary burning plasmas aiming at ignition.
    (ii) FIRE offers an opportunity for the study of burning plasma physics in conventional and advanced tokamak configurations under quasi-stationary conditions and would contribute to plasma technology.
    (iii) ITER offers an opportunity for the study of burning plasma physics in conventional and advanced tokamak configurations for long durations with steady state as the ultimate goal, and would contribute to the development and integration of plasma and fusion technology.
4. There are no outstanding engineering-feasibility issues to prevent the successful design and fabrication of any of the three options. However, the three approaches are at different levels of design and R&D. There is confidence that ITER and FIRE will achieve burning plasma performance in H–mode based on an extensive experimental database. IGNITOR would achieve similar performance if it either obtains H–mode confinement or an enhancement over the standard tokamak L–mode. However, the likelihood of achieving these enhancements remains an unresolved issue between the assessors and the IGNITOR team.
5. The development path to realize fusion power as a practical energy source includes four major scientific elements:
    (i) Fundamental understanding of the underlying science and technology, and optimization of magnetic configurations
    (ii) Plasma physics research in a burning plasma experiment
    (iii) High performance, steady-state operation
    (iv) Development of low-activation materials and fusion technologies
6. A strong base science and technology program is needed to advance essential fusion science and technology and to participate effectively in, and to benefit from, the burning plasma effort. In particular, the development path for innovative confinement configurations would benefit from research on a tokamak-based burning plasma experiment.

For inertial fusion energy, major conclusions from the forum are:

1. The National Ignition Facility (NIF) is expected to produce a burning inertial fusion plasma. The National Nuclear Security Administration is currently building the National Ignition Facility.
2. Laser systems for Inertial Fusion Energy have made impressive progress in efficiency, pulse rate, and lifetime. KrF lasers require further improvement in

lifetime, and solid-state lasers require improvement in the cost of major components.

3. The heavy ion fusion program has made excellent progress in basic beam science. Several new science experiments have recently begun operations. Integrated experiments at moderate beam energy and current, including focusing intense beams in the chamber environment remain the important technical issues.
4. There has been impressive progress in z-pinch targets and good progress in conceptual power plant designs. Producing economical recyclable transmission lines at low cost remains the most important issue.
5. Chamber technology and target fabrication and injection are being placed on a sound scientific basis. For example, experiments on dry-wall damage limits are underway. Scaled hydraulics experiments have identified nozzle designs that can create all liquid jet configurations required for thick liquid chambers, and a target injection experiment is under construction. For heavy-ion fusion there is now a chamber design where the final focus magnets and chamber structures have predicted lifetimes exceeding 30 years.
6. There is broad international interest in fast ignition. If fast ignition is successful, it will produce higher energy gains than conventional targets. So far the target experiments have been encouraging, particularly the recent Japanese results. Fast ignition power production is at a rudimentary level for all drivers. An integrated research plan is required.

Fusion offers a clean and safe new energy source. With no carbon dioxide emissions, fusion energy provides a long-term solution to the problem of global warming. The next major steps for how to bring this new energy source to humanity are now on the table for consideration by policy-makers.

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