DOE/ER-0345

Advanced Energy Projects
FY 1987 Research Summaries

September 1987

U.S. Department of Energy
Division of Advanced Energy Projects
Office of Basic Energy Sciences
Office of Energy Research

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Washington, D.C. 20545

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OFFICE OF BASIC ENERGY SCIENCES

DIVISION OF ADVANCED ENERGY PROJECTS (AEP)

Program Description

What projects are supported?

This Division supports exploratory research on novel concepts related to energy. The research is usually aimed at establishing the scientific feasibility of a concept and, where appropriate, also at estimating its economic viability. Because projects supported inevitably involve a high degree of risk, an indication of a high potential payoff is required. An immediate, specific application of the concept is not an absolute prerequisite for consideration; thus,, for example, proposers of schemes leading to the development of gamma-ray lasers are not required to justify their proposals by discussing potential applications of such lasers.

The concepts supported are typically at too early a stage of scientific verification to qualify for funding by DOE programs responsible for technology development. Where doubt exists, such programs are consulted, prior to proposal consideration by AEP, in order to establish their possible interest in the project.

Projects not supported

The AEP Division does not support ongoing, evolutionary research. Neither does it support large scale demonstration projects.

Period of support and funding levels

By design the period of support is finite, generally not exceeding three years. It is expected that, following such a period, the concept will either be at a stage where it can be supported by a technologically appropriate organization or branch of DOE, or else it will be dropped. Annual funding level for projects varied from about $30,000 to a maximum in the $400,000 range.

Who can propose?

Unsolicited proposals can be submitted by universities, industrial organizations, nonprofit research institutions or private individuals. Consideration is also given to ideas submitted by scientists working at national laboratories.

Proposal evaluation

Awards are based on the results of an evaluation process which usually involves a review by external reviewers. Regardless of the outcome of the evaluation, proposers receive copies of reviewers' reports.

Questions asked of the reviewers depend on the subject of the proposal. Some typical questions are listed below:

1. Is the proposed concept new? How does it compare with other work in the field?

2. Are there basic flaws in the scientific (technical) arguments underlying the concept?

3. Are the technological requirements of the proposed concept, including material requirements, within the realm of either present or near term future capabilities?

4. Is there anything about the concept which makes its economics manifestly untenable, even under reasonably optimistic assumptions?

5. Is the anticipated benefit to the public high enough to warrant the Government's involvement in the R&D effort?

Preproposals desired

It is suggested that before a formal proposal is prepared, the proposer should submit a brief outline of the proposed work. The outline should provide enough background information to enable a decision as to whether or not the proposed work programmatically fits the mission of AEP.

Proposals

Once a programmatic interest of AEP in the proposed project has been established, a proposal should be submitted along the guidelines specified in the "Office of Energy Research Special Research Grants Program Guide for the Submission of Applications." Each proposal must contain:

- A cover page.

- A 200-300 word abstract, written in plain English, describing the essence of the project in terms understandable to a layman. The abstract should be in a form suitable for inclusion in DOE program presentations, such as this brochure.

- A technical discussion of the proposed concept and a description of the proposed work. While the discussion should be kept brief, there is no formal limitation on the number of pages allotted to this section of the proposal. Since it is this section that will form the basis for the evaluations by technical reviewers, the proposer is urged to make certain that all aspects of the proposed project which are relevant to forming a judgment of the project's merits are adequately covered.

- A statement of work specifying all tasks to be performed in the course of the proposed work. A sample statement of work can be found on page 28.

- Description of available facilities.

- Resumes of key personnel.

- Detailed information on any support for the proposed or related work, past, present or anticipated, including proposals submitted, or about to be submitted, to other organizations.

- A cost estimate for the proposed effort.

<u>Further information</u>

Inquiries should be addressed to:

Dr. Ryszard Gajewski, Director
Division of Advanced Energy Projects
Office of Basic Energy Sciences
ER-16, GTN
Department of Energy
Washington, DC 20545

Phone: 301/353-5995

<u>Heavy Ion Fusion Accelerator Research</u>

In addition to the program described above, the Division manages DOE's Heavy Ion Fusion Accelerator Research (HIFAR) program. The HIFAR objective is to acquire an appropriate data base for future decisions on heavy ion fusion based on induction linac drivers. Inquiries regarding HIFAR should be addressed to Dr. Walter M. Polansky, HIFAR Program Manager, ER-16, GTN, Department of Energy, Washington, DC 20545, phone 301/353-5935.

OFFICE OF BASIC ENERGY SCIENCES

DIVISION OF ADVANCED ENERGY PROJECTS

Summaries of Projects Active in FY 1987

This section contains brief summaries of all projects active in this Division during Fiscal Year 1987 (October 1, 1986-September 30, 1987). The intent of this compilation is to provide a convenient means for quickly acquainting an interested reader with the program in Advanced Energy Projects. More detailed information on research activities in a particular project may be obtained by contacting directly the principal investigator identified below the project title. Some projects will have reached the end of their contract periods by the time this book appears, and will, therefore, no longer be active. Those cases in which work was completed in FY '87 are indicated by the footnote: *Project completed. The annual funding level of each project is shown.

1. *MEASUREMENT OF THE EFFICIENCY OF MUON-CATALYZED FUSION

BRIGHAM YOUNG UNIVERSITY
Provo, Utah 84602

Steven E. Jones
Department of Physics and Astronomy

Date Started: September 1, 1985

$228,000

Anticipated Duration: 2 years

In conventional approaches to nuclear fusion, hydrogen isotopes are heated to temperatures approaching or exceeding those found in the sun. The fusion reaction then occurs, releasing energy. As early as 1947, it was hypothesized that an elementary particle known as a muon could catalyze fusion so that it could proceed at "cold" temperatures, such as room temperature. However, theorists soon predicted that the reaction would proceed too slowly to be of much interest. Interest revived a few years ago when Soviet theorists postulated the existence of a resonance mechanism whereby the "cold fusion" reaction would go very quickly. They argued that it might be possible to achieve as many as 110 fusion reactions per muon. Experiments to test these new ideas have actually exceeded the predictions: as many as 150 fusions (average) per muon have been achieved. Still higher fusion yields are anticipated. The objective of the program is to explore the limits of muon catalyzed fusion to provide answers to questions regarding energy applications.

*This project is being continued at S&J Scientific Company, project number 36.

2. *EXTREME ULTRAVIOLET COHERENT RADIATION DEVICE; TRANSVERSE OPTICAL KLYSTRON**

BROOKHAVEN NATIONAL LABORATORY
Upton, New York 11973

C. Pellegrini
National Synchrotron Light Source

Date Started: September 26, 1983

$313,000

Anticipated Duration: 4 years

This project is for the development of a new radiation source to be incorporated into the VUV storage ring of the National Synchrotron Light Source (NSLS) which will produce coherent radiation from 500 Å - to 2000 Å. Specifically, this radiation source is a Transverse Optical Klystron (TOK) which makes use of a high power laser in the visible region and a permanent magnet undulator structure in conjunction with the circulating electron beam bunches in the storage ring to produce radiation at the harmonics of the laser. The basic approach to this objective is to overlap the macrobunch of electrons in a storage ring, in the field of an undulator magnet, with the radiation of an external laser. As a consequence, the electrons receive energy modulation, at an appropriate laser wavelength, due to coupling of the transverse electric field of the laser with the transverse velocity induced by the periodically varying field of the undulator (modulator section). While traversing the undulator, the energy modulation of the electrons will convert into spatial bunching at the laser wavelength (dispersion section). In the downstream part of the undulator, the electrons will have optimal bunching and radiate coherently at the harmonics of the laser (radiation section). A third harmonic TOK "pumping" scheme rather than the first harmonic pumping mode will be used in order to avoid unacceptable (for electron storage ring operation) undulator minimum gap parameter values.

*Project completed.
**Performed in cooperation with BELL LABORATORIES, 600 Mountain Avenue, Murray Hill, New Jersey 07974, Richard R. Freeman and Brian Kincaid co-principal investigators.

3. GENERATION OF RADIATION BY INTENSE PLASMA AND ELECTROMAGNETIC UNDULATORS

UNIVERSITY OF CALIFORNIA, LOS ANGELES
405 Hilgard Avenue
Los Angeles, California 90024

Chan Joshi

Date Started: July 1, 1987

$300,000

Anticipated Duration: 3 years

This program involves the generation of short wavelength, UV-VUV, radiation by intense plasma and electromagnetic undulators. In this concept a relativistic electron beam is wiggled by either the oscillating electric field of an intense plasma density wave or by an electromagnetic wave causing it to radiate. Using these schemes it is proposed to generate tunable radiation in the 1500 Å - 3 μm range from an electron beam of only 1.5 MeV energy. The plasma wave with an effective wiggler strength parameter $a_w \approx 0.1$, wavelength $\lambda_w \approx 100$ μm and number of periods $N \approx 100$ will be excited by resonantly beating two laser beams in a plasma. The electrons are made to wiggle transversely at the plasma frequency ω_p by injecting them parallel to the plasma wavefronts. Because of relativistic Doppler shift the radiated frequency is upshifted to $2\gamma^2\omega_p$. For even shorter wiggler wavelengths a powerful CO_2 laser, $\lambda_w \approx 10$ μm, $a_w \approx 1$, will be used. By counter propagating this laser beam with the electron beam it is proposed to generate 1500 Å VUV radiation. Because of the high wiggler strengths, some harmonic generation is expected. An applications study will also be undertaken to identify technologies which would likely be impacted by these sources.

4. *ELECTROCHEMICAL AND ELECTRO-CATALYTIC PAIRED ORGANIC REACTIONS IN UNDIVIDED FLOW CELLS

UNIVERSITY OF CALIFORNIA, LOS ANGELES
Los Angeles, California 90024

Ken Nobe
Department of Chemical Engineering

Date Started: July 1, 1984

$64,000

Anticipated Duration: 39 months**

Paired electrochemical syntheses for the production of organic chemicals can reduce energy consumption by as much as 50% compared to conventional electrochemical syntheses. A paired synthesis is more energy efficient because both the anodic and cathodic reactions contribute simultaneously to the formation of the final product(s). Additional energy savings can be achieved by performing the paired synthesis in an undivided flow cell and by incorporating an electrocatalytic hydrogenation as the cathodic partner of the paired reaction scheme. Moderate temperature, ambient pressure electrochemical hydrogenations at high surface area active electrocatalytic cathodes such as Raney nickel can be more energy efficient than chemical catalytic hydrogenations. The objectives of this research program are: 1) devise electro-organic paired syntheses, such as the oxidation and reduction of glucose to gluconic acid and sorbital, employing an active electrocatalytic cathode; 2) design, model and test continuous undivided flow cells for paired syntheses; and 3) evaluate the economic feasibility of the paired syntheses as opposed to producing the same chemicals individually by conventional chemical or electrochemical methods.

*Project completed.
**Includes no cost extension.

5. MUONIC MOLECULAR STRUCTURE, μ-STICKING PROBABILITIES AND FUSION RATES FOR MUON CATALYZED FUSION

CALIFORNIA STATE UNIVERSITY, LONG BEACH
1250 Bellflower Blvd.
Long Beach, California 90840

Chi-Yu Hu
Physics/Astronomy Department

Date Started: August 1, 1986

$60,000

Anticipated Duration: 2 years

In the muonic molecules such as $(dt\mu)^+$, $(dd\mu)^+$, the muon "confines" the two nuclei in a region small enough that fusion can occur. The average number of fusions induced by each muon determines the upper limit on energy production. In order to predict the average number of fusions per muon and other properties in the muon-catalysis cycle, it is essential to understand the details of the muonic molecular structures. The purpose of this project is to make extremely accurate calculations of the $(dt\mu)^+$ and $(dd\mu)^+$ molecular structures and then to use these wave functions to determine fusion rates, μ-sticking probabilities and other parameters necessary to understand the mesomolecular formation process and the fusion process. In this collaboration with the theoretical and the experimental teams at Brigham Young University, Los Alamos National Laboratory, and the Lawrence Livermore National Laboratory, the ultimate goals are to understand completely the muonic molecular structures and the muon-catalysis cycle.

6. MUON-CATALYZED FUSION IN GASES OF HD AND H_2 + D_2 MIXTURES

CALIFORNIA STATE UNIVERSITY, LOS ANGELES
5151 State University Drive
Los Angeles, California 90032

Konrad Aniol
Physics Department

Date Started: September 15, 1986

$28,000

Anticipated Duration: 2 years

Current measurements of muon induced fusion in deuterium-tritium mixtures show that the sticking probability is about 0.4%. At this level of sticking, other processes, such as the formation of ddμ or pdμ muonic molecules, have significant effects on the loss of muons from the fusion cycle. The molecular formation rates of ddμ and pdμ are about 100 times smaller than that of the dtμ . Nevertheless, because of their substantially larger sticking probability, they are important sources of muon loss at the tenth of a percent level. Measurements have been made of the relative formation rates of ddμ and pdμ molecules in gas samples of H_2 + D_2 and HD. Substantially different temperature dependences of ddμ formation rates in these two gas samples were observed, but not of the type predicted by theory. In addition, temperature dependence was observed in pdμ formation more pronounced than predicted, and a difference in absolute yield of pdμ formation between HD and H_2 + D_2 where none was anticipated. It is planned to remeasure the ddμ and pdμ rates in a new target cell over a larger temperature range. It is important to verify, in a new experimental set-up, whether the preliminary experimental results are correct.

7. *NEW POLYMER ELECTRODES AND CONDUCTORS BASED ON POLY(HYDROQUINONE/QUINONE) OXIDATION/REDUCTION SYSTEMS

CASE WESTERN RESERVE UNIVERSITY
Cleveland, Ohio 44106

Morton H. Litt
Department of Macromolecular Science

Date Started: September 15, 1983

$161,000

Anticipated Duration: 3-1/2 years

This project has the following goals: 1) To synthesize soluble linear fused ring polyaromatic polymers (ladder polymers) which have attached 1,4-hydroxyl groups; 2) To characterize these polymers. The polymer should be a good electrical conductor. It is expected that the hydroxyl groups can be reversibly oxidized and reduced - making this material a good candidate for a very high capacity electrode. High molecular weight polymers will be made into oriented fibers and films and their mechanical properties as well as electrical properties studied. Fibers of these polymers should be like graphite fibers, but should be solution processable.

*Project completed.

8. ALPHA STICKING FRACTION CALCULATIONS IN MUON CATALYZED FUSION

DUKE UNIVERSITY
Durham, North Carolina 27706

L.C. Biedenharn
Physics Department

Date Started: September 15, 1986

$54,000

Anticipated Duration: 2 years

Recent experiments on deuterium-tritium fusion, catalyzed by muons, show an unexpectedly large number of fusions per muon. This indicates that thermonuclear energy production, via muon catalyzed fusion, should be considered as a possibility. The single most important parameter characterizing this process is the "alpha sticking fraction" W_s (the fraction of the muons lost by capture on the alpha particle per fusion cycle) since the average number of fusions per muon--which determines the feasibility for energy production--cannot exceed $(W_s)^{-1}$. A precise calculation of W_s is now important for determining a theoretical upper limit for feasibility studies; no such calculation currently exists. A cooperative program will be conducted for an accurate calculation of W_s. The calculation of W_s involves two different disciplines: nuclear physics (the $^5He(3/2+)$ resonance is crucial) and molecular physics. Eigenphase-shift techniques will be used to develop nuclear wavefunctions in the critical short distance regime.

9. ACCURATE ALPHA STICKING FRACTIONS FROM IMPROVED THREE-BODY CALCULATIONS RELEVANT FOR MUON CATALYZED FUSION

UNIVERSITY OF FLORIDA
Gainesville, Florida 32611

Krzysztof Szalewicz
Department of Physics

Date Started: September 1, 1985

$132,000

Anticipated Duration: 29 months

Interest in muon-catalyzed fusion is experiencing a dramatic revival. Experiments by Jones et al have shown that under proper conditions a single muon can catalyze about one hundred fifty fusions in its life time. This is much more than theory had predicted. The objective of this project is to calculate highly accurate values of the probability for a muon to stick to the alpha particle synthesized during the fusion. Stuck muons are lost for further fusions and at present this process seems to determine the fusion yield. The sticking probability will be extracted from high-accuracy three-body wavefunctions for muonic molecules containing the hydrogen isotopes. These functions will be computed with and without strong force modification to the Coulombic interaction between the nuclei. Better theoretical understanding of the process may be crucial for guiding future experimental work.

10. *DETECTION AND CHARACTERIZATION OF NOVEL METAL-BINDING PROTEINS

GENERAL ELECTRIC COMPANY
P.O. Box 8
Schenectady, New York 12301

David S. Holmes
Corporate Research & Development

Date Started: July 1, 1984

$144,000

Anticipated Duration: 3 years

The principal research objectives are 1) the development of a High Pressure Liquid Chromatography (HPLC) system for the separation and detection of metal-binding proteins; 2) implement the HPLC technique for analyzing candidate organisms for the presence of metal-binding proteins; 3) to chemically synthesize and characterize metallothionein-like proteins. Current work has included a new HPLC on-line detection technique using a combination of bichiconicic acid and p-chloromer-curibenzoate to identify proteins with copper bound to them. Methods have been developed for a two-dimensional HPLC to provide a rapid separation of complex protein mixtures effectively and efficiently. Fragments of Neurospora metallothionein have been synthesized and characterized. Synthesis and purification of metallothionein and metallothionein analogs will be continued for synthetic model peptides.

*Project completed.

11. A VISIBLE TUNABLE SOURCE

HUGHES AIRCRAFT COMPANY
P.O. Box 9399, M/S 3C923
Long Beach, California 90810

I-Fu Shih
Advanced Products Laboratory

Date Started: September 1, 1985

$134,000

Anticipated Duration: 39 months*

The objective of this program is to further understand the Salisbury-Smith-Purcell effect so that useful devices based on this effect can be developed. Salisbury-Smith-Purcell radiation occurs when an electron beam grazes a conducting grating. A tunable radiation source based on the Salisbury-Smith-Purcell effect could have wide-spread applications; for example, such a device can be used in interferometric sensors for acoustic, electromagnetic, pressure, or temperature sensing. These sensors can be used for geophysical exploration, and for a broad class of diagnostic, test, or control equipment. This program will focus on a feature of Salisbury's model that has not been exploited to date. The Salisbury model suggests that it is important to use a low divergence electron beam and to reflect some of the electrons from the grating surface to form sheets of periodic space charge above the grating. Both theoretical and experimental investigations are planned. The theoretical task is to refine the preliminary analysis to more accurately predict the radiation characteristics. The experimental task is to assemble an apparatus and to characterize the radiation.

*Includes no cost extension.

12. MECHANISTIC STUDY OF THE EFFECT OF MAGNETIC FIELDS ON SCALE FORMATION

THE JOHNS HOPKINS UNIVERSITY
Baltimore, Maryland 21218

J.L. Katz
Department of Chemical Engineering

Date Started: September 1, 1985

$89,000

Anticipated Duration: 3 years

This project involves investigation of the inhibition of scale formation by magnetic water treatment. Although commercial treatment devices are available, there is major controversy whether it works and how it works. Nonetheless, such devices have attracted great interest because, if effective, they are easy to use, reliable and very inexpensive. This project involves the testing of a mechanism which is able to account for all experimentally observed facts. The mechanism examined here builds on earlier work by Zubarev who described magnetic water treatment in terms of nucleation phenomena. Preliminary work in our laboratory has shown that under certain conditions the application of magnetic fields can change the concentration of ferric hydroxides in saturated solutions. These hydroxides may control the deposition of calcium salts from solution by providing heterogeneous nucleation sites. Additional experiments involving magnetic field strengths and magnetic field gradients in these processes are planned.

13. APPLICATION OF PERMANENT MAGNETS TO ACCELERATOR TECHNOLOGY AND GENERATION OF RADIATION WITH ELECTRON STORAGE RINGS AND FREE ELECTRON LASERS

LAWRENCE BERKELEY LABORATORY
Building 80-101
Berkeley, California 94720

Klaus Halbach

Date Started: October 1, 1985

$296,000

Anticipated Duration: 3 years

Because of saturation properties of soft ferromagnetic materials and of problems associated with the cooling of coils, the magnetic field strength achievable in small working volumes becomes smaller as the linear dimensions of an electromagnet become smaller. Since permanent magnets do not have the coil cooling problems, they can produce much larger fields than electromagnets when magnetically relevant dimensions have to be small. For that reason, permanent magnet undulators/wigglers and charged particle beam handling magnets have been developed over the last few years. It is the purpose of this project to further explore the magnet devices with regard to their reliability and field quality. Consequently, the effect of construction and material tolerances on field quality will be investigated, and improved construction methods will be developed. In addition, work will proceed to incorporate permanent magnet materials into electromagnets, to make it possible to produce with permanent magnets assisted electromagnets fields of the same strength that permanent magnets produce. This work is particularly important for tapered undulators in free electron lasers, where one needs the combination of permanent magnet strength and electromagnet variability. In addition to developing new concepts, the tools employed to achieve these goals (a combination of analytical models, computer analysis and synthesis, and experimental work) will be perfected.

14. ACCELERATION OF A COMPACT TORUS PLASMA RING

LAWRENCE LIVERMORE NATIONAL LABORATORY
P.O. Box 5511
Livermore, California 94550

Charles Hartman

Date Started: July 1, 1985

$446,000

Anticipated Duration: 4 years

This project has the objective of demonstrating acceleration of plasma rings confined by the dipole and entrapped $\dot{B}$ magnetic fields of a compact torus. The 6 m long accelerator is in the form of a coaxial rail-gun with the plasma ring, which acts as a moving short, accelerated by a 250 kJ capacitor bank. Successful acceleration will yield 10^{-5} to 10^{-3} gram plasma rings with 100 kJ kinetic energy and velocities up to about 5×10^8 cm/sec. Rapidly moving plasma rings will be tested for focusing by injecting them into a conducting core where eddy currents will compress the magnetic field and confined plasma to small size. This new type of collective accelerator employing magnetic confinement will allow access to power, power density, and energy density regimes heretofore inaccessible in the laboratory. Following demonstration of acceleration, applications can be tested, including rapid compression of rf fields to produce an ultra high power rf source, nanosecond generation of high temperature radiation, a fast opening in megampere switch, and, in a scaled up accelerator, focusing to produce an efficient, simple inertial fusion driver.

15. DETECTION AND ENRICHMENT OF FRACTIONALLY CHARGED PARTICLES IN MATTER

LAWRENCE LIVERMORE NATIONAL LABORATORY
P.O. Box 808, L-482
Livermore, California 94550

Charles D. Hendricks
Y Division, Laser Program

Date Started: May 1, 1982

$254,000

Anticipated Duration: 5-1/2 years

This project is an experimental search for fractionally charged particles in matter. Such particles may be a manifestation of free quarks. At the heart of the experiment is a charge-to-mass measurement on very uniform mass particles. Thus, a measurement of q/m will yield relative values of the charge of the particles. Because most of the particles should have charges which differ by integer values of one electron charge, only relative charge measurements between particles need be made to determine the presence of fractional charges. Liquid drops which are about 45 micrometers in diameter and spaced about 750 micrometers apart are made at a rate of approximately 3×10^4 drops per second. These values depend on the particular parameters set into the experiment as it is being done. The drops traverse the space between two vertical, parallel plates which may be maintained at a DC potential difference up to about 60 kV. With no potential between the plates the drops travel along a straight vertical line downward between the plates. With a high potential between the plates, the drops are deflected transversely along paths which depend on the charge on each drop. Data is being taken to determine the relative charges on the drops and, thus, determine the presence or absence of fractional charges.

16. THEORETICAL STUDY OF MUON-CATALYZED FUSION

LOS ALAMOS NATIONAL LABORATORY
MS-J569
Los Alamos, New Mexico 87545

James S. Cohen
Theoretical Division

Date Started: December 29, 1983

$293,000

Anticipated Duration: 6 years

This study is designed to formulate a detailed description of the muon-catalyzed fusion cycle, with the objectives of aiding the experimental program and obtaining parameters needed to evaluate the ultimate limitations on energy production. Nuclear fusion occurs when a negative muon ($\bar{\mu}$, an unstable particle about 200 times as massive as the electron) is stopped in a high-density mixture of deuterium and tritium and the small $dt\mu$ mesomolecule is formed. Experiments at the Los Alamos Meson Physics Facility have detected 150 fusions per muon. Some unexpected transient behaviors and dependencies of the mesomolecular-formation and muon-loss rates on temperature and target density have been observed; understanding of these effects may lead to still higher yields. The physical problems being addressed theoretically include muon capture and transfer, muonic molecule formation (with nonthermal and hyperfine effects) and structure, and muon loss (to impurities as well as helium) and regeneration. In collaboration with the experimental team, tests of theoretical predictions are planned.

17. NUCLEAR EXCITATION BY A HIGH-BRIGHTNESS UV LASER

LOS ALAMOS NATIONAL LABORATORY
Los Alamos, New Mexico 87545

Peggy L. Dyer
Physics Division

Date Started: July 1, 1986

$358,000

Anticipated Duration: 3 years

In the conceptual two-step pumping scheme for a gamma-ray laser, the most difficult remaining problem lies in exciting nuclei from long-lived storage isomers to nearby short-lived states (that will then spontaneously decay to upper lasing levels), without destroying the solid state structure required for the Mossbauer effect and for Borrmann modes. A novel mechanism recently proposed for this transfer will be experimentally investigated: nuclear excitation by electrons driven to oscillate collectively by a bright, picosecond ultraviolet laser. As a test case it will be attempted to excite the 75-eV isomer of ^{235}U, the excitation signal being delayed internal conversion electrons. Following parameter-dependence studies with a vapor target in a collision-free environment, nuclear excitations in solid substrates of the crystalline form required for a gamma-ray laser will be investigated. Finally, nuclear isomeric targets will be used, in preparation for first experiments to look for stimulated emission in nuclei.

18. *LARGE APERTURE RARE GAS HALOGEN POWER AMPLIFIER FOR FEMTOSECOND OPERATION AT EXTREME PEAK POWER

LOS ALAMOS NATIONAL LABORATORY
P.O. Box 1663
Los Alamos, New Mexico 87545

C.A. Fenstermacher
Defense Research Programs
Fusion Research and Applications

Date Started: March 1, 1985

$375,000

Anticipated Duration: 2 years

A collaborative research effort between the University of Illinois, Chicago Circle, and the Los Alamos National Laboratory has been underway for several years with the goal of producing a high brightness, extremely short pulse laser system operating at 248 nm to produce the extreme power believed needed to pump x-ray lasers. Work at the University of Illinois has identified a mechanism for x-ray laser pumping, and current research results show high promise. Based upon this, a laser pumping system concept has been developed and implementation is underway. A major component of this laser oscillator-amplifier chain is the final amplifier which is proposed to be a large aperture KrF amplifier module. Because of its current efforts in large KrF amplifier development for the Inertial Confinement Fusion program, the Laboratory has developed an in-depth expertise in all the related technologies and is therefore in a unique position to oversee the development of this prototype amplifier. Preliminary survey indicates that an x-ray pre-ionized discharge amplifier of dimensions 10x10x100 cm is within the state of the art and will provide output energy in the 1-2 joule range in a 5 ps pulse.

*Project completed.

19. ANTIPROTON TECHNOLOGY

LOS ALAMOS NATIONAL LABORATORY
Los Alamos, New Mexico 87545

M.V. Hynes
Physics Division

Date Started: November 15, 1985

$499,000

Anticipated Duration: 3 years

From the initial observation of the antiproton in 1955 until the present, matter-antimatter annihilation as a compact energy source has been at best a visionary concept whose realization appeared beyond reach. A number of technological developments in both particle and atomic physics have brought the prospect of antimatter as an energy source much closer. The possibility now exists for performing experiments with the objective of storing substantial numbers of cold antiprotons, a critical step toward an antimatter energy source. As a part of experiment PS200 at CERN to measure the gravitational acceleration of antiprotons a number of interrelated problems central to evaluating prospects for antimatter storage as a potential advanced energy source will be investigated both experimentally and theoretically. These are: 1) demonstrate the storage of low temperature protons, antiprotons and $^-$H ions externally injected into a Penning type ion trap, 2) the cooling of trapped antiprotons to low temperatures ($\leq 10^{o}$K), 3) trap a substantial quantity of antiprotons and release them in a controlled manner, and 4) carry out theoretical investigations in condensed matter, nuclear, and particle physics to establish a framework for further experimentation with low temperature antiprotons relevant to improved storage concepts.

20. EXPERIMENTAL INVESTIGATION OF MUON-CATALYZED FUSION

LOS ALAMOS NATIONAL LABORATORY
P.O. Box 1663
Los Alamos, New Mexico 87545

Melvin Leon
MP Division

Date Started: July 1, 1985

$780,000

Anticipated Duration: 4 years

The remarkable ability of a single negative muon to catalyze many d-t fusions has given rise to speculations about the possibility of harnessing this reaction for practical power production. In order to put such discussions on a sound basis, it is essential that as complete an understanding as possible be developed of the subtle and intricate molecular physics involved. To this end, it is intended to investigate the physics of muon-catalyzed fusion, continuing the experimental program at LAMPF of the Brigham Young University-Los Alamos National Laboratory-Idaho National Engineering Laboratory collaboration. Our long range goals are to understand completely the muon-catalysis cycle, and to determine the maximum number of d-t fusions that can be obtained from a single negative muon.

21. *DEVELOPMENT OF A BROADLY TUNABLE FREE-ELECTRON LASER FOR THE EXTREME-ULTRAVIOLET SPECTRUM

LOS ALAMOS NATIONAL LABORATORY
P.O. Box 1663, MS-J564
Los Alamos, New Mexico 87545

Brian E. Newnam
Chemistry Division

Date Started: June 1, 1985

$329,000

Anticipated Duration: 3 years

The overall goal of this project is to determine the feasibility of a free-electron laser (FEL), based on a single rf linear accelerator, for production of broadly tunable, coherent radiation extending from the extreme ultraviolet to the visible spectrum (>50-400nm). The inherent temporal structure will be continuous trains of 10- to 30-ps pulses. Initial calculations indicate that below 200 nm the peak and average power output would surpass the capabilities of any existing, continuously tunable sources by many orders of magnitude. The present research will extend present FEL theory to XUV wavelengths for which a three-space dimensional FEL code has been developed to numerically simulate variations of key oscillator parameters. Electron beam, magnetic undulator, and resonator optics parameters will be optimized to attain maximum laser gain and output power. To reach still shorter wavelengths in the x-ray region, e.g. 5 nm, methods to enhance production of the optical harmonics of the FEL will be analyzed.

*Project completed.

22. *LIQUID METAL THERMO-ACOUSTIC ENGINE**

G. W. Swift
Physics Division

$285,000

LOS ALAMOS NATIONAL LABORATORY
Los Alamos, New Mexico 87545

Date Started: September 27, 1983

Anticipated Duration: 4 years

A sound wave is usually thought of as consisting of pressure oscillations, but always attendant to the pressure oscillations are temperature oscillations. The combination produces a rich variety of "thermoacoustic" effects. These effects are usually so small that they are never noticed in everyday life, but under the right circumstances they can be harnessed to produce powerful heat engines, heat pumps, and refrigerators. This project is a combined theoretical and experimental study of thermoacoustic effects in liquid sodium. In the liquid sodium thermoacoustic engine, heat flow from a high temperature source to a low temperature sink will generate a high-amplitude acoustic wave in the sodium. This acoustic power will be converted to electric power by a simple magnetohydrodynamic effect at the acoustic oscillation frequency. Hence the engine will produce electrical power from heat with no moving parts. In a kilowatt laboratory model engine the heat-to-acoustic and the acoustic-to-electric conversion processes are studied.

*Project completed.
**Project originated by the late John C. Wheatley

23. *RESEARCH ON MILLIMETER AND SUBMILLIMETER RADIATION FROM ROTATING ELECTRON BEAMS IN RIPPLED MAGNETIC FIELDS

William W. Destler, Univ. of Maryland
George Bekefi, MIT

$153,000

UNIVERSITY OF MARYLAND
College Park, Maryland 20742
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Cambridge, Massachusetts 02139

Date Started: July 1, 1984

Anticipated Duration: 3 years

The objective of this project is to determine if a circular geometry Free Electron Laser can be constructed by subjecting a rotating electron beam to a transverse wiggler magnetic field. In this concept, a rotating electron beam is produced by passing a non-rotating cylindrical beam through a narrow magnetic cusp, and the transverse wiggler field is produced by samarium-cobalt magnets placed behind smooth conducting boundaries interior and exterior to the beam. Potential advantages of such a device include a more compact geometric configuration and internal feedback resulting from the recirculation of the electromagnetic field around the device. The latter feature may mean that the device can operate as an oscillator without external mirrors, in contrast to conventional Linear Free Electron Lasers. Work is being pursued theoretically and on three different experiments operating at a range of electron energies and currents.

*Project completed.

24. *MAGNETIC ENHANCEMENT AND DEMINERALIZATION OF EASTERN COALS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Cambridge, Massachusetts 02139

David R. Kelland
Francis Bitter National Magnet Laboratory

Date Started: June 1, 1984

$331,000

Anticipated Duration: 3 years

The inorganic sulfur and mineral content of high sulfur coals can be reduced by high gradient magnetic separation (HGMS). Enhancement of the magnetization of the coal pyrite through selective heating by microwave irradiation to convert the pyrite to more magnetic pyrrhotite should improve demineralization performance. This research program, carried out in cooperation with General Electric-Schenectady, is an attempt to verify indications of successful microwave pretreatment of coals and investigate the effect of magnetic enhancement on HGMS performance. Microwave experiments on coal have produced pyrite conversion to troilite/disordered pyrrhotite, Fe_3O_4 and Fe. The magnetization of mineral pyrite has been enhanced in both air and inert gas by high voltage electrical discharge in our effort to study the mechanism of conversion. Coal characterization, in particular by Mossbauer, electron microprobe, and magnetization measurements is being carried on along with baseline magnetic separations on three Eastern coals.

*Project completed.

25. BIOLOGICAL X-RAY HOLOGRAMS

MCR TECHNOLOGY CORPORATION
P.O. Box 10084
Chicago, Illinois 60610

Keith Boyer

Date Started: September 1, 1986

$249,000

Anticipated Duration: 39 months*

A new ultrahigh brightness x-ray technology is emerging which will enable high contrast imaging of the pure living state on an atomic scale, a microvisualization of biological materials impossible to achieve by any other known means. The goal of the proposed program is the development of the technology and instrumentation needed for the application of x-ray biological microholograms to living matter. The approach used involves the use of ultrahigh brightness ultraviolet lasers as the technical means for producing the needed short wavelength radiation. The instrumentation required to control the ultraviolet energy features as the focus of this program.

*Includes no cost extension.

26. THE MAGNETICALLY INSULATED INERTIAL CONFINEMENT FUSION (MICF)-A NOVEL APPROACH

UNIVERSITY OF MICHIGAN
Ann Arbor, Michigan 48109-2104

T. Kammash
Department of Nuclear Engineering

Date Started: June 1, 1987

$89,000

Anticipated Duration: 3 years

The objective of this project is to study the relevant physics issues that bear directly on the potential of the Magnetically Insulated Inertial Confinement Fusion (MICF) concept as a power-producing reactor. In this novel approach the favorable aspects of both magnetic and inertial fusions are utilized in that the hot, dense fusion grade plasma is physically contained by a metallic shell while its heat is insulated by a strong, self-generated magnetic field. Recent experimental studies at Osaka University using 100 Joule, CO_2 laser impinging on a target of parylene shell of few milimeters in radius have resulted in a Lawson parameter (product of density and confinement time) of $5x10^{12}$ sec cm^{-3} at a plasma temperature of 0.5 keV. In contrast to implosion type inertial confinement schemes the MICF approach allows for the creation of the desired plasma within a shell by means of laser radiation that enters through a hole in the shell and strikes the fuel-coated inner surface. The return currents generated by the energetic ablated electrons give rise to the strong magnetic field that provides the desired thermal insulation. Because of this unique arrangement the lifetime of the burning plasma will be significantly higher than in conventional implosion type inertial fusion and the energy efficiency will be superior since the input laser energy is put directly into the plasma. It is therefore expected that the ignition conditions will be much less severe, and the energy multiplication will be much larger than in the conventional counterpart and this project is aimed at verifying these properties and how they impact the reactor aspects of this concept.

27. APPLICATION OF HIGH POWER MODULATED INTENSE RELATIVISTIC ELECTRON BEAMS FOR DEVELOPMENT OF A WAKE FIELD ACCELERATOR

NAVAL RESEARCH LABORATORY
Washington, D.C. 20375-5000

Moshe Friedman

Date Started: August 1, 1986

$336,000

Anticipated Duration: 3 years

Future progress in accelerators and their applications depend critically on the development of new mechanisms capable of generating high voltage gradients. The objective of this program is to show that high electric fields can be established in a structure by the wake field of a modulated intense relativistic electron beam (MIREB) propagating through the structure. The simplicity and high efficiency of generating MIREBs with power $\gtrsim 10^{10}$ watts by an external low power RF source suggests advantages of a wake field accelerator over a more conventional approach to generating high currents of high energy particles. It is anticipated that at the end of the project, proof-of-principle results demonstrating particle acceleration through a voltage gradient $\gtrsim 100$ MV/m will be at hand with scaling laws needed to design practical devices for future applications.

28. THE CHIRPED-PULSE FREE-ELECTRON LASER

UNIVERSITY OF NEW MEXICO
800 Yale Blvd., N.E.
Albuquerque, New Mexico 87131

Gerald T. Moore
Center for Advanced Studies

Date Started: September 1, 1987

$95,000

Anticipated Duration: 1 year

A theoretical and numerical investigation is to be made of pulsed free-electron lasers in which there is a dependence of the electron energy on the time of injection into the wiggler. Such devices are expected to produce coherent optical pulses whose frequency varies (chirps) over the pulse length by a large amount. Such pulses have never before been produced, and should have a number of applications. Chirping should produce enhanced efficiency in the high-power regime, where the electrons become trapped by the fields and slowed down. Combining chirping with tapering of the wiggler wavelength or magnetic field may also lead to a new type of electron accelerator in which energy is transferred from slower electrons to faster electrons via the laser field.

29. REDUCTION IN ENERGY AND OPERATING COSTS FOR ENZYMATIC CELLULOSE HYDROLYSIS BY A NOVEL METHOD FOR ENZYME RECOVERY

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831

Charles D. Scott
Chemical Technology Division

Date Started: July 1, 1986

$175,000

Anticipated Duration: 3 years

The objective of this program is to significantly reduce the costs associated with enzymatic cellulose hydrolysis for the production of high energy fuels and chemicals by demonstrating the feasibility of a novel method for the recovery of the enzyme cellulase from aqueous solutions and from undigested cellulosic residues. The method is based upon the ability of specific absorbent molecules to either "mop" up cellulase from solution or to effect the desorption of cellulase from the residues because of their affinity for the enzyme. Subsequent release of cellulase from the absorbents will allow reuse of the enzyme. For example, cellulase absorbed onto inorganic kieselguhr granules coated with concanavalin A desorbs from this support when contacted with cellulose. The work will be divided into three categories: (1) identification of appropriate support materials with affinity for cellulase, (2) determination of the effect of fuels and chemicals (fermentation products) on the affinity of appropriate supports for cellulase, and (3) design and development of suitable reactor systems for enzymatic cellulose hydrolysis with enzyme recovery.

30. RESEARCH ON X-RAY OPTICS WITH THE ULTIMATE AIM OF PRODUCING A SYNCHROTRON RADIATION PUMPED SOFT X-RAY LASER

UNIVERSITY OF OREGON
Eugene, Oregon 97403

Paul L. Csonka
Institute of Theoretical Science

Date Started: January 1, 1985

$121,000

Anticipated Duration: 44 months*

The immediate goal of the project is to achieve significant improvements in the areas of synchrotron radiation focusing, pulse shaping and the development of new types of radiation energy filters. These results are expected to lead to superior x-ray imaging, higher radiation brilliance, better spectral and time resolution for a variety of experiments with a wide field of applications, including materials science, solid state physics and biology. Furthermore, these developments are designed so as to ultimately permit construction of a soft x-ray Li laser pumped with synchrotron radiation, with a repetition rate which cannot be matched by other methods.

*Includes no cost extension.

31. *VALIDATING THE PARAMAGNETIC LOGGING EFFECT

PARAMAGNETIC LOGGING, INC.
3123 198th Place S.E.
Bothell, Washington 98012

W. Banning Vail

Date Started: September 28, 1984

$152,000

Anticipated Duration: 35 months**

The Paramagnetic Logging Effect (PLE) is a recently predicted new magnetic phenomenon which will serve as the physical basis of a new borehole device capable of the direct measurement of the volume of petroleum reserves around a drill-hole to a radius of 50 feet or more into formation. The nucleons chemically bound in water and oil present in formation are preferentially aligned in the earth's magnetic field causing the natural nuclear paramagnetism within the formation. This paramagnetism causes a slight alteration in the strength of the earth's magnetic field in the vicinity of a borehole adjacent to the formation. Repeated application of an ac magnetic field at the Larmor frequency of the nucleons present yields an amplitude modulation of the earth's magnetic field. The magnitude of such modulation yields the total number of nucleons present and the phase contains information used to distinguish oil from water and identify the viscosity of oil present. The purpose of the project is to systematically study the new physical effect in a 4,800 gallon plastic tank filled first with water, then oil, and finally with mixtures of oil and water. The influence of borehole casing on these results will also be studied.

*Project completed.
**Includes no cost extension.

32. HOLOGRAPHIC RUGATE STRUCTURE FOR X-RAY OPTICS APPLICATION

PHYSICAL OPTICS CORPORATION
3305 Dow Avenue
Redondo Beach, California 90278

Joanna Jannson
Optics Lab

Date Started: September 25, 1986

$234,000

Anticipated Duration: 38 months*

A new approach to x-ray optics fabrication is based on the single-step holographic fabrication of highly-efficient x-ray dispersion elements, as well as imaging optics, gratings, lenses and mirrors. In this investigation, the holographic recording of interference patterns produced by two coherent electromagnetic waves is used to create the desired transmission and reflection Bragg holographic structures in the soft x-ray region of less than 30 nm. For applications involving grazing incidence, an argon laser can suffice as a recording coherent source, while for generating normal incidence optics, x-ray laser radiation will be used to create the large number of Bragg multilayers (1000). Unlike conventionally deposited multilayer films, these Bragg structures are quasi-sinusoidal in composition and thus eliminate the problems with discrete interfaces. As a result, such holographic optics possess superior mechanical and laser damage properties, higher operating efficiency, and is potentially more economical to be mass-produced.

*Includes no cost extension.

33. THIN-FILM COMPOSITE MEMBRANES FOR ARTIFICIAL PHOTOSYNTHESIS

PORTLAND STATE UNIVERSITY
Portland, Oregon 97207

Carl C. Wamser
Portland State University

Date Started: July 15, 1985

$243,000

Anticipated Duration: 40 months*

The objective of this program is to develop polymeric membranes which will be useful for photosensitization of separate oxidation and reduction reactions on opposite sides of the membrane. Ultimately these redox reactions will be coupled to the oxidation and reduction of water or other energy-storing reactions. Membranes will be optimized with respect to the following characteristics: a) absorption of the solar spectrum, b) photoinduced electron transport across the membrane, c) photosensitization of appropriate redox reactions at the membrane surfaces, d) durability, and e) economic considerations.

*Includes no cost extension.

34. STUDY OF THE FEASIBILITY OF X-RAY LASING ACTION IN A CONFINED PLASMA COLUMN BY USING A POWERFUL PICOSECOND LASER

PRINCETON UNIVERSITY
P.O. Box 451
Princeton, New Jersey 08544

Szymon Suckewer
Plasma Physics Laboratory

Date Started: January 1, 1985

$1,135,000

Anticipated Duration: 6 years

The main goal of this program is the experimental investigation of methods based on a powerful picosecond laser (PP-laser) of obtaining high gain and lasing action, initially in the spectral region 100-200 Å, as well as to study possibilities of creating high gain at shorter wavelengths in the region 60-70 Å. Theoretical modeling of obtained results should make it possible to predict conditions for lasing action at 10-20 Å using the same experimental method. The basic idea is to provide interaction of a PP-laser with a confined plasma column by resonance multiphoton excitation of ions in order to obtain, in a short time, a large population inversion in multi-electron high-Z ions as well as in H- and Li-like ions of low-Z elements (low-Z elements are considered here for picosecond laser powers significantly exceeding 10^{15} W/cm^2). The interaction of the PP-laser with a plasma column, which is created by a CO_2 laser, distinguishes this project from studies of the interaction of a PP-laser with cold gas or solid targets. Ions at the proper state of ionization will be created independently in the plasma, and the role of the PP-laser will be reduced to providing a high population inversion. Such a plasma column has favorable conditions for population inversion and gain even without a picosecond laser pulse due to fast radiation. The experimental program has three stages: (i) the design and construction of the PP-laser based on KrF* excimer laser, (ii) study of the process of the interaction of the PP-laser with ions in a recombining plasma column by photo-ionization and multiphoton ionization, and (iii) creation of strong population inversion (high gain) in multi-electron ions by multiphoton excitation.

35. SOFT X-RAY LASER MICROSCOPE

PRINCETON X-RAY LASER
P.O. Box 3526
Princeton, New Jersey 08540

Szymon Suckewer

Date Started: September 1, 1986

$288,000

Anticipated Duration: 38 months*

It is planned to design and construct a Soft X-ray Laser Microscope which will be incorporated into the Soft X-ray Laser Experiment presently operating at a wavelength of 182 A at the Princeton University. This design will also have a provision to adapt the microscope to a new system involving a Soft X-ray Laser significantly below 100 A, with very short pulses (1 - 10 ps), currently under study at Princeton University. Therefore, the uniqueness of the Soft X-ray Microscope design will be in the application of coherent radiation from a soft x-ray laser.

*Includes no cost extension.

36. *INVESTIGATION OF PARAMETERS CRITICAL TO MUON-CATALYZED FUSION

S&J SCIENTIFIC COMPANY
P. O. Box 7070
University Station
Provo, Utah 84602

Steven E. Jones

Date Started: September 1, 1987

$235,000

Anticipated Duration: 2 years

It has been demonstrated (in conjunction with others on the program) that muon catalysis cycling rates increase rapidly with increasing deuterium-tritium gas temperatures and densities. Furthermore, muon-capture losses are significantly smaller than predicted before the experiments began. As a result of these effects, muon-catalyzed fusion yields of 150 fusions/muon (average) have been achieved. The fusion energy thereby released, nearly 3 GeV/muon, significantly exceeds theoretical expectations, and still higher yields are expected. Therefore, it is proposed to explore the limits of muon-catalyzed fusion, to provide answers to questions regarding energy applications of muon-catalyzed fusion.

*This project is a continuation of project number 1.

37. MAGNETICALLY INSULATED IMPACT FUSION

SCIENCE APPLICATIONS INTERNATIONAL CORP.
206 Wild Basin Road, Suite 103
Austin, Texas 78746

Daniel C. Barnes

Date Started: May 1, 1987

$199,000

Anticipated Duration: 18 months

This theoretical study will develop and investigate a concept for combining magnetic insulation of particle energy with impact driven compression of thermonuclear fusion targets. A novel approach to formation of a wall-confined spheromak inside an imploding metallic liner is considered. The resulting system is expected to achieve a few hundred times inertial energy confinement. Thus, in contrast to uninsulated impact fusion targets, present or near-term electromagnetic launch technology could deliver the impact of 10-20 km/s required to produce significant thermonuclear yield. Energy confinement, target preparation, and shell hydrodynamics will be investigated. Experimentally relevant target designs will be developed and analyzed.

38. *GAS-LOADED, FREE ELECTRON LASER

STANFORD UNIVERSITY
Stanford, California 94305

Richard H. Pantell
School of Engineering

Date Started: August 1, 1984

$373,000

Anticipated Duration: 3 years

The purpose of this project is to demonstrate free-electron laser (FEL) interaction in a gaseous medium by obtaining energy transfer from an electron beam to an electromagnetic wave. Synchronism between the electrons and the electromagnetic wave is achieved primarily by reducing the phase velocity of the wave. The advantage of this approach over the vacuum FEL is that at a fixed wavelength the particle energy is lower, resulting in higher gain per unit length and reduced equipment cost and size. As a first step, the propagation of a 40 MeV electron beam from a linear accelerator through hydrogen gas in the pressure range from one to 1000 Torr will be studied. The picosecond nature of the beam precludes many of the beam-plasma instabilities that can occur with a longer pulse, and there has not been a prior investigation of beam propagation through a plasma for our range of parameters. Beam dimensions will be observed by fluorescence emission and angular divergence will be measured by Cherenkov radiation. It is anticipated that multiple scattering will be the primary problem encountered. This limits the length of the FEL, but not before significant gain can be obtained. The second step will be to add gas to an existing FEL, to observe a shift in wavelength as a function of gas pressure.

*Project completed.

39. FOCUSED SHOCK DRILLING EXPLORATORY RESEARCH PROGRAM

TETRA CORPORATION
4905 Hawkins NE
Albuquerque, New Mexico 87109

William M. Moeny

Date Started: March 1, 1985

$285,000

Anticipated Duration: 37 months*

The objective of this program is to determine the feasibility of the high energy focused shock drill as a new approach to drilling oil or gas wells. This technology utilizes electrical sparks in water to fracture rock, taking advantage of recent advances in pulse power technology. This program is to construct a proof of principle focused shock drill and demonstrate rock cutting characteristics at very high energy and power levels. This machine is expected to have greater than a ten fold energy increase and 10 to 100 fold pulse power increase over previous spark drilling schemes. The characteristics of focused shock drilling will be determined as a function of energy deposition and peak power; also studied will be the impulse transmitted to the rock, rock fracture rate, and the steerability of the drill.

*Includes no cost extension.

40. *MOMENTUM-RICH BEAM STUDY

TRW
MS-01/1020
1 Space Park
Redondo Beach, California 90278

Alfred Maschke

Date Started: September 25, 1985

$263,000

Anticipated Duration: 1-1/2 years

The objective of this study is to establish the feasibility of producing neutral heavy ion beams with energies of a few hundred keV, and sufficient brightness that they might be used to implode a small volume of deuterium-tritium fuel. Computer simulations with the LASNEX code indicate that a beam temperature of .1 eV or less, with an average current density of 10 mA/centimeter squared should be adequate to achieve thermonuclear ignition. Cesium beams of the requisite brightness have been produced with both hot tungsten button sources and liquid metal field emission sources. The key experiments now underway are to demonstrate that this brightness can be preserved in the resonant charge exchange neutralization process.

*Project completed.

41. *A CHEMICAL METHOD OF ACHIEVING THE ACCELERATION OF MACROPARTICLES TO ULTRAHIGH VELOCITIES

UNIVERSITY OF WASHINGTON
Seattle, Washington 98195

A. Hertzberg
Aerospace and Energetics Research Program

Date Started: June 1, 1985

$192,000

Anticipated Duration: 20 months

The collision of macroparticles at velocities in excess of 100 km/sec has been suggested as an effective method of creating a controlled thermonuclear burn. An exploratory program of theoretical studies is being carried out on a new approach which is capable in principle of accelerating large macroparticles (up to 100 grams) to velocities of 100 km/sec. The method employs a novel gasdynamic approach whereby relatively large masses (several kilograms) may be accelerated using chemical energy to velocities in the 50 km/sec range and possibly higher. The overall ballistic efficiency of this approach (ballistic efficiency is defined as the conversion of chemical energy into kinetic energy) appears to be about 25%. With the achievement of these velocities of a relatively large mass it is possible in principle to use linear velocity multiplication techniques with sophisticated buffers to carry heavy macroparticles into the 100 km/sec range and beyond. The availability of heavy macroparticles in this velocity range suggest the creation of a pulsed light source with blackbody radiation intensity of 10^{15}W/cm^2 to perhaps as high as 10^{17}W/cm^2 with output energies of several megajoules. A program of theoretical studies is being carried out to examine the potential of this concept and its applications. If these studies prove to be encouraging, design of critical experiments will be initiated.

*Project completed.

42. AERODYNAMIC FOCUSING OF PARTICLES AND HEAVY MOLECULES

YALE UNIVERSITY
P. O. Box 2159
Yale Station
New Haven, Connecticut 06520-2159

Juan Fernandez de la Mora
Department of Mechanical Engineering

Date Started: July 1, 1987

$70,000

Anticipated Duration: 2 years

Theoretical predictions indicate that, by accelerating a gas-particle mixture through a converging nozzle, it is possible to concentrate dense beams of small uncharged particles into a narrow focus under previously unexplored conditions. Because high resolution aerodynamic focusing could be exploited in a variety of applications, including "direct writing," basic studies are proposed in order to assess its limits and potential technological impact. Experiments with micron-size aerosol particles (for which Brownian motion effects are negligible) will first examine the ratio between the diameters of the nozzle exit and the focal region size, for which theory predicts values well in excess of 100. These studies will be subsequently extended down to the molecular level, by substituting the suspended particles with neutral vapors of a heavy species (Au, WF_6, etc.) diluted in gaseous H_2 or He. The non-negligible Brownian motion of the heavy component leads then to a finite diffusive broadening of the focal region and sets a limit to the writing resolution attainable. Two theoretical approaches are proposed to study this defocusing phenomenon, one based on Brownian-dynamics simulations and the other exploiting the smallness of the random velocity as compared with the mean velocity of the heavy molecules. The phenomenon will also be studied experimentally, first visually by laser-induced fluorescence (LIF) of I_2 molecules seeded in high-speed jets of H_2 and He and also by sampling from He-Hg jets through a small orifice in a plate and analyzing for the concentration of Hg.

SAMPLE

Statement of Work

1) Project Objective

The proposer shall investigate the electrocatalytic oxidative dehydrogenation of ethylbenzene and butane in solid electrolyte fuel cells. The effort is directed toward defining optimal operating conditions for achieving high yields of styrene and butadiene with simultaneous electric energy generation.

2) The work to be performed consists of the following tasks:

2.1. Construction of tubular stabilized zirconia fuel cells with a platinum cathode and an iron oxide or platinum anode. Both anode materials are quite promising and a decision between the two will be made after preliminary runs.

2.2. Measurement of the styrene cell activity and yield as a function of temperature, inlet ethylbenzene concentration and external resistive load.

2.3. Measurement of the cell electric power output and overpotential as a function of the operating parameters described in 2.2.

2.4. Determination of the nature of the overpotential according to the results of 2.3. If ohmic overpotential dominates, a small well mixed cell with thin (150 microns) electrolyte discs will be constructed to increase power density.

2.5. Development of correlation for styrene yield and electrical power output in terms of operating and design parameters for use in future scale up.

2.6. Repeat tasks 2.2. through 2.5. using butane and/or butene as the fuel.

2.7. Preliminary engineering and economic analysis according to the results of 2.2. through 2.6.

3) Deliverables

The proposer shall provide the data of experiments performed according to paragraphs 2.2., 2.3., 2.4., 2.5. and 2.6. along with analyses and conclusions based on this data.

4) Performance Schedule

4.1. Complete construction of cells 3 months after start of work.

4.2. Complete ethylbenzene experiments within 12 months after start of work.

4.3. Complete butane and butene experiments and data analysis 20 months after start of work.

4.4. Complete data correlation, economic analysis and final report 24 months after start of work.

OFFICE OF BASIC ENERGY SCIENCES

DIVISION OF ADVANCED ENERGY PROJECTS

Fiscal Year 1987 Program Data

FY '87 Budget

Operating Funds....................$7,500,000

Capital Equipment Funds..............$330,000

Distribution of Projects by Institutional Sector

Universities	42%
Small Business	16%
Other Industry	7%
DOE Laboratories	33%
Federal Laboratories	2%

In addition, AEP managed the Heavy Ion Fusion Accelerator Research (HIFAR) program, with a budget of $5,260,000 in operating funds and $645,000 in capital equipment funds. The majority of the HIFAR effort is underway at the Lawrence Berkeley Laboratory. Supporting research is performed by the Los Alamos National Laboratory, the Lawrence Livermore National Laboratory, the Naval Research Laboratory, the Stanford Linear Accelerator Center, and the Argonne National Laboratory.

INVESTIGATOR INDEX
(Project Numbers)

INSTITUTIONAL INDEX
(Project Numbers)