P-22: Hydrodynamic and X-Ray Physics

Subcritical Experiments: Data Recording

G. Allred [(505) 667-2497], D. Bartram, T. Petersen (P-22)

The JTO-1 trailer at the Nevada Test Site (NTS) provides much of the high-speed data-recording capability for the P-22 activities in the U1a underground complex. Amplitude calibration and absolute timing of approximately 200 data-recording channels have been performed, using simulated signals generated in the downhole "zero" room that are transmitted in some cases over fiber-optic links. While preparation continued on the first subcritical event (Rebound), dry runs were performed on a routine basis to confirm system reliability.

Radiation Science

R. Bartlett [(505) 667-5923], J. Benage, G. Idzorek (P-22)

P-22 is collaborating with other Los Alamos groups and with Sandia National Laboratories (SNL) personnel on several pulsed-power radiation-driven campaigns on PBFA-Z (the Z-pinch radiation driver at SNL). The two most active efforts at this time are the Integrated Compression Experiment and the Dynamic Hohlraum Experiment. In the former experiment, several aspects relevant to weapons physics are addressed simultaneously, with the result that designs and codes can be tested in an integrated manner. In the Dynamic Hohlraum Experiment, the goal is to create high-temperature hohlraums and to drive inertial confinement fusion (ICF) capsules by using the pinch itself to form the hohlraum. By using the pinch or the end-on radiation to drive the experiment, more energy will be available than would be possible through the more conventional approach of radially coupling the radiation from the pinch to a secondary hohlraum.

P-22 is involved in the definition of the experiments and in fielding diagnostics on the shots. We also analyze and interpret the results. In the past we have fielded filtered silicon diode arrays, pinhole cameras, and a transmission-grating spectrometer. We have also been involved in the calibration of these instruments at the National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory (BNL), where Los Alamos owns and maintains three synchrotron beamlines. Calibration of these instruments is very important to the interpretation of the results.

High-Explosive Pulsed Power

D. Bartram [(505) 667-2501], G. Allred, O. Garcia, T. Petersen, J. Stokes, L. Tabaka (P-22)

P-22 is working with DX Division, preparing for a series of upcoming tests at the Lawrence Livermore National Laboratory (LLNL) facility in Area 4 at NTS known as BEEF (Big Experimental Explosive Facility). These tests, Ranchito, Ranchero, and Caballero are part of the High-Explosive Pulsed-Power (HEPP) program.

P-22 is performing the diagnostic recording for all of these experiments. These will include Faraday rotation, Rogowski loops, B-dots, and voltage probes. The first shot, Ranchito III, will be recorded by the LLNL bunker personnel under the guidance of P-22 and DX-3. Subsequent experiments are planned to be recorded in a P-22 trailer that will be moved into a recently completed protective enclosure. Current plans and support funding (from Bechtel Nevada) suggest that there will be two experiments in FY97 and some preliminary work for a third.

The facility is currently completing two years of development and certification. The first official experiment to be performed will be the LANL Ranchito III shot, which is currently scheduled for the first week in March 1997.

Radiation Source/Switch Development

J. Benage [(505) 667-8900], R. Newton (P-22), F. Wysocki, T. Ortiz (P-24)

The radiation-source project has been focused on the development of a plasma flow switch for use on the Atlas pulsed-power facility when it becomes operational in FY 2000. This switch consists of two components: an aluminum wire array and a plastic barrier film. The switch works by carrying an electric current for a few microseconds, during which the switch moves down a coaxial transmission line driven by the magnetic force from the current. It then transfers the current to another area, called the load region, as it passes by. This allows the machine to provide electric current to the load region on a time scale much shorter than the natural time scale of the machine, which is necessary if the Atlas facility is to be used to produce a radiation source for weapons-physics experiments.

The effort in this past year has been focused on the initial conditions produced in the switch plasma and on how to manipulate these conditions. We have done a series of experiments on the P-24 Colt facility and the P-22 Pegasus II facility. These experiments indicate that our past designs have not produced the right conditions in the switch. The plasma does not assemble as a single switch but seems to come together in two pieces, creating a thick plasma sheath and not producing in the coaxial conductor the current rise times that are needed. We believe the reason for this is that the machine parameters are not well matched to the requirements for this initial formation. We are planning another set of experiments on Colt in the near future to investigate this discrepancy between parameters and requirements in more detail and to attempt to design a slightly different switch to compensate for the machine parameters available to us. The overall goal is to understand this initial formation process and to determine what is required to get the best performance. Once we have reached this goal, we are planning more experiments to investigate the interaction of the switch with whatever is in the load region. This effort will move us a long way toward a working switch for Atlas.

Dense-Plasma Equation-of-State Project

J. Benage [(505) 667-8900], J. Workman (P-22), G. Kyrala, S. Evans, P. J. Walsh (P-24)

The purpose of the dense-plasma equation-of-state (EOS) project is to measure the EOS of aluminum under dense-plasma conditions. By "dense plasma" we mean material that is 0.1–1.0 times the solid density of aluminum and has a temperature of tens of electronvolts. These conditions are such that the material is ionized and in the plasma state, but interactions between particles in the plasma are very strong and the linear theories used to describe the properties of the plasma are no longer valid. It is under just such conditions that the thermodynamic properties of materials are least well known and where there are no data available to compare to theory.

We have designed a novel way of producing a dense plasma and will use a standard technique for determining the EOS of this plasma. The standard technique, which has been mainly used on solids, is to produce a shock and then measure the velocity of the shock and the density of the material in front of and behind the shock. Using these measurements and the conservation equations across the shock front, one can determine the density, pressure, and internal energy of the material and thus the EOS of the material under those conditions. We produce our plasma by using a small capacitor bank to electrically heat an aluminum wire to a temperature of ~2 eV. This aluminum plasma is allowed to expand into a vacuum through a rectangular slit, producing a uniform plasma that is used as a target for a powerful laser. The laser is focused onto this plasma, producing a shock that propagates through it. We then use an x-ray backlighter to image this plasma and measure its density and the velocity of the shock.

We have begun preliminary measurements of the x-ray backlighter source and have nearly completed construction of the new capacitor bank that will be used to produce these plasmas. We will soon be testing this bank and using the backlighter to make preliminary measurements of the target plasma we produce. We have also begun construction of the laser needed for producing the shocks in the plasma, and we expect this laser to be completed by August 1997, at which time we expect to begin measurements of the EOS of the plasma. We are also in the process of designing and constructing an x-ray microscope for imaging the shock propagation through the plasma. This diagnostic should also be ready for operation in August.

Optical Constants Research on LANL Synchrotron Beamlines

R. L. Blake [(505) 667-7369] (P-22)

A program of measuring atomic constants has been active on LANL beamlines for seven years. Our experience and precision x-ray spectrometer/reflectometer, combined with existing LANL beamlines at NSLS at BNL, place us in a unique position to contribute high-accuracy (~0.1%–1% 3σ-error) measurements of both the real and imaginary parts of the complex dielectric constants of elements and materials. We are able to make these measurements over a wide energy range, from 50 eV to 15 keV, including all of the edge structure that is largely nonexistent in literature compilations for most of the energy range. The hardware and computer software is transportable between LANL beamlines.

From combined reflectivity and transmission measurements, we have provided new or improved optical constants of gold, iridium, molybdenum, palladium, and platinum over the energy range 2–15 keV. Iridium and the polymer polyimide ($C_{22}H_{10}O_4N_2$) have also been measured from 50 to 1000 eV. Measurement precision has varied from 0.1 to 1.0 percent, depending on the beamline and the circumstances. Present accuracy of a few percent will soon be improved to better than one percent by using multiple techniques to refine the sample thicknesses and smoothness. Detailed measurements through the M-edges of gold, platinum, and iridium have provided new values of the x-ray absorption edge energies that differ by 30 to 40 eV from photoelectron spectroscopy binding energies. These differences have been explained with atomic modeling for gold; they are due to the slow onset of the $3d * f$ transition. Further band structure modeling confirms this explanation and confirms the observed x-ray absorption fine structure as well.

Self-Directing Elastic-Backscatter Lidar

D. A. Clark [(505) 667-5054] (P-22), collaborators from NIS and Bechtel Nevada

Lidar (light detection and ranging) has many applications in the fields of atmospheric research and environmental monitoring. Elastic-backscatter lidar, also called Mie lidar, can “see” aerosols in the air, even if the concentration is very slight and the aerosol cloud is not visible to the eye. Elastic-backscatter lidar systems have been used to detect aerosol emissions from industrial stacks and debris clouds from transient events such as above-ground explosions. However, they have not been used to track the path of debris clouds or to map cloud evolution.

A new adaptive, scanning, self-directing, elastic-backscatter lidar that automatically tracks and maps isolated clouds has been developed at Los Alamos. It has been used to gather cloud data from two above-ground explosive tests. Accurate cloud volume, density distribution, and track information was obtained from small, fast-moving, low-density, invisible debris clouds. The new lidar control system utilizes the backscatter signal itself to direct the lidar toward the cloud and minimize the scan dimensions. As the cloud evolves, both spatially and temporally, the system dynamically readjusts the scan to cover the entire volume of the cloud. Confinement of the scan region to the immediate vicinity of the cloud allows more scans in a given time, producing high-resolution information during the cloud evolution.

Cloud-tracking lidar can be used as part of an environmental monitoring program to assess the migration of emissions from transient events. It can also direct other remote-sensing devices for species identification.

High-Energy Liner Experiment

D. A. Clark [(505) 667-5054], T. Petersen, L. Tabaka, B. Anderson (P-22), collaborators from the NWT Program office, DX, and X Divisions

Magnetically driven, imploding liner systems can be used as a source of shock energy for materials EOS studies; implosion-driven, magnetized-plasma fusion experiments; and similar applications. Such systems can play an important role in support of nuclear-weapons stockpile stewardship by allowing us to verify our abilities to perform accurate calculations. The imploding liner is a cylinder of conducting material through which a very high current is passed in the longitudinal direction. Interaction of the current with its own magnetic field causes the liner to implode at high velocity. Experiments requiring high-velocity impact or volume reduction are placed at the center of the liner. In order to be effective, the liner must remain in a condensed state (not vaporized), retain its cylindrical shape (liner stability), and attain a high velocity during the implosion. In order to meet these requirements, liners must be thick and of large diameter, be manufactured to precise tolerances, and have high convergence ratios. High energy is required to move these heavy liners. Robust and accurate diagnostics are needed to measure the liner performance and target responses.

In August 1996, a collaboration of scientists from LANL and the All-Russian Scientific Institute of Experimental Physics (VNIIEF) of Sarov, Russia, conducted a high-energy liner experiment in Sarov. It was the highest-energy and largest liner experiment ever performed. The purpose of the experiment was to measure performance of the explosive pulsed-power generator and the heavy imploding liner, to test the capabilities of various diagnostics under extreme conditions, and to obtain data for comparison with performance calculations. A 5-tier, 1-m-diameter explosive disk generator provided electrical energy to drive a 48-cm-outside-diameter, 4-mm-thick aluminum-alloy liner having a mass of about 1 kg onto an 11-cm-diameter diagnostic package.

The experiment was a great success. Peak current was greater than 100 million amperes and the liner kinetic energy was more than 20 megajoules. Results of this American-Russian collaborative effort will provide needed information for improved performance in future high-energy liner systems.

Nuclear Weapons Archiving Project (NWAP) in P-22

K. Croasdell [(505) 667-2483], D. Bartram, G. Idzorek, J. Lamkin, D. Mills, J. Pelzer, D. Thayer, B. Wright, C. Young, L. Zongker (P-22)

Several objectives and priorities for Science-Based Stockpile Stewardship (SBSS) have been established by LANL and the nation as a whole. Weapon-design competence is presently viewed as the cornerstone of this stewardship. In the absence of any new nuclear testing, designing nonnuclear physics experiments and applying new computational skills to past NTS data will be important steps in the development of our predictive capability and in the improvement of our ability to solve unanticipated nuclear-weapons problems.

P Division is the steward of much of the data recorded in past NTS tests. Collecting the data, putting it into a usable format, and maintaining the expertise required for interpretation of the data are crucial tasks for the present group of weapons-physics scientists in P Division.

In P-22, NWAP has grown from a funding base of $100 K in FY94 to $1.21 M in FY97. We are addressing four major tasks in this project.

Collection/analysis of reaction-history experiments. We completed our review and reanalysis of the reaction-history data from the W76 weapon system in FY95. The actual data files and metadata were placed on the Common Event Data System (COEDS) and have been transferred to LLNL to satisfy requirements of the Dual Revalidation Program. COEDS is a weapons-information database that resides in XCM for the use of the LANL weapons community. In FY96, we concentrated on the W87 and B61 systems. In FY97, we continued to work on the B61 data. New analysis requirements for FY97 include reanalyzing events related to the W80 system and events related to tests that are unusual and not related to a specific weapon system.

Experimental procedure documentation and training. We are using weapons-test data and our staff expertise to document experimental procedures and build a foundation for training future scientists. In FY97 one of our primary tasks is to describe how to perform a reaction-history measurement. We are also updating and expanding a glossary on COEDS of terms that relate to weapons testing. We are writing a general electromagnetic-pulse (EMP) report, addressing the technical basis for EMP experiments and writing physics reports for several NTS events dating back to the early 1980s. We are working with Bechtel to develop 1990s hardware and software platforms for converting and working with the historical data; this task will occupy us well into FY98.

Collection and analysis of advanced diagnostic experiments. P-22 is learning what advanced diagnostic experiments were fielded and is planning to suggest appropriate reprioritizations of the list of tasks that we are pursuing. Many of these advanced diagnostic experiments were unclassified, resulting in inconsistent organization of the initial archiving of the event. In several instances this deficiency makes it very difficult to locate pertinent data for reanalysis. We are interpreting and documenting shot-physicist notebook quotations to obtain more details of these NTS experiments.

Completion of physics reports on the most recent NTS events. Only two of the six experimentalists involved in the original NTS events still work as full-time staff members for P-22, so completion of this task becomes ever more important. Divider, Whiteface A, Whiteface B, Sundown A, Sundown B, and Junction are the first shots we are examining. Victoria, Lubbock, and Houston will need extensive work. The archiving-project members have contributed information for the P-Division Internal Weapons-Physics Report and to the Nuclear Weapon Technology "Green Book," which describes the procedures for stockpile stewardship.

P-22 will continue to address requests as needed to support the weapons program. Reaction-history data about the W76 were given to LLNL to use in the Dual Revalidation Program, and W87 reaction-history data were collected from LLNL for the X-Division weapons designers to use in the Life Cycle Program. Data archived for the B61 were instrumental in the certification process for the B61 mod 11. We have participated in the interlaboratory information group (NWIG) to establish data-transfer standards between the three nuclear laboratories, the production plants, and the U.K. Atomic Weapons Establishment (AWE). We may perform analyses of U.K. shots if funding becomes available.

High-Speed Multiwavelength Infrared Pyrometer

D. Holtkamp [(505) 667-8082], P. Rodriguez, J. Studebaker (P-22),
G. Schmitt (DX-1)

P-22 has assembled a high-speed, multiwavelength infrared (IR) pyrometer for use in Pegasus II and high-explosive (HE) experiments. We expect to be able to measure temperatures between 500 and 1300 K. The unit uses four liquid-nitrogen-cooled detectors (HgMgTe) operating over various wavelength bands between 1 and 5 µm. These detectors are coupled via four 1-mm-diameter IR fibers to a position that views the surface of interest. The instrument has been repackaged by Bechtel Nevada into an electromagnetic-interference- (EMI-) and debris-shielded box for use in pulsed-power and HE environments. The bandwidth of the system is approximately 10 MHz. Improvements are planned that will extend the measurements to colder temperatures and higher bandwidths. Calibrations are currently in progress, and we expect to field the instrument at Pegasus and in HE shots in early 1997.

Radial Radiography at Pegasus II

D. V. Morgan [(505) 665-6679], D. Platts, D. Martinez (P-22),
B. Carpenter (P-24)

At Pegasus II, electromagnetically driven implosions in a cylindrical geometry are observed using three radially oriented, flash x-ray sources. Our three x-ray sources backlight the target with tungsten line and bremsstrahlung x-rays with an endpoint energy of approximately 270 keV. The x-ray pulse duration for each source is approximately 20 ns, which is quite short compared to the time scale of the implosion. The radiographs are recorded on film and deliver quantitative information about the position and density of the imploding material. Recent improvements to the three radial x-ray imaging systems include reduced x-ray scattering, improved source collimation, blur reduction, and an improved signal-to-noise ratio. We have developed a computer code that can generate a simulated radial radiograph of both static and dynamic Pegasus targets. Radial radiography was an important diagnostic for Liner Stability, Megabar, Ejecta, and Liner Gap experiments at Pegasus in 1995 and 1996. We expect that radial radiography will continue to provide quality data for future Pegasus and Atlas experiments.

Fiber-Optic Data-Link System

T. Petersen [(505) 665-2786], D. Bartram, G. Allred (P-22), collaborators from Bechtel Nevada

A new fiber-optic link system has been produced in association with Bechtel Nevada to deliver experimental data from hazardous areas to data-recording areas. The hazards that were thus circumvented include both severe electrical and high-explosive hazards. The transmitters are enclosed in an EMI-shielded enclosure that is battery powered for electrical isolation and has fiber-optic-coupled calibration and monitor functions. The optical receivers also have monitor functions. Two different fiber-link modules are interchangeable in this system, a 200-Hz to 75-MHz light-emitting-diode (LED) link and a 2-kHz to 450-MHz laser link. They have a linear signal level of 0.5 V and a signal-to-noise ratio of better than 40 dB. There are about 100 channels available of each fiber link. At present this system is in use on Pegasus II, the Atlas Test Bay, BEEF (at NTS), Ancho Canyon, and the Integrated Test Stand.

Ejecta Experiments at the Pegasus II Pulsed-Power Facility

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When a shock wave reaches a solid/gas (or liquid/gas) interface, pieces of the solid or liquid can be emitted into the gas region. This material can range in size from submicron to hundreds of microns and is referred to as ejecta. The amount, size, and velocity of ejecta will depend on material properties such as grain size, surface finish, and the state of the shock wave in the material. Ejecta occur in a nuclear weapon when a shock wave interacts at interfaces between weapon materials and gases. At these interfaces, materials can be injected into the gas, contributing to the mix of weapon materials and gas, which in turn has an effect on the performance of the nuclear device. In order to characterize the ejecta, P Division has developed an in-line Fraunhofer holography technique to make measurements of ejecta in a dynamic system. This diagnostic has been developed and implemented on numerous experiments based at the Pegasus II Pulsed-Power Facility. This facility has the capability of driving many megaamperes of current through an aluminum cylinder (liner) that is 400 μm thick, 10 cm in diameter, and 2 cm high. Physics experiments are performed inside the cylinder, making use of its cylindrical geometry. For the ejecta experiments, a 3.0-cm-diameter target cylinder is placed inside the liner cylinder. When the liner impacts the target cylinder, a shock wave is set up in the target. The shock wave then propagates through the 400-μm-thick target, and at the target/vacuum interface, ejecta are emitted. An additional 1.6-cm-diameter cylindrical collimator with various slit openings is used to control the amount of ejecta that passes through to the axial center. This target assembly consists of three cylinders with the same axis. To make the ejecta holographic measurement, a 60-mJ, 100-ps, 1.5-cm-diameter laser pulse is transported along the collimator axis. The laser beam then interacts with the ejecta, which passed through the collimator slits some time after the liner cylinder impacted the target cylinder. The actual hologram is made when the scattered light from the ejecta interferes with the unscattered laser light (reference beam) at the plane of the film. In order to measure particles a few microns in size, the holographic film should be placed a few centimeters from the ejecta. However, at this distance the film would be destroyed in the experiment. To address this problem, an optical transfer system was developed, which relays the interference pattern 93 cm from the ejecta to the holographic film. The hologram contains information about particles ranging in size from a few microns to a hundred microns in diameter, over a volume of 1 cm^3. In addition to the holography diagnostic, a visible shadowgraphy and dark-field imaging technique has also been developed. This diagnostic does not provide three-dimensional information like holography, but it provides time- and spatially resolved data about the ejecta front as it moves through space. This diagnostic makes use of a long-pulsed ruby laser (with a 450-μs pulse), in which the laser beam passes through the ejecta and a framing camera is used to make time-dependent, spatially resolved shadowgrams of the ejecta. This technique has been applied to many experiments successfully. Ejecta data have been obtained for both aluminum and tin targets for which the target surface finish and shock strength have been varied.

Liner Gap 7

J. L. Stokes [(505) 667-4900] (P-22), P. Brown, M. Fell, P. Jones (Atomic Weapons Establishment, Aldermaston, England), R. D. Fulton, D. Platts, D. L. Martinez, D. M. Oró (P-22), A. W. Obst, N. S. P. King (P-23), B. Carpenter (P-24), P. J. Adams, J. A. Guzik, (XTA), H. Oona (DX-3)

Liner Gap 7 was successfully fired on April 11, 1996, at 2:35 p.m. This was the first test fielded in collaboration with the Atomic Weapons Establishment (AWE) in the U.K. The classified target was designed by Peter Brown and Michael Fell (AWE) and was built by LANL in MST-7 by Wally Anderson and his crew. The process from concept to actualization was completed in a very short period of time: the definition occurred March 9, and the shot was fired April 11.

The normal gap diagnostics were fielded by LANL. These included axial x-ray images at two different times, radial x-ray images at three different times, framing cameras looking at a backlighter for shock position, radial visible imaging at three different times, as well as the normal machine diagnostics. All systems returned good data, and the axial imaging data were the best to date. They showed shock structure that we did not expect to see, but having seen it, we reexamined the calculations and found that it had been calculated before the shot.

We were extremely pleased with the results, as was AWE. As a result of the good-quality data from Gap 7, AWE expects to continue our collaboration on future tests. The next joint test will be in the second quarter of FY97.

In June 1996 we reviewed the Gap 7 data with B-Division members at Livermore, and they were very interested. They have proposed to do tests with us on Pegasus, and we are looking forward to this collaboration as well.

Peter Adams and Joyce Guzik (XTA) are designing Gap targets for the Gap tests in FY97.

Liner Gap Experiments

J. L. Stokes [(505) 667-4900], R. D. Fulton, D. Platts, D. L. Martinez, D. M. Oró (P-22), A. W. Obst, N. S. P. King (P-23), B. Carpenter (P-24), P. J. Adams, J. A. Guzik (XTA), H. Oona (DX-3), E. Chandler, P. Egan (LLNL), collaborators from Bechtel Nevada

We are planning three Gap shots for FY97. The first two shots are planned as a campaign. We have chosen designs for the first two shots from a list of ideas for future shots. Some calculations were done on several of the ideas and one of the more interesting was chosen to be the first shot, in February 1997. The second shot is already designed and will follow a week later.

We are improving the axial x-ray imaging system for the first campaign of Gap shots. The new system will be a single optical path that will be split in the screen room. This will solve the vignetting problem. We also hope to have new cameras for this new system. One small disadvantage will be that there will be only two cameras on this system, which means no redundancy for either image capture. One advantage is that this is a simpler system and should be fielded more easily. This updated system is expected to be in place by the second campaign, which is scheduled for the summer of 1997.

The Dirac Series of Experiments at Multimegagauss Magnetic Fields

L. R. Veeser [(505) 667-7741], P. J. Rodriguez, D. E. Bartram, D. A. Clark (P-22), collaborators from DX, T, and X Divisions, All-Russian Scientific Institute of Experimental Physics, Bechtel Special Technologies Laboratory, and Bechtel Nevada

In May 1996 we began a series of experiments using explosive-driven flux compression generators that produce microsecond-time-scale, megagauss magnetic fields at Firing Point 88 in Ancho Canyon. The series was named for P. A. M. Dirac, whose contributions to quantum theory are basic to all of the physics in the series. The experiments attracted scientists from Japan, Australia, Russia, and several U.S. laboratories, including Louisiana State and Florida State Universities and the National High Magnetic Field Laboratory. We used two types of generators, inexpensive Los Alamos–designed strip generators, capable of 130-T fields, and more elaborate Russian MC1 generators, which can produce over 1000 T (10 MG). In addition to recording the data for all of the experiments, P Division participated in several of the research efforts, including improved-geometry glass crystals to optically monitor high magnetic fields, a technique of particular interest to us because we will be producing very high fields on the Atlas Pulsed-Power Facility when it comes on line in 1999. We measured the Faraday rotation of polarized laser light in the diluted magnetic semiconductor CdMnTe, in which the spin exchange between magnetic ions (Mn^{2+} in this case) and the band electrons produces a large splitting of the band and consequently a giant Faraday effect. We took some interesting data, which we are now trying to interpret, and we will make further measurements. We also fielded a first attempt to determine a measurement standard for ultrahigh magnetic fields using samarium or europium. The ions Eu^{3+} and Sm^{3+} encounter jumps in Faraday rotation when the Zeeman-split excited states cross the ground states in energy. The critical fields at which these jumps occur are determined only by atomic constants and are unaffected by the environment in which the ions find themselves. This last experiment was unsuccessful because of a lack of light in our sample, so we will repeat it. All of the experiments, and perhaps some new ones, will be continued when the series resumes in the summer of 1997.

Equation of State (EOS) of Plutonium

L. R. Veeser [(505) 667-7741], P. J. Rodriguez, D. A. Clark, D. M. Oró, G. D. Allred, R. D. Fulton, O. F. Garcia (P-22), F. H. Cverna, N. S. P. King (P-23), collaborators from DX, X, and ESA Divisions, Sandia and Lawrence Livermore National Laboratories, and Bechtel Nevada

Following the decision by DOE to use NTS for experiments involving plutonium and uranium isotopes that are hazards to the environment, we are preparing a measurement of the EOS of delta-phase plutonium to increase our understanding of the physics of nuclear weapons. The first of these experiments, Rebound, is being fielded jointly by P Division, DX Division, and the rest of the support groups formerly responsible for experiments on underground nuclear tests (UGTs). We will have three experimental assemblies contained underground in a way similar to UGTs. In each assembly we will accelerate a steel flyer plate with high explosives, and the plate will impact several flat plutonium samples. By measuring the plate velocity and the velocity of the shock waves induced in the plutonium for each explosive configuration, we will obtain three EOS data points for plutonium at pressures between 80 and 230 GPa. Each impact will produce a shock that travels back through the flyer plate, unloads into the vacuum, and returns toward the plutonium as a rarefaction. For each assembly we will determine the sound speed in the shock-heated plutonium from the position where the rarefaction overtakes the shock in a heavy glass sample on the back of the plutonium. The sound speed results will be used to determine the shock pressures at which phase changes occur in plutonium. Jointly with experimenters from Livermore, we will measure a point on the plutonium release adiabat by placing a low-density foam on one of the samples and measuring the shock velocity in the foam that is induced by the unloading of the plutonium shock. Finally, DX and Sandia will measure the spall strength of shocked plutonium using a VISAR interferometer to follow the velocity of the back surface of one of the samples. The role of P Division is similar to its UGT role: participating in the experiment design, fielding the diagnostics and recording equipment, and working on the data interpretation. We have carried out seven local experiments substituting copper for the plutonium to test out the diagnostics and procedures, and we will execute Rebound in 1997.

Isentropic Compression of Argon

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Los Alamos National Laboratory and the All-Russian Scientific Institute of Experimental Physics are performing a set of experiments to explore the conductivity and possible metalization of argon when it is compressed to more than five times its normal density. The experiments use a magnetic field of several megagauss generated by a Russian MC1 explosive-driven flux-compression generator. The field compresses a small metallic tube (~14 mm in diameter by 180 mm long) containing solidified argon. A probe in the center of the tube measures the electrical conductivity to the walls, and a 60-MeV betatron serves as a source for a radiographic measurement of the compression at a point near its maximum. For a compression of ~4.9 times (at a calculated pressure of about 7 Mbar and temperature of 2000 K), we measured a conductivity of 8 $\Omega^{-1}\bullet\text{cm}^{-1}$, more characteristic of electron hopping than incipient metalization. Upon increasing the compression to about 5.1 and improving the probe design, we saw a conductivity of 75 $\Omega^{-1}\bullet\text{cm}^{-1}$, still far from a metal. The radiographically measured compression of 5.1 is theoretically above metalization for body-centered cubic (bcc) lattice structure, but below metalization for face-centered cubic (fcc) and hexagonal close pack. A transition from fcc to bcc is predicted to occur at a compression of 3.91. Because of the temperature, substantial fractions of each lattice structure are expected. Calculations of the lattice indicate that we are in a region where the highest point in the valence band is above the lowest point in the conduction band, but the two points occur at different places in the crystal structure. As a result, indirect transitions are needed for an electron to move from one atom to another. In view of the surprisingly small conductivity and its variation with compression, we are planning substantial improvements in the experiment, including a repeat of the low-compression measurement with the new conductivity probe and a measurement with a Teflon insulator inside the tube wall to verify that the observed conductivity was due to the argon and that the insulators in the experiment remained nonconducting at the high pressures obtained. The compression remains at its maximum for a very short time, at most a few hundred nanoseconds, so we intend to measure the compression curve with time to confirm the timing of the radiograph relative to peak compression. For this, the betatron has been modified to produce a series of three pulses per event. We will use a thin scintillator—to convert to visible light the x-rays transmitted through the tube—and an electronic camera that will record the images. We will also begin to measure the conductivity of krypton, which has a similar lattice structure but is expected to metalize more easily than argon, to determine the compression at which full metalization of krypton occurs.

Beam Diagnostics for the Dual-Axis Radiographic Hydrodynamic Test (DARHT) Accelerator

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Microwave diagnostics are being developed by P-22 to monitor the diameter of the electron beam of the DARHT linear accelerator. Nonintrusive diameter measurements are needed in the DARHT beam-transport sections to ensure proper focusing of the beam on the x-ray-generating target. A two-pass microwave interferometer at 24 GHz has been assembled for this purpose. It is currently undergoing trials on the Integrated Test Stand (~4 MeV, ~4 kA). Looking ahead to the more stringent requirements of DARHT itself (~20 MeV), a microwave resonator concept has been examined in detail. The latter approach, at 8 GHz, offers increased sensitivity and better control of geometrical factors.