Overview of High Power Laser Programs for ICF in China

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The laser fusion programs in China were first proposed by Prof. Ganchang Wang in 1964 and subsequent laser technology development projects were conducted. Unfortunately, the programs were interrupted for more than ten years and officially restarted in 1976. China Academy of Engineering Physics(CAEP), located in Mianyang city, is carrying out the ICF programs. Shanghai Institute of Optics and Fine Mechanics is the main collaborator in laser technology development. National High-Tech ICF Committee was set up in 1993 and additional ICF projects have been conducted since then to support the existing programs with nation-wide collaboration.

Solid-state laser technology has preferably been developed for application to inertial confinement fusion in China. XG-I laser facility was built at CAEP in 1984 with a few tens Joules output at 1μm and then upgraded to XG-II to deliver 1-ns pulse of 150J at 3ω to the target early nineties. The two-beam SG-I laser facility was built at National Laboratory on High Power Laser and Physics, Shanghai, in 1986, which could produce 2 x 800J red light pulses. The SG-I facility had been operated for physical experiments until 1994 when the upgrading project to SG-II began. The SG-II was completed for its eight-beam output of 8 x 700J at 1ω early 2000 and direct-drive implosion and hohlraum physics experiments were performed then for activation. In the experiments, neutron yields of 4×10^9 for exploding pusher targets and 6×10^8 for ablative targets were produced. The radiation temperature in the hohlraums reached 180eV. The SG-II was operated with four-beam 3ω output for experiments early 2001 and eight-beam output is expected to deliver for experiments in a few months. The SG-II is featured with its double-pass main amplifiers which have only six Nd:glass slabs for each beam, leading to a small active medium thickness and, therefore, a good beam quality.

Meanwhile, a program to build the SG-III facility (1) of new generation of high-power solid-state laser has been carried out in recent years. The baseline design suggests that the SG-III be a 64-beam laser facility to produce 60-kJ,1-3-ns pulses of blue light. The sixty-four beams are grouped into eight bundles with clear optical apertures of 30cm x 30cm. Sixty beams will be used for target irradiation, while the rest four beams for backlighting or x-ray laser probing. The main amplifier column in each of the eight bundles contains eight beamlets stacked 4 high by 2 wide. The cavity and booster amplifiers are optimized to have 9 and 5 or 8 and 6 glass slabs with a thickness of 38mm. Glass slabs and flashlamps are designed to assemble into cassettes for prompt installation into frame assembly units of the amplifiers and easy replacement for maintenance.

To reduce technical risk, the Technical Integration Line (TIL)(2), has been proposed to build first. The TIL is a prototype of one bundle of the SG-III and is planned to first integrate the subsystems for demonstrating all the new technologies. The conceptual design was completed in 2000 and is now in the phase of engineering design and construction. In addition, the TIL will be operated for target experiments with 10-kJ blue light pulses. As an important step, an amplifier laboratory has been built with three amplifier modules to measure the gain coefficient, to study wavefront distortion and thermal recovery and to clarify how to remove the pumping released airbone particles. Brand-new power conditioning modules with preionization circuit have been developed.

Great progresses have been made in developing key laser technologies in China to support the ongoing laser projects, in particular the construction of the SG-III facility. Large laser N31 glass slabs of 300mm x 570mm have been produced with the required specifications. Flashlamps made of Ce-doped quarts with a bore diameter of 32mm and an arc length of 140cm are in the phase of pilot production. KDP crystal growth technique has been qualified and finishing as well as coating techniques have been developed. Adaptive optical systems has been tested to compensate low-mode wavefront distortion. A prototype plasma electrode Pockels cell with a clear aperture of 240mm x 240mm has successfully been tested. Matellized self-healing capacitors with an energy density of $0.5J/cm^3$ have been developed and commercialized.

A KrF excimer laser program has been conducted for many years as an alternative drive technology and a 100-J facility, Heaven-I(3), has been built in China Institute of Atomic Energy, Beijing. The preamplifier and the main amplifier are electron beam pumped and optical angular multiplexing technique is used to shorten the pulse duration from over 100ns to 23ns.

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3. Y.Shan, N.Yang, W.Ma, et.al., " Six-beam hih power KrF excimer laser system with energy of 100J/23ns", Proceedings of SPIE, Vol.4424, 104(2000).