MEETING REPORTS

SUMMARY OF THE U.S.-JAPAN JOINT SEMINAR ON GENERATION AND APPLICATION OF HOT DENSE LASER PLASMAS, HONOLULU, HAWAII, AUGUST 8–12, 1988

The fourth joint U.S.-Japan seminar in a series devoted to dense laser-produced plasmas, sponsored by the National Science Foundation and the Japanese Society for Promotion of Science, was held at the East-West Center in Honolulu, Hawaii, August 8–12, 1988. Following in the tradition of the earlier seminars, this meeting was most successful in providing an exchange of information and ideas on this important and rapidly growing area of science plasmas and applications.

The first U.S.-Japan joint seminar on this topic was held in Kyoto, Japan in 1972; the second was in 1976 in Rochester, New York; and the third was in 1982 in Nara, Japan. There was a general feeling among participants at the present seminar that the large time gap between recent meetings is undesirable, so the target for the fifth joint seminar is 3 years from now.

The present seminar was attended by 10 U.S. participants, 7 Japanese participants, 13 Japanese observers, and 5 foreign observers. G. H. Miley (University of Illinois) served as the U.S. coordinator, while S. Nakai (Osaka University) was the Japanese coordinator. The United States served as the host for the seminar. J. P. McMahon, logistics officer of the East-West Center, made all local arrangements and provided staff support for the meeting.

Since details of the various presentations will be published in the full-length papers prepared for *Laser and Particle Beams* (scheduled for release in 1989), the present summary mainly concentrates on remarks made in the closing panel discussion session.

Members of the closing panel were the following:

United States
- G. Miley (Chair) (University of Illinois)
- R. Jensen (Los Alamos National Laboratory)
- A. Guenther (Air Force Weapons Laboratory)
- M. Prelas (University of Missouri, Columbia)

Japan
- S. Nakai (Chair) (Institute of Laser Engineering)
- C. Yamanaka (Institute for Laser Technology)
- K. Niu (Tokyo Institute of Technology)
- H. Takuma (Institute for Laser Science)

G. Miley opened the session by observing that the topics covered in this conference represent four key technological "spin-off" areas of inertial confinement fusion (ICF), namely, new lasers, particle acceleration, plasma processing, and diagnostics. As shown by the seminar presentations, new developments in these areas, like ICF, have grown explosively in recent years. Stimulation of new ideas among workers in the various areas has played an important role in this growth. The present seminar series provides an important contribution to this process by bringing together leading scientists with a variety of different backgrounds. Miley asked that care be taken to maintain the good communication among these areas in the future in view of the natural tendency of areas to isolate themselves as they mature. He also noted the importance of developing new mechanisms for transferring technology developed in ICF research to industry. The new Institute for Laser Science at Osaka University, headed by C. Yamanaka, appears to be an important model for doing this.

In his remarks, R. Jensen stressed the importance of developing a laser driver suitable for next-step experiments and an eventual ICF reactor. He noted that the solid-state laser, with advanced technology such as diode flashlamps, is a serious contender. However, other lasers such as KrF must also be carefully evaluated. Gas lasers have the significant advantage of flow cooling for high-repetition operation. He also commented on the wide-ranging impact that spin-offs from ICF research have had and cited the X-ray laser as a key example. The development of a practical X-ray laser will clearly have an extremely important impact on many areas of science, ranging from biology to metallurgy. A significant fraction of the ICF budget is, in effect, still going into this development and the work involves use of major ICF facilities worldwide.

C. Yamanaka cited the "happy days" enjoyed by ICF researchers in recent years, but he warned that we now face a strong challenge in taking the next step to breakeven

conditions. He noted that the present seminar is unique in providing such a wide coverage of presentations, including drivers, diagnostics, laser/plasma interactions, implosion physics (including important new developments in volume ignition using stagnation-free implosions), target manufacturing (including the application of lithographic technology to target manufacture), and plasma generation (including spectroscopy and high-power switching). Yamanaka also briefly commented on the history of this seminar series, noting that the 1972 meeting was important for first bringing U.S. ICF technology to Japan, the 1976 meeting was highlighted by reports of new major laser facilities, and 1982 showed the increasing interest in the area with a record 66 attendees, while the present meeting stresses ICF spin-off areas. He expressed concern about the decision by the U.S. Department of Energy to restrict attendance due to classification issues. He questioned this restriction being placed on a bilateral meeting while full participation is apparently encouraged in international meetings. As a result, he noted that the presentations by "Third World" representatives were even more important to the present meeting than in the past.

Finally, C. Yamanaka compared ICF and magnetic confinement fusion relative to international collaboration. Magnetic fusion energy (MFE), with Joint European Torus, International Thermonuclear Experimental Reactor, etc., has a close collaboration while ICF appears fragmented. He called for increased collaboration in ICF in the interest of mutual benefit, not only for fusion scientists, but for future generations who will need fusion energy.

A. Guenther agreed with C. Yamanaka about the unfortunate limitations put on U.S. attendance at this seminar. He too acknowledged the important contributions by Third World participants. In comments about the presentations, he also stressed the importance of spin-off areas. For example, developments in switching technology and the increased understanding of damage effects in optics should impact future science and medicine. Also, X-ray lasers represent a most important new radiation source, which will strongly influence future science. He noted that the important advances in optical coating technology reported by Japanese researchers will provide an important complement to U.S. work in this area. He concluded by citing energy production and X-ray lasers as the focal points for this seminar series.

H. Takuma concentrated his remarks on the development of the KrF laser as an alternate ICF driver. Advantages of KrF include its advanced state of development. It is scalable to high powers with an amplified spontaneous emission limit of 500 kJ in microsecond operation. A high efficiency is possible (~10% overall) along with a relatively uniform transverse power density, a high repetition rate (~1 Hz), pulse compression and shaping, and compatible optics. A peak energy of 600 kJ in a single beam is predicted. Takuma also cited the advanced semiconductor solid-state laser as a driver candidate with high efficiency, low heat load, and long life. However, the high cost of components and the intensity dependence of the refractive index remain as key development issues. He also suggested exploration of the FEL is warranted, but its potential of achieving the high pulse power required for ICF remains uncertain.

M. Prelas reported on the results from a written survey of opinions on driver issues, which indicated a strong leaning toward diode-pumped solid-state systems and KrF. He suggested that ICF has a stronger chance for commercial power development than MFE because, as shown by this seminar, ICF has remained open to new ideas. He too stressed the importance of developing a "brand X" laser for the driver for a commercial power plant and pointed to the nuclear-pumped laser as one possibility. He also predicted a coming scientific revolution in chemical kinetic studies, biological systems, etc., that would be initiated as the results of spin-offs from ICF technology.

K. Niu also focused his remarks on the development of new lasers as the future ICF driver. He cited excimers, X-ray lasers, gamma-ray lasers, and FELs. In addition to laser issues, he outlined advances and remaining issues in diagnostics, target compression physics, and optics damage. He also stressed the importance of international cooperation in ICF development, especially in view of the large costs associated with advanced facilities. Niu concluded with an observation about economic issues for fusion energy from ICF. The income from a 1-GW(electric) plant is about $20 billion. Costs for a fission plant are about $2 billion and for a fast breeder about $6 billion. The key question is the cost for a fusion plant. Among the many issues that will influence costs are the ability to ignite a burn with minimum energy expenditure and the development of cheap manufacturing techniques for ICF targets.

Following these remarks by the panel members, the discussion was opened to input from other participants, and a lively interchange occurred. S. Nakai closed the discussion by reviewing the remarkable progress made in ICF research and stressed that we are now ready to demonstrate ignition. The achievement of reactor operation, however, will require a large step in laser development from the present 100 kJ/pulse to the megajoule level and ultimately to high repetition rates corresponding to megawatt-level operation. He stated that fusion research is vital to the ultimate existence of mankind.

G. Miley closed the meeting by thanking the participants for their strong input, which made this fourth U.S.-Japan seminar on dense plasmas so successful.

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SUMMARY OF THE U.S.-JAPAN WORKSHOP ON D-^{3}He FIELD-REVERSED CONFIGURATIONS, URBANA-CHAMPAIGN, ILLINOIS, OCTOBER 5–8, 1988

The objective of this workshop was to plan for a proposed D-^{3}He field-reversed configuration (FRC) reactor design study. A review of the status of the physics data base and the identification of critical issues involved in a design study were the main topics of discussion. Also, preliminary organizational plans for undertaking the design study were developed. Planning will be completed at a workshop tentatively scheduled for March 1989 in Japan and workshops to initiate the design effort itself are proposed for the 1989–1990 exchange period.

Japanese participants in this workshop included H. Momota (Nagoya University), A. Ishida (Niigata University), S. Ohi (Osaka University), M. Ohnishi (Kyoto University), and Y. Tomita (Nagoya University).