DOE/ER-0150/3

Advanced Energy Projects
FY 1985 Research Summaries

September 1985

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

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U.S. Department of Energy
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Office of Basic Energy Sciences
Office of Energy Research
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 x-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

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.

Funding levels

Annual funding level for projects varied from about $50,000 to a typical maximum in the $350,000 to $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 30.

- 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.

Further Information

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, D.C. 20545

Phone: 301/353-5995

OFFICE OF BASIC ENERGY SCIENCES

DIVISION OF ADVANCED ENERGY PROJECTS

Summaries of Projects Active in FY 1985

This section contains brief summaries of all projects active in this Division during Fiscal Year 1985 (October 1, 1984-September 30, 1985). 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 '85 are indicated by the footnote: *Project completed. The annual funding level of each project is shown.

1. EXTREME ULTRAVIOLET AND SOFT X-RAY INSTRUMENTATION FOR MICROCHARACTERIZATION OF MATERIALS

ALTEX CORPORATION
P.O. Box 10084
Chicago, Illinois 60610-0084

Charles K. Rhodes

Date Started: August 15, 1984

$250,000

Anticipated Duration: 2 years

High quality, short pulse, excimer laser systems are prime candidates for the generation of spectrally-bright coherent radiation in the extreme ultraviolet and soft x-ray spectral regions. Such excimer systems consist of (1) a unit generating a short, high-quality pulse at visible wavelengths, (2) a frequency shifter, and (3) a chain of ultraviolet amplifiers. The objective is to develop a prototype laser system which delivers a tunable, high quality pulse of $\sim$10 psec duration in the range of $\sim$740 - 780 nm. In conjunction with suitable wavelength shifters, this instrument will cover the ultraviolet spectral range down to and probably below 240 nm. Its integration as the front end of an ultrahigh spectral brightness KrF laser system will result in a compact, low-cost laboratory instrument, delivering powers of $>$10 GW at 5 eV photon energy. This new technology would overcome the fundamental limitations of the low-brightness incoherent sources presently available and permit application to a broad spectrum of technical areas relevant both to pure scientific and industrial spheres.

2. THE CONTINUOUS MEMBRANE COLUMN; A LOW-ENERGY ALTERNATIVE TO DISTILLATION

BEND RESEARCH, INC.
64550 Research Road
Bend, Oregon 97701-8599

Walter C. Babcock
Membrane Separations Division

Date Started: February 5, 1982

$121,000

Anticipated Duration: 3 1/2 years

The objective of this program is to evaluate membrane separation as an energy-efficient alternative to distillation. The study is focused on the separation of isopropanol from water, a process currently performed by distillation and azeotropic distillation. Work is under way in the areas of membrane development and assessment of membrane performance in a "continuous column" module configuration. Results thus far have been positive; for example, energy-consumption calculations based on membrane performance in laboratory tests indicate a 44% savings in energy is possible when a hybrid membrane/distillation approach is used in place of distillation alone to produce a 90 vol % isopropanol-in-water azeotrope.

3. *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

$173,000

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. Our experiments to test these new ideas have actually exceeded the predictions: we have achieved as many as 160 fusions (average) per muon. Still higher fusion yields are anticipated. If we can achieve many hundreds of fusions per muon or reduce the cost of generating muons, power production by means of muon-catalyzed "cold" fusion may become economical.

*This project is a continuation of project number 15.

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

BROOKHAVEN NATIONAL LABORATORY
Upton, New York 11973

C. Pellegrini, A. van Steenbergen
National Synchrotron Light Source

Date Started: September 26, 1983

$240,000

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. Recent design studies focused on using the third harmonic TOK "pumping" scheme rather than the first harmonic pumping mode in order to avoid unacceptable (for electron storage ring operation) undulator minimum gap parameter values. The third harmonic TOK pumping scheme was adopted and the final fixed gap undulator parameters arrived at. The design of the TOK undulator has now been completed and a construction contract has been placed. Construction of the "vacuum envelope" of the TOK structure is being carried out and design work on the external photon line is in progress. The laser has been acquired and is presently being modified to better match the experiment parameters.

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

5. MOMENTUM-RICH BEAM STUDY

BROOKHAVEN NATIONAL LABORATORY
Upton, New York 11973

Alfred Maschke

Date Started: April 29, 1983

$250,000

Anticipated Duration: 2 years

The objective of this study is to establish the feasibility of producing 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 around .1 eV, and an average current density of 10 mA/centimeter squared should be adequate to achieve thermonuclear ignition. In the first phase of the program, it was determined that the extracted ion beam temperature corresponds to the source temperature of about .1 eV.

*This project is being continued at TRW, project number 43.

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

UNIVERSITY OF CALIFORNIA
Los Angeles, California 90024

Ken Nobe
Department of Chemical Engineering

Date Started: July 1, 1984

$71,000

Anticipated Duration: 3 years

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. Preliminary batch reactor experiments of three new electroorganic syntheses have been performed: a) the electrohydrosulfurization of the coal liquid compound, benzothiophene, b) the electrohydrogenation of benzene and c) the paired electrochemical syntheses of hexamethylenediamine and dimethyladipate.

7. BIOEXTRACTION OF IRON FROM IRON OXIDES; REDUCTION OF COKE DEMAND IN STEEL PRODUCTION BY MICROBIAL BENEFICIATION

CALIFORNIA INSTITUTE OF TECHNOLOGY
Pasadena, California 91125

Michael R. Hoffmann
Engineering and Applied Science

Date Started: August 15, 1983

$79,000

Anticipated Duration: 3 years

The objective of this project is to determine the potential uses of iron-metabolizing microorganisms for a variety of industrial and commercial applications. A research program is being carried out to study the kinetics and mechanisms of the bacterial dissimilative iron reduction. Pseudomonas sp. 200 was selected for detailed study based upon screening experiments in which the organism reduced Fe(III) 10 times more rapidly than other microorganisms tested and 2-3 times faster than the highest Fe(III) reduction rates reported in the scientific literature. Pseudomonas sp 200 is capable of electron transport to ferric iron at rates characteristic of transport during aerobic respiration. At such rates, the use of bacteria for reductive dissolution of iron oxides (e.g. rust removal) or extraction of iron from ores may be commercially feasible. Experimental iron-reduction rates are clearly dependent upon the chemical speciation (i.e., the particular chemical forms) of Fe(III). Furthermore, rates of microbial dissolution of iron oxides are inversely dependent upon mineral stability (reduction rate of amorphous $Fe(OH)_3(s)$ > goethite > hematite). Future work will include an investigation of fundamental genetic characteristics of Pseudomonas sp. 200.

8. 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

$140,000

Anticipated Duration: 2 years

Two linear fused ring polyaromatic polymers (ladder polymers) which have attached 1,4 hydroxyl and carbonal groups are being synthesized. The first polymer has alternating benzene and oxygenated rings. The second polymer, not as far advanced in synthesis, has three oxygenated rings for each benzene ring. The first polymer has now been obtained in a soluble crystallizable form of reasonable chain length. It is a semiconductor as presently prepared. Its use as a secondary anode is being studied; cyclic voltammetry measurements on cast films have been started. Fibers will be made in the near future. The polymer crystal structure will also be studied. The second polymer has been made in low molecular weight. Various synthetic approaches to raise its molecular weight are under study.

9. CATALYSIS OF DIRECT METHANOL ELECTRO-OXIDATION IN BUFFERED ELECTROLYTES

EIC LABORATORIES, INC.
111 Downey Street
Norwood, Massachusetts 02062

S. B. Brummer
Battery Division

Date Started: July 15, 1983

$151,000

Anticipated Duration: 3 years

The objective of this program is the exploration of concentrated, aqueous $K_2CO_3/KHCO_3$ solutions as electrolytes for direct methanol-air fuel cells. A major goal of the program is the identification and development of electrocatalyst systems that are stable in the electrolyte and efficiently catalyze the electro-oxidation of methanol at low potentials. Numerous non-noble metal, noble metal and binary systems were evaluated as potential electrocatalysts in the $K_2CO_3/KHCO_3$ electrolyte. A number of systems, particularly binary systems containing platinum, were identified as potential electrocatalysts. Further evaluation of these systems in half cell tests are planned.

10. ULTRASONIC ATOMIZATION FOR COMBUSTION EFFICIENCY IN OIL BURNERS

ENERGY & MINERALS RESEARCH COMPANY
964 E. Swedesford Road
Exton, Pennsylvania 19341

Jeffrey Solash

Date Started: June 1, 1984

$115,000

Anticipated Duration: 2 years

This project involves the use of ultrasonics to produce an atomized fuel oil. Prior work indicated that the droplet size of the atomized fluid might be controlled by adjusting the area of liquid presented to the ultrasonic field. A number of variables thought to affect the atomization and particle size distribution were examined. A rotating screen device was constructed to feed liquid to the ultrasonic field. It was found that the feed rate could be changed without affecting atomization. Screen pore size and ultrasonic frequency appear to affect the particle size distribution. Detailed particle size data are being taken. A prototype continuous ultrasonic atomizer has been constructed and will be further tested.

11. 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

$119,000

Anticipated Duration: 2 years

Interest in muon-catalyzed fusion is experiencing a dramatic revival lately. Recent experiments by Jones et al have shown that under proper conditions a single muon can catalyze about one hundred sixty 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.

12. 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

$148,000

Anticipated Duration: 3 years

A search has been initiated for novel metal-binding proteins in two unusual groups of microorganisms (Thiobacillus and Sulfolobus). Initially, an analysis has been made of the acidophilic organisms, Thiobacillus ferrooxidans and Acidophilium organovorum, for the presence of novel metal-binding proteins. Secondly, model studies are conducted to determine the feasibility of using novel chromatographic techniques for the detection of metalloproteins. Two approaches have ben used to screen T. ferrooxidans and A. organovorum. The uptake of copper ion has been studied by growing cultures of these strains to determine if they exhibit an uptake pattern characteristic of a protein-mediated binding. Atomic absorption spectroscopy is used to determine cellular metal ion content as a function of cell growth. T. ferrooxidans cultures are pulse-labeled with ^{35}S-cysteine, then cell extracts prepared and analyzed by polyacrylamide gel electrophoresis (PAGE) and autoradiography.

13. FLUID DYNAMIC ENERGY SEPARATION

GEORGE WASHINGTON UNIVERSITY
Washington, D.C. 20052

C.A. Garris
School of Engineering and Applied Sciences

Date Started: September 15, 1983

$147,000

Anticipated Duration: 3 years

The object of this study, the "energy separator", is a new kind of cooling and heating device that promises advantages of energy economy in a number of applications. This device has only one moving part, a free-spinning rotor, and its operating mechanism is very simple: it splits an initially uniform flow into two subflows and causes one of these to do work on the other. The energy separator derives its potential merit primarily from the fact that it permits the energy extracted from the cooled subflow to appear in the other subflow not as heat but rather in the form of recoverable mechanical energy. Experimental work has been in progress on four radically different models. An analysis has been developed for the selection of the configuration and operating conditions that will maximize the separation of energy under any given set of constraints, and its results are presently being used for design and evaluation. Critical comparisons are being made between energy separators and conventional devices and promising applications identified.

14. 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

$146,000

Anticipated Duration: 1 year

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.

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

IDAHO NATIONAL ENGINEERING LABORATORY
EG&G Idaho, Inc., P.O. Box 1625
Idaho Falls, Idaho 83415

Steven E. Jones
Scientific Information AGM

Date Started: March 8, 1982

$390,000

Anticipated Duration: 3 1/2 years

It is rather remarkable that the muon (symbol μ, an elementary particle like the electron) can induce the fusion reaction: $\mu + d + t \rightarrow \mu + He + n + 17.6$ MeV. Thus, the muon serves as a catalyst for the fusion process, permitting it to proceed rapidly without the need for high (plasma) temperatures. Is muon-catalyzed fusion just a scientific curiosity or could power production be achieved? Results so far show that the reaction proceeds more rapidly than theoretically predicted. Moreover, the loss of muons due to capture by the synthesized helium ion is significantly less than expected. Consequently, fusion energy yields are larger than anticipated. Still, the output energy is less than the energy needed to initially produce a muon. Research continues in an effort to improve the energy balance.

*This project is being continued at Brigham Young University, project number 3.

16. GENERATION OF STIMULATED EMISSION IN THE SOFT X-RAY RANGE BY NONLINEAR PROCESSES WITH EXCIMER LASERS

UNIVERSITY OF ILLINOIS AT CHICAGO
Chicago, Illinois 60680

Charles K. Rhodes
Department of Physics

Date Started: September 15, 1983

$200,000

Anticipated Duration: 2 years

Studies of multiphoton ionization of atoms have revealed several unexpected characteristics. The confluence of the experimental evidence leads to the hypothesis that the basic character of the atomic response involves highly organized coherent motions of entire atomic shells. The important regime, for which the radiative field strength E is greater than an atomic unit (e/a_o^2), can be viewed in approximate correspondence with the physics of fast ($\sim$10 MeV/amu) atom-atom scattering. This physical picture provides a basis for the expectation that stimulated emission in the x-ray range can be produced by direct highly nonlinear coupling of ultraviolet radiation to atoms.

17. PRODUCTION OF ULTRAHIGH MAGNETIC FIELDS

JAYCOR
11011 Torreyana Road
San Diego, California 92138

Franklin S. Felber

Date Started: September 15, 1984

$290.000

Anticipated Duration: 2 years

A general method has been proposed for producing controlled ultrahigh magnetic fields up to the order of 100 MG. The general method involves imploding a plasma in which a magnetic field has been entrained. The imploding plasma compresses the magnetic field to high strengths. The optimal method for producing the imploding plasma appears to be a gas-puff Z pinch. The objective of this experimental program is to produce and measure controlled ultrahigh magnetic fields by this method. In the first year, the gas-puff Z pinch facility at the University of California at Irvine is being used for high-field tests at several megagauss. In the second year, a high-current gas-puff Z pinch facility will be used to demonstrate production of ultrahigh magnetic fields in the 15 to 20 MG range, which exceeds the highest controlled fields produced in this country. Potential applications of ultrahigh magnetic fields include reducing fusion ignition thresholds, producing collimated beams of gamma radiation, accelerating particles, and producing high-energy densities (hundreds of $eV/\mathring{A}^3$) under controlled conditions for studies of plasma physics, atomic physics, and material properties.

18. 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

$94,000

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 presented 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.

19. FREE ELECTRON LASER AT THE ETA*

LAWRENCE BERKELEY LABORATORY
University of California
Berkeley, California 94720

A.M. Sessler and D. Prosnitz

Date Started; February 8, 1982

$330,000

Anticipated Duration: 44 months

The purpose of this experiment is to develop a tapered-wiggler Free Electron Laser (FEL) as an efficient microwave source between 35 and 40 GHz. A potential application of this source is as a high peak power source for high energy particle acceleration. The Lawrence Livermore National Laboratory's Experimental Test Accelerator provides the high-current, high voltage (1 kA, 4 MeV) low emittance electron beam used to drive the FEL amplifier. The electron beam wiggler which is electromagnetic, has no iron, and is pulsed; there is microwave input and microwave output diagnostics. Initial operation was developed at 8 mm wavelength, with the capability of studying 2 mm and 4 mm in the future. Beams of up to 450 A have been transported through the wiggler and super-radiant oscillations from noise have been observed as a function of length. This radiation (about 1 kW), which is coherent, has a gain of 13 dB/m and shows no sign of saturation in the 3 m wiggler. In an amplifier mode, with 23 kW fed in from a magnetron, the untapered wiggler, when tuned to resonance, gives 180 MW. Further study of the physics of a tapered FEL is planned.

*Experimental Test Accelerator at Lawrence Livermore National Laboratory

20. 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

$300,000

Anticipated Duration: 3 years

This project has the objective of demonstrating acceleration of plasma rings confined by the dipole and entrapped B_θ magnetic fields of a compact torus. The 6 m long accelerator under construction 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.

21.*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

$250,000

Anticipated Duration: 4 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.

*Projects 21 and 29 are cooperative interlaboratory projects.

22. PUMPING OF GAMMA-RAY LASERS; EXPERIMENTAL AND THEORETICAL

LOS ALAMOS NATIONAL LABORATORY
Los Alamos, New Mexico 87545

G.C. Baldwin
Physics Division

Date Started: September 27, 1983

$300,000

Anticipated Duration: 3 years

For a laser to operate with recoilless nuclear transitions--which require that the active material be in a cool solid host--the pumping must be done in two steps, first creating and isolating a long-lived nuclear isomer and then transferring its excitation to a nearby state that can emit a relatively narrow Mossbauer line. Our experiments (in collaboration with MIT) have demonstrated that a selective ionization technique can separate isomers; we are now preparing to demonstrate a second method, using light-induced drift in a buffer gas of atoms selectively excited by a laser. Because the transfer step may involve a highly converted transition, apparatus with which to demonstrate an effect of atomic excitation on the conversion rate of the 75-eV isomer U-235m has been built and is ready to begin taking data. To enable prediction of the kinetics of a graser system, and therefore better understanding of the required nuclear and solid-state parameters, a theoretical study of the evolution of a superradiant state after the transfer step is in progress. This research is closely coordinated with (internally funded) work in the Theoretical Division to identify nuclides with appropriate properties and to investigate two proposed mechanisms for interlevel transfer.

23. MAGNETIC REFRIGERATION FOR EFFICIENT CRYOGEN LIQUEFACTION

LOS ALAMOS NATIONAL LABORATORY
P.O. Box 1663, MS K764
Los Alamos, New Mexico 87545

John A. Barclay
Physics Division, Group P-10

Date Started: February 1, 1982

$270,000

Anticipated Duration: 3 1/2 years

The objective of this work is to consider conceptual designs, test models of those designs, and develop a data base for compact, reliable, high-efficiency magnetic refrigeration, with special emphasis on application of this technology to liquefaction of cryogens. Data base generation consists of literature evaluation and experimental work. Design data on magnetic materials, fluid dynamics, heat transfer, pump, drive motors, dewars and magnets are being compiled. Experimental results on the physical, thermomagnetic, transport, and mechanical properties of several intermetallic rare earth compounds have shown that several materials are suitable magnetic refrigerants between 4 K and 300 K. Specific samples that have been worked on during FY 85 include $ErAl_2$, $Er_xGd_{1-x}Al_2$ and $HoAl_2$. Amorphous magnetic materials are also being considered as refrigerants because they may have larger adiabatic temperature changes than some of the intermetallic compounds mentioned above. Heat transfer in magnetic refrigerators has been carefully studied including optimization of several geometries. Experiments to demonstrate the best geometries are underway. Several helium-gas pumps have been tested and several efficient drive mechanisms have been located. Further successful tests have been done on a 4-to-20 K magnetic refrigerator prototype. Several key problems in this temperature range have been identified and have led to new designs. Design work on a 20-to-77 K device for hydrogen liquefaction is also underway.

24. THEORETICAL STUDY OF MUON-CATALYZED FUSION

James S. Cohen
Theoretical Division,

$202,000

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

Date Started: December 29, 1983

Anticipated Duration: 3 years

This theoretical 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 (μ^-, 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. In recent experiments at the Los Alamos Meson Physics Facility up to 160 fusions per muon (on average) have been detected. Some unexpected and potentially important dependencies of the mesomolecular-formation and muon-loss rates on temperature and target density have also been observed. Our theoretical efforts have succeeded in explaining a transient behavior in muon cycling and in revealing a faster mechanism for resonant dt formation. A new theoretical method is being developed for extremely accurate calculations of molecular structure, which are required for describing the energetics of mesomolecular formation. A side-chain mechanism has been proposed to explain the observed target dependence of muon loss ("sticking"). In collaboration with the experimental team, tests of recent theoretical predictions are being planned.

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

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

$750,000

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

Date Started: March 1, 1985

Anticipated Duration: 1 year

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.

26. 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

$800,000

Anticipated Duration: 2 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, we intend to investigate the physics of muon-catalyzed fusion, continuing the experimental program at LAMPF of the Idaho National Engineering Laboratory (INEL)-Los Alamos 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.

27. 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

$250,000

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. Complementary to this theory and design effort, research on two other critical issues will be conducted under other sponsorship. These are the development of high-reflectance, resonator mirrors for the 30- to 110-nm spectrum and a high-brightness electron injector for the rf linear accelerator.

28. LIQUID METAL THERMO-ACOUSTIC ENGINE

LOS ALAMOS NATIONAL LABORATORY
Los Alamos, New Mexico 87545

J. C. Wheatley
Physics Division

Date Started: September 27, 1983

$290,000

Anticipated Duration: 3 years

Liquid sodium is uniquely suited for use in a newly developed thermoacoustic heat engine cycle because it has an extremely low Prandtl number as well as substantial thermal expansion coefficient, compressibility, and density. An accurate thermoacoustic theory for the engine has been developed and applied to optimize a design using sodium as the working fluid for operation between 1000K and 400K. Heat exchangers, an a.c. magnetohydrodynamic generator, and a variable reluctance generator have also been designed and built; both generators will convert the engine's acoustic energy output to electrical energy. Measurements obtained on a preliminary version of the variable reluctance generator show 80% conversion efficiency, and a likelihood of increasing this substantially. Most of the remaining hardware is nearing completion and will be tested soon.

29.*DETECTION AND ENRICHMENT OF FRACTIONALLY CHARGED PARTICLES IN MATTER

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

George Zweig
Theoretical Division

Date Started: May 1, 1982

$270,000

Anticipated Duration: 3 1/2 years

The basic unit of electric charge is one third that of the electron. It is therefore natural to ask if isolated particles of fractional charges $\pm$ 1/3e, $\pm$ 2/3e, $\pm$ 4/3e. . . . exist freely as elements of the earth. William Fairbanks' group at Stanford University has concluded that they do. Negative fractionally charged particles are interesting because they could replace electrons in atoms, molecules and solids, leading to super-dense states of matter. Under certain circumstances they would even catalyze fusion reactions. This project is a combined theoretical and experimental effort to search for fractionally charged particles in a wide variety of materials, to determine which materials are most abundant in fractionally charged particles, and to enrich the fractional charge content of sample materials. The crystal chemistry of fractionally charged particles is being theoretically developed and those materials most likely to contain enhanced concentrations of fractionally charged atoms are being identified. These materials will then be obtained, analyzed and used as samples for the experimental studies.

*Projects 21 and 29 are cooperative interlaboratory projects.

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

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

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

Date Started: July 1, 1984

$168,000

Anticipated Duration: 2 years

The production of millimeter and submillimeter radiation from rotating electron beams interacting with an azimuthally periodic wiggler magnetic field is being studied experimentally and theoretically. Initial studies using a 2 MeV, 1 kA, 6 cm radius rotating beam interacting with wiggler fields with six and twelve spatial periods around the azimuth have produced in excess of 200 kW of power at frequencies of 90 and 180 GHz, respectively. The radiation frequency spectra have been measured in this range using a grating spectrometer, and the effects on radiation production of variations in electron energy, current, pulse length, and wiggler periodicity and magnitude are currently being investigated. Two long pulse, low voltage experiments are currently under construction.

31. 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

$397,000

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. Preliminary microwave experiments on coal in air have produced pyrite conversion to troilite/disordered pyrrhotite, Fe_3O_4 and Fe. The increase in saturation magnetization was from 2 to 3 orders of magnitude over that of the control, untreated coal. The irradiation time was 10 seconds. 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 Mössbauer, electron microprobe, and magnetization measurements is being carried on along with baseline magnetic separations on 3 Eastern coals.

32. PERVAPORATION; A LOW-ENERGY ALTERNATIVE TO DISTILLATION

MEMBRANE TECHNOLOGY AND RESEARCH, INC.
1030 Hamilton Court
Menlo Park, California 94025

Richard W. Baker

Date Started: April 15, 1983

$141,000

Anticipated Duration: 32 months

The object of this project is to develop selective pervaporation membranes. Pervaporation is a membrane separation process that could offer substantial energy savings compared to distillation. The principal problem inhibiting the development of pervaporation is the lack of suitably selective membranes. Thin film composite membranes have been made and evaluated in laboratory membrane cells and as small modules. Currently, we are using 0.7 micron thick silicone rubber composite membranes; other membranes have been made and are under test with model organic solvent mixtures. Based on the experience obtained with these model mixtures, we are determining the applicability of pervaporation to more economically significant organic mixtures. In particular, we are concentrating on the recovery of organic solvents from industrial effluent streams. These solvents represent both a pollution problem and a reuse opportunity. This data will be used to perform a technical and economic analysis of the process.

33. HIGH-FLUX, EXTENDED-PULSE ION ACCELERATOR

UNIVERSITY OF NEW MEXICO
Albuquerque, New Mexico 87131

S. Humphries, Jr.
Institute for Accelerator and
Plasma Beam Technology

Date Started: September 27, 1983

$89,000

Anticipated Duration: 3 years

The objective of the program is to develop new technology for high flux plasma sources to generate ions and extractors to accelerate them to high energy. Success of the technology could motivate new industrial processes for ion implantation and materials modification. Metal vapor vacuum arcs as high flux plasma sources have been investigated. Ion species from deuterium (deuterated titanium electrodes) to indium have been produced and analyzed with a time-of-flight spectrometer. Useful flux exceeds 0.1 A/cm^2. Arrays of arcs have been triggered in parallel to generate 25 A pulses of Al+ ions. A new arc geometry that will extend operation to multi-ms pulses with high reproducibility and long lifetime is being developed. A magnetically insulated plasma source to generate ions from gases has produced ms pulses of argon ions at 0.5 A/cm^2. This source is presently being upgraded for higher flux. A new method of ion extraction based on electrostatic control grids that decouples ion optics from the properties of the plasma source has been developed. This method can lead to significant enhancement of beam brightness for applications such as ion beam lithography.

34. 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

$195,000

Anticipated Duration: 2 years

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. To date research has been concentrated on the construction and testing of focusing devices.

35. VALIDATING THE PARAMAGNETIC LOGGING EFFECT

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

W. Banning Vail

Date Started: September 28, 1984

$200,000

Anticipated Duration: 15 months

The Paramagnetic Logging Effect (PLE) is a recently predicted and experimentally confirmed magnetic phenomenon which will serve as the basis of a new borehole device capable of the direct measurement of the volume of petroleum reserves around a cased drill-hole to a radius of 50 feet or more into formation. The PLE allows measurement of the natural nuclear paramagnetism of oil and water in formation using the earth's magnetic field naturally present and an artificially applied A.C. magnetic field. The amplitude of the PLE yields the total oil and water saturation within a well defined zone around the borehole and the phase of the signal is used to separate oil and water and to determine the viscosity of the oil present by measuring T_1 times (longitudinal relaxation rates). Recent laboratory measurements on liquids resembling varieties of crude oil have been performed using a 4800 gallon plastic tank. These measurements have verified the physical behavior of the PLE predicted by theory and have shown that the T_1 time of a single component liquid can be directly measured with the PLE. Four major milestones remain to be reached during the project: integration of new, more sensitive induction coils into the experimental system; substantial digitization of the electronic measurement process; separation of T_1 times of multicomponent mixtures; and direct measurement of the PLE through borehole casing.

36. THIN-FILM COMPOSITE MEMBRANES FOR ARTIFICIAL PHOTOSYNTHESIS

PORTLAND STATE UNIVERSITY
Portland, Oregon 97207

Carl C. Wamser
Portland State University

Date Started: July 15, 1985

$245,000

Anticipated Duration: 3 years

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.

37. 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

$600,000

Anticipated Duration: 2 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 of the proper stage 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.

38.*DEPOSITION OF HIGH QUALITY $CuInSE_2$ BY SPRAY PYROLYSIS

RADIATION MONITORING DEVICES, INC.
44 Hunt Street
Watertown, Massachusetts 02172

Gerald Entine

Date Started: September 15, 1982

$116,000

Anticipated Duration: 3 years**

The ultimate success of any terrestrial photovoltaic energy conversion approach requires that the following factors be satisfied: 1) high individual solar cell conversion efficiency, 2) low cost per unit area to produce the cells, 3) adequate availability of the constituent materials to produce the cells, 4) long term stability. $CuInSe_2$ is a material which promises to meet these requirements, but to date can only be made using expensive laboratory techniques. This project is being carried out to examine the properties of $CuInSe_2$ prepared by spray pyrolysis. $CuInSe_2$ is a promising solar cell material and spray pyrolysis is a technique well-suited for use in a low cost manufacturing process. High quality, uniform and continuous films have been produced and characterized, and solar cell devices tested.

*Project completed
**Includes no cost extension.

39.*IONIZATION FRONT ACCELERATOR

SANDIA NATIONAL LABORATORIES
Albuquerque, New Mexico 87185

Craig L. Olson
Plasma Theory Division - 1241

Date Started: June 1, 1981

$190,000

Anticipated Duration: 4 years

It is the goal of collective accelerators to produce high gradient particle acceleration using the collective fields of an ensemble of charged particles. That goal has now been achieved with the Ionization Front Accelerator (IFA). The IFA uses laser photoionization of a special working gas to control the motion of the potential well at the front of an intense relativistic electron beam (IREB). A second generation system (IRA-2) has been operated that includes an IREB machine (1.0 MV, 30 kA, 35 nsec) with laser-triggered switches, a beam conditioning cell to steepen the current rise time, a heated experimental cell with Cs as the working gas, a dye laser (852.1 nm) to pre-excite the Cs, an XeCl laser (308 nm) to photoionize the excited Cs, an electro-optic deflector to provide a continuous sweep of the XeCl laser beam, and beam front and ion diagnostics. The deflector system produces a quadratic temporal sweep of the XeCl laser beam over 30 cm in 20 ns. Initial experiments demonstrated that only 0.001 J/cm^2 of dye laser and 0.0005 J/cm^2 of swept XeCl laser are needed to control 1,000 J of IREB energy. Full IFA-2 experiments have produced 5 MeV H^+, 10 MeV D^+, and 20 MeV He^{++}, demonstrating ion trapping and acceleration in the IREB potential well controlled by the swept laser. These results demonstrate that accelerating fields of 33 MV/m over 30 cm have been achieved with a controlled collective accelerator for the first time. Ultimately, IFA systems may control fields of 100 MV/m to 1 GV/m or higher.

*Project completed

40.*SYNTHESIS AND PHOTOELECTROCHEMICAL CHARACTERIZATION OF SEMICONDUCTING GROUP VIII TRANSITION METAL CHALCOGENIDES AND PNICTIDES

SOLAR ENERGY RESEARCH INSTITUTE
1617 Cole Boulevard
Golden, Colorado 80401

Bruce Parkinson
Photoconversion Research Branch

Date Started: September 26, 1983

$172,000

Anticipated Duration: 2 years

Semiconducting electrodes, which are illuminated in the proper solution, are capable of converting solar energy directly into useful chemicals and fuels. Conventional semiconductor materials do not contain the elements (Fe, Co, Ni, Ru, Rh, Pd, Os, Ir, Pt) which are known to be most active for the catalytic conversion of simple molecules (CO_2, H_2O, CO, N_2) to useful fuels and chemicals (HCO_2H, H_2, O_2, CH_3OH, NH_3, N_2H_2, CH_2O). Crystals of new semiconductors (i.e., PdPs, PdPSe, PdP_2, $Pd_3(PS_4)_2$, PtS_2), containing group VIII metals combined with a chalcogen (S, Se, Te) and/or pnicogen (P, As), have been synthesized and grown and their electronic properties (bandgap, carrier type and mobilities, doping densities etc.) examined with photoelectrochemical techniques. Materials with suitable electronic properties and stability to photocorrosion reactions have been tested for catalytic activity towards the reactions of interest.

*Project completed

41. GAS-LOADED, FREE ELECTRON LASER

STANFORD UNIVERSITY
Stanford, California 94305

Richard H. Pantell
School of Engineering

Date Started: August 1, 1984

$374,000

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, we will study the propagation of a 40 MeV electron beam from a linear accelerator through hydrogen gas in the pressure range from one to 1000 Torr. 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.

42. FOCUSED SHOCK DRILLING
EXPLORATORY RESEARCH PROGRAM

TETRA CORPORATION
4905 Hawkins NE
Albuquerque, New Mexico 87109

William M. Moeny

Date Started: March 1, 1985

$278,000

Anticipated Duration: 33 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 will 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.

43.*MOMENTUM-RICH BEAM STUDY

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

Alfred Maschke

Date Started: January 15, 1985

$200,000

Anticipated Duration: 18 months

The objective of this study is to establish the feasibility of producing 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 around .1 eV, and an average current density of 10 mA/centimeter squared should be adequate to achieve thermonuclear ignition. In the first phase of the program, it was determined that the extracted ion beam temperature corresponds to the source temperature of about .1 eV. The second phase, which is currently under way, will measure the beam temperature after acceleration, to verify that acceleration can be done without further heating of the ions. The beam heating caused by resonant charge exchange will also be measured.

*This is a continuation of project number 5.

44. COGENERATION OF ELECTRIC ENERGY AND USEFUL CHEMICALS IN A HIGH TEMPERATURE FUEL CELL

TUFTS UNIVERSITY
Medford, Massachusetts 02155

Michael Stoukides
Department of Chemical Engineering

Date Started: April 1, 1984

$77,000

Anticipated Duration: 2 years

Solid electrolyte fuel cells can be used to generate simultaneously electric energy and useful industrial products. The present project examines the synthesis of hydrogen cyanide in zirconia cells with appropriate electrodes. A platinum electrode deposited on the outside wall of an yttria stabilized zirconia solid electrolyte is exposed to the ambient air. A platinum-rhodium electrode deposited on the inside wall is exposed to CH_4-NH_3 mixture and serves as a catalyst as well. At 1 atm total pressure and temperatures about 1000°C oxygen passing through the O-- conducting solid electrolyte will oxidize the CH_4-NH_3 mixture to produce HCN and H_2O. In the same time the current produced will convert into electric power part of the free energy of the reaction. Due to the significant homogeneous gas-phase reactions that occur at these temperatures a specific design for the reactor cell has been prepared. The primary goal is to establish optimal operating conditions for maximum HCN yield.

45. 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

$220,000

Anticipated Duration: 3 years

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.

46.*ANALYSIS OF IMPACT FUSION TARGET DYNAMICS

UNIVERSITY OF WASHINGTON
Seattle, Washington 98195

F.L. Ribe
Aerospace and Energetics Research Program

Date Started: April 15, 1983

$79,000

Anticipated Duration: 3 years

The purpose of this project is to study the conversion of rectilinear projectile motion to a spherical or quasi-spherical implosion. In conjunction with rail-gun experiments at Westinghouse Research Center, we provide dynamical calculations to describe the impact of rail-gun projectiles with a solid target. In FY '84, a one-dimensional (1-D) hydrodynamic numerical calculation was successfully developed, run, and compared to analytical scaling calculations. In FY '85, this 1-D code has been refined to take account of (1) thermal conduction in both the gas and the metal shell and (2) radiation loss in the gas. The scope of the present work is to extend the numerical calculations to the two-dimensional case of two projectiles approaching each other from opposite directions. The object of the calculation is to show how the initial rectilinear motion of the two projectiles can be converted into a quasi-spherical cavity implosion at approximately the rectilinear velocity. The 2-D model has been coded and a few cases have been run successfully. Initial results are encouraging for shaping the cavity.

*Projects 46 and 47 are interlaboratory projects.

47.*INVESTIGATION OF HIGH-VELOCITY ELECTROMAGNETIC LAUNCHER BEHAVIOR FOR USE IN IMPACT FUSION

WESTINGHOUSE R&D CENTER
1310 Beulah Road
Pittsburgh, Pennsylvania 15235

Y. Chia Thio
Electrotechnology Department

Date Started: July 18, 1983

$389,000

Anticipated Duration: 4 years

In conjunction with impact fusion modeling study conducted at the University of Washington, Seattle, the present program is directed towards investigating the problems associated with the electromagnetic acceleration of gram-size projectiles to ultrahigh velocity. The program involves the construction over the four year period of a multi-stage railgun using distributed energy injection which has the potential of accelerating a 1 g projectile to velocity in excess of 20 km/s. Theoretical considerations in the first year of the program clearly indicated that plasma ablation, arc restrike, plasma armature instability, plasma turbulence and non-ideal plasma properties could potentially degrade accelerator performance. Experimental investigations of these problems began in the second year with the commissioning of the SUVAC-1 launcher facility. More than 20 firings were made with the facility. A 1.4 g polycarbonate projectile was successfully accelerated to 5.3 km/s. Close agreement was obtained with theoretical predictions which take proper account of the plasma armature mass.

Projects 46 and 47 are interlaboratory projects.

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) Scope of Work

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 three months after start of work.

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

4.3. Complete butane and butene experiments and data analysis twenty 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 1985 Program Data

FY '85 Budget

Operating Funds.....$10,312,000

Capital Equipment Funds.....$321,000

Distribution of Projects by Institutional Sector

Universities	39%
Small Business	20%
Other Industry	9%
DOE Laboratories	32%

INVESTIGATOR INDEX
(Project Numbers)

INSTITUTIONAL INDEX
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