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Progress Report to DOE
Inertial Confinement Fusion Program
Naval Research Laboratory
Washington, DC 20375

FY 1989

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II. FY89 ACCOMPLISHMENTS IN KrF PROGRAM

The FY89 research closely followed the agreed-upon work statements. The following paragraphs quote each of the work statements and compares them with the actual accomplishments.

1. *Install and test the oscillator at LANL.*

The oscillator was delivered and installed at LANL in January. This NRL oscillator had the high contrast ratio and bandwidth capabilities that were promised.

2. *Complete and operate an oscillator for echelon-free ISI.*

This oscillator has both a broad bandwidth and a multimode transverse structure. The key question was whether the output would be sufficiently uniform to serve as the front end for the Nike echelon-free ISI concept. Our goal is an intensity nonuniformity of no more than $\pm 1\%$. We did complete and operate an oscillator system, and we were able to demonstrate a nonuniformity of $\pm 2\%$. This is close enough so that we do not believe that there will be a fundamental problem. We have purchased another commercial oscillator that should give us the improved uniformity, and we have started a program in diagnostics so that we can be sure that we can measure down to this very low level of nonuniformity. This next system will be tested in FY90.

3. *Assemble and test 20 cm amplifier. Characterize its performance and present data to DOE and LANL in the Spring of 1989.*

We have assembled and begun testing of the 20 cm amplifier. We expect to have it operating as a laser by the end of September. Performance will be characterized and presented to our colleagues by the end of the calendar year.

4. *Design and partially purchase the 50 cm amplifier.*

We have designed a pulsed power system for this amplifier, and we have purchased Marx bank components. The aperture size has increased slightly to 56 cm.

5. *Initiate construction of the laser enclosure.*

The enclosure was submitted to NRL contracting early this calendar year. Award of the contract is expected by January, 1990. The enclosure is based upon the one at LANL and takes advantage of the knowledge gained with that enclosure. The Nike enclosure differs somewhat, with three walls instead of two, and a double floor with insulation and heating.

6. *Complete conceptual design of the target area.*

Design of the target area and target alignment system is proceeding a little slower than expected because staff was diverted by an internal reorganization. Work is now proceeding rapidly, with the assistance of LANL who provided NRL with a set of drawings for their Aurora target facility.

Because the KrF program now includes computational and theoretical work, this section also includes a short review of the FY89 Glass Laser proposal for computation and theory.

7. *Study the effect of ISI on the early-time hydrodynamics of accelerating foils.*

A series of computations was performed as promised. We found that the only effective way to control the early-time perturbations of ISI was to buffer the outside of the target with a very low density material that compressed inward during the first nanosecond of the laser pulse. Rochester has said that the use of one micron laser light during this early time was also effective; we found an effect, but it was insufficient for a high-gain pellet. We still do not have a complete parameter survey on this early time effect, and plan to complete this study in FY90.

8. *Evaluate hot-cold fuel mix using both 2D and 3D computer codes.*

We have developed the 3D computer code as promised, and used both it and the 2D code to study mix. Working in collaboration with LANL, with computer time that they generously offered to us, we simulated both single-mode and multimode perturbations. The single mode simulations showed that the Rayleigh-Taylor instability produces a new secondary instability as the spikes fall through the lower density material. This could be an important source of hydrodynamic turbulence in the underdense plasma that modifies various plasma instabilities. Our multimode simulations were compared to the new theory of Haan (LLNL) and were in excellent agreement on the saturation regime.

9. *Develop improved analytical models of the effect of ISI upon the plasma instabilities.*

This research was subcontracted to Parvez Guzdar of the University of Maryland, and to Gene Tracy of the College of William and Mary. Both contracts were very successful this year. Prof. Guzdar has been studying the quarter-critical absolute instability with ISI. His simulations show that narrow bandwidths will enhance the instability while a broad bandwidth will help quench the instability. He presented some of these results at the last Anomalous Absorption Conference and has prepared a draft copy of his research. Prof. Tracy has been developing a new type of analytical theory that studies the behavior of laser

light and plasma waves in a time-dependent turbulent medium such as would be created by ISI. So far, he has applied his analysis to the standard ponderomotive filamentation instability, and has submitted a paper for publication. He also presented some of his work at the above conference and plans to extend the analysis to other phenomena.

10. *Develop improved model of the effect of ablation upon the Rayleigh-Taylor instability.*

This was a year of major change in our understanding of the Rayleigh-Taylor instability. Last September we found a computational error in our previous simulations of this instability. By November we had developed a complete new set of computational studies and we found that the growth rate of this instability fit the simple dispersion relation of Takabe et. al. In November we also discovered to our delight that our colleagues at LLNL had developed the identical dispersion relation. Since the same relation has now been developed by three independent methods -- a Lagrangian code at LLNL, an Eulerian code at NRL, and a theory at Osaka -- our level of confidence is quite high, within the restriction of the physics that was included in the models. Since then we have explored the effect of additional stabilization due to soft radiation preheat, and we find that this extra physics satisfies the same dispersion relation. We are currently exploring various ways of driving shells inward using radiation, in parallel with our colleagues at LLNL and Rochester.

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