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The research project involved two graduate students, Mr. David B. Goldstein and Ms. Laurie E. Schneider. Both students have obtained the Master Degrere at the end of the first year of the program. David Goldstein was dedicated to the measurements of nuclear reactions in hot plasmas generated from plasma focus discharges with peak electrode current of not less than 0.6 MAmp. Laurie Schneider was dedicated to optimizing the characteristics of scintillaton detector/phoromultiplier systems for X-rays. The overall performance of D. Goldstein was excellent. The overall performance of Laurie Schneider was of excellent quality.

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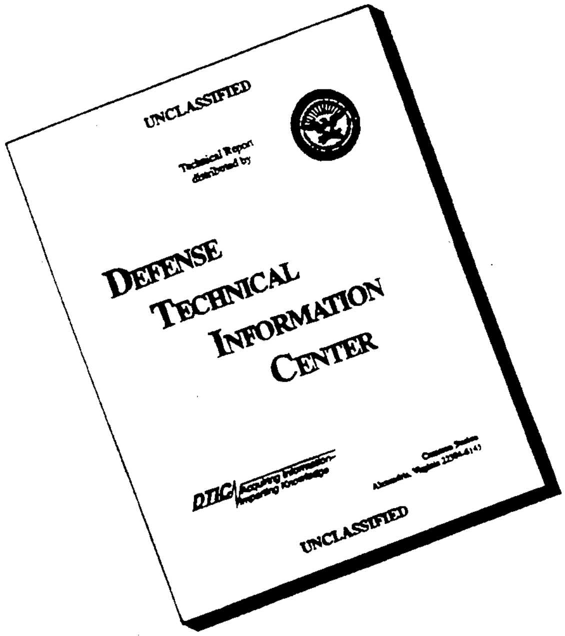

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Final technical report for the period 01 June 92 - 31 May 95
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Program Manager Dr. Robert J. Barker

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Summary. The three year project involved two full-time graduate students and addressed the emission from plasma focus discharges of ion beams, of ion cluster beams and of plasma structures in which MeV ions were confined by the structure self-fields. Plasma nuclear reactivity and plasma-structure imaging were recorded during the operation of two plasma focus machines - one machine for each graduate student - with powering capacitor bank of 7 kJ at 18 kV and 5 kJ at 18 kV, respectively.

The research project involved two graduate students, Mr. David B. Goldstein and Ms. Laurie E. Schneider, both fully supported during the Academic year by the AASERT Grant which included the Tuitions of the Graduate School of Stevens Institute of Technology and Summer salary.

The requirements on the students were (a), 50% of their time dedicated to graduate courses, with the obligation of obtaining satisfactory grades at the end of each course and (b), 50% time of research activity as Graduate Research Assistants in the Plasma Laboratory of the Physics Department. Both students have obtained the Master Degree at the end of the first year of the program.

During the first year David Goldstein has obtained a total of 17 credits. with quite satisfactory grades. The laboratory work was dedicated to the measurements of nuclear reactions in hot plasmas generated from plasma focus discharges with peak electrode current of not less than 0.6 MAmp. A variety of gas mixtures were used to fill the discharge chamber, such as deuterium, helium isotopes, carbon (methane and/or propane), nitrogen, oxygen. The objective was to measure the plasma reactivity in terms of reactions such as $D + D$, $D + {}^3He$, $D + {}^{12}C$, $D + {}^{14}N$, $D + {}^{16}O$, etc. The progress in operating the plasma focus machine with a 7 kJ powering capacitor bank, the data acquisition system and the methods of data analysis was substantial and above average performance. Mr. Goldstein has co-authored the presentation of a paper at the 1993 IEEE Int. Conf. on Plasma Science in Vancouver with title: "High-Z and Low-Z Nuclear Reactions in the Plasma Focus Pinch".

During the first year Laurie Schneider earned 17 credits with quite satisfactory grades. Her work in the laboratory was dedicated to optimizing the characteristics of scintillation detector/photomultiplier systems for X-rays of energy above 30 keV and 2.5 MeV neutrons from D + D - nuclear reactions generated in the plasma focus pinch. Ms. Schneider learned the technique of detecting the internal structure of plasma lumps ejected from the plasma-focus pinch and impacting on filtered CR-39 targets. The non-uniform internal structure of the plasma lumps was recorded via the non-uniform distribution of etched ion tracks on the exposed CR-39 targets.

A steady progress was made during the first year in this activity, during which Schneider became also proficient in operating her 5 kJ plasma focus machine. At the end of the first year L. Schneider co-authored the presentation of a paper with title "Plasmoid Structure from MeV Ions Imaging" at the 1993 IEEE Int Conf. on Plasma Science in Vancouver.

During the second year of the program Mr. Goldstein has successfully carried out over a twelve month period systematic measurements of the yield of D + ^{3}He, D + ^{12}C, D + ^{14}N and other nuclear reactions in plasma focus discharges, directly related to the proposed subject of his PhD thesis "Plasma Domains of Enhanced Nuclear Reactivity". From the analysis of the experimental data he has substantially contributed to the determination of (i), the effect on the reaction yield of variations of pressure, voltage and filling gas composition in the discharge chamber and (ii), the distribution in space of the localized plasma domains of high nuclear reactivity where a major fraction of the nuclear reactions occurs.

This effort was part of the general objective of the laboratory activity, i. e., the determination of the structure and characteristics the plasma lumps of high energy density generated in, and ejected from, plasma focus discharges.

Some of the results of Goldstein's research activity were reported in two communications to the APS Plasma Division Conference (S. Louis, Nov. 1993) and to the 1994 IEEE Int. Plasma Conf. in S. Fe (June 1994), with title "Azimuthal Anisotropy in the Distribution of Fusion Products and Fast Ion Emission in PF Discharges".

David Goldstein co-authored with other members of the plasma laboratory team also a full-length paper on Physics Letters A (Vol.192, pp.250-257, 1994) : *"Observation of Plasma Structures with Fast Ions and Enhanced Fusion in Plasma Focus Discharges"*. A total of 15 credits were earned with excellent grades by Goldstein during the same period.

The overall performance of D. Goldstein was excellent.

During the second year of the program Laurie Schneider worked on several projects bearing on the proposed subject of her PhD work "Energy density in self field dominated plasmas". She designed, built and tested a system of CR-39 targets and suitable ion filters. This effort included methods to apply mylar ion filters covering the CR-39 targets with variable spacing between filter and target surface and a systematic experimental work for recording etched ion tracks on the CR-39 produced by the impacting ion clusters.

Simultaneous measurements with scintillation detectors and photomultipliers were carried out during the exposure of the ion targets. A number of neutron and X-ray bursts were monitored at different voltages of the photomultiplier in order to determine the characteristics of a variety of scintillation detector systems. Different distances from the pinch to the scintillation detectors were also used. Two new small scintillation detectors - one for neutrons and the other for X-ray - were built. L. Schneider co-authored two communications, one to the APS Plasma Division Conference in S. Louis (Nov. 1993) and the other, with title "Plasma Focus Discharges With Multiple Current Sheets", to the 1994 IEEE International Conference on Plasma Physics in S. Fe (June 1994), at the beginning of the third year of the program. A total of 10.5 credits (A grades) were earned by L. Schneider during the same period, in spite of her serious health problems, which ultimately led her to move back to Tennessee in the third year of the program. The overall performance of Laurie Schneider was of excellent quality.

During the third year of the program an extensive use was made of methods and information acquired during the first two years, for determining basic characteristics of the ion beams accelerated and trapped inside dense plasma structures ejected from the plasma focus pinch. A systematic source of information was the measurement in each discharge, of the reaction yield for a variety of nuclear reactions involving different nuclear species, as listed above. The different threshold energy of the observed reactions provided, with the corresponding reaction yield, the high-energy profile of the ion energy distribution. The non-uniform distribution of the plasma reactivity in the discharge chamber was monitored by using an array of Geiger detectors inside the chamber, via (i), the Geiger detection of the quantity of β-radioactive nuclei [as ^{13}N, ^{15}O, etc.] generated by the reactions in the plasma and via (ii), the radioactivity induced on selected external targets by ejected ion beams.

David Goldstein earned 15 credits (A and B grades) during the Fall semester (Aug. '94 - Dec. '94) and the following Spring semester (Jan. '95 - June '95) of the third year. His outstanding performance in the laboratory also during the third year of the program is described via the titles of publications and presentations to conferences he has co-authored with other members of the Plasma Laboratory team during this last phase of the program:

"*2D Mapping of DPF Plasma Sources*", Proc. 22-nd Int. Conf. on Plasmas and Ionized Gases, July 1955.

"*Correlation Between Nuclear Reaction Yields Induced by Fast and Slow Ions*", Rec. 1995 IEEE Int. Conf. on Plasma Science.

"*MeV Ions Trapped in Plasma Domains Far From the Plasma Focus Pinch*", Bull. Am. Phys. Soc., Division of Plasma Physics, Nov. 1994 Meeting.

"*Strong and Weak Coupling of Fusion Reaction Yield and Current Distribution in MA PF Discharges*", Bull. Am. Phys. Soc., Division of Plasma Physics, Nov. 1994 Meeting.