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# **HIGH SPATIAL RESOLUTION IMAGING OF INERTIAL FUSION TARGET PLASMAS USING BUBBLE NEUTRON DETECTORS**

**FINAL REPORT FOR THE PERIOD  
NOVEMBER 1, 2000 THROUGH OCTOBER 31, 2002**

**by  
R.K. FISHER**

**Work prepared under  
Department of Energy Grant  
No. DE-FG03-00SF22228 and  
Contract No. W-7405-ENG-48**

**MAY 2003**



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**GENERAL ATOMICS PROJECT 30085  
MAY 2003**



## HIGH SPATIAL RESOLUTION IMAGING OF INERTIAL FUSION TARGET PLASMAS USING BUBBLE NEUTRON DETECTORS

**Principal Investigator: Raymond K. Fisher in collaboration with University of Rochester, Laboratory for Laser Energetics; Association Euratom-CEA; and Lawrence Livermore National Laboratory**

Bubble detectors, which can detect neutrons with a spatial resolution of 5 to 30  $\mu$ , are a promising approach to high-resolution imaging of NIF target plasmas. Gel bubble detectors were used in successful proof-of-principle imaging experiments on OMEGA. The results were presented in an invited talk at the October 2001 meeting of the Division of Plasma Physics of the American Physical Society and published in *Physics of Plasmas* [1].

Until recently, bubble detectors appeared to be the only approach capable of achieving neutron images of NIF targets with the desired 5  $\mu$  spatial resolution in the target plane. In 2001, NIF reduced the required standoff distance from the target, so that diagnostic components can now be placed as close as 10 cm to the target plasma. This will allow neutron imaging with higher magnification and may make it possible to obtain 5  $\mu$  resolution images on NIF using deuterated scintillators.

Having accomplished all that we can hope to on OMEGA using gel detectors, we suggested that our 2002 NLUF shots be used to allow experimental tests of the spatial resolution of the CEA-built deuterated scintillators. The preliminary CEA data from the June 2002 run appears to show the spatial resolution using the deuterated scintillator detector array is improved over that obtained in earlier experiments using the proton-based scintillators.

Gel detectors, which consist of  $\sim 10$   $\mu$  diameter drops of bubble detector liquid suspended in an inactive support gel that occupies  $\sim 99\%$  of the detector volume, were chosen for the initial tests on OMEGA since they are easy to use. The bubbles could be photographed several hours after the neutron exposure. Imaging NIF target plasmas at neutron yields of  $10^{15}$  will require a higher detection efficiency detector. Using a liquid bubble chamber detector should result in  $\sim 1000$  times higher neutron detection efficiency which is comparable to that possible using scintillation detectors.

A pressure-cycled liquid bubble detector will require a light scattering system to record the bubble locations a few microseconds after the neutron exposure when the bubbles have grown to be  $\sim 10$   $\mu$  in diameter. The next major task planned under this grant will be to perform experimental tests to determine how accurately the spatial distribution of the bubble density can be measured under the conditions expected in NIF. The bubble density will be large enough to produce significant overlap in the two-dimensional images, so that we will need to be able to measure bubbles behind bubbles. One of the goals of these tests is to determine if a simple light transmission approach is feasible. One of the concerns at very high bubble densities is that light scattered out of the path can be rescattered back into the transmitted light path by bubbles in neighboring paths.

This is a report of research performed at the National Laser Users Facility of the University of Rochester Laboratory for Laser Energetics and supported by the U.S. Department of Energy under Grant No. DE-FG03-00SF22228 and Contract No. W-7405-ENG-48.

[1] R.K. Fisher, et.al., *Phys. Plasmas* **9**, 2182 (2002).