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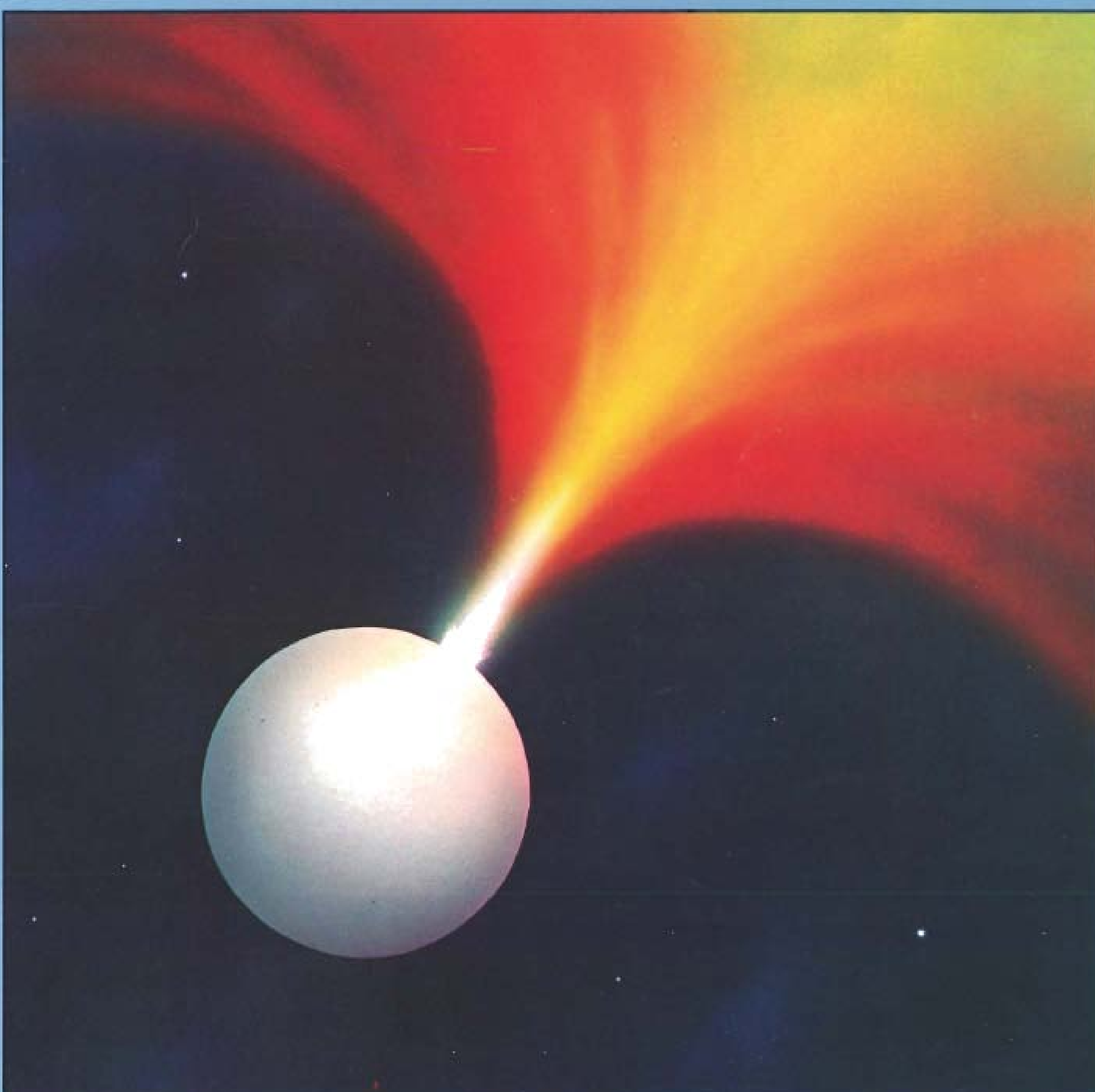
Los Alamos Science

LOS ALAMOS NATIONAL LABORATORY



Inside This Issue

EDITOR'S NOTE

Science and technology try to find and fashion the order in nature, but as much as the planners would have it otherwise, this creative process, rather than being orderly, is filled with paradox and surprise. That a mission-oriented laboratory, devoted primarily to weapons development, provides an environment where this process can flourish is itself paradoxical. But the facts speak for themselves. This issue presents three exciting research projects that emerged in surprising ways from weapons research and development.

The first is the work on gamma-ray bursts. These dynamic stellar events, clues to our changing universe, were discovered as a result of the Vela satellite-surveillance mission to detect exo-atmospheric nuclear weapons tests. The discovery surfaced unexpectedly from persevering, mission-oriented efforts at Los Alamos to remove ambiguities from the data and to differentiate local from cosmic events. The same care and caution that characterized the surveillance studies is present in this issue's article on the current understanding of gamma bursts. While the editors are privy to the authors' lively speculations, the authors preferred to omit them from the article because as part of a national laboratory they see themselves as more vulnerable to criticism than their counterparts in academia. This curious blend of boldness and caution is a fact of life at the Laboratory. It can be both a virtue and a handicap in the process of discovery.

The nuclear microprobe, a new instrument to examine the elemental composition of very small objects, is the second subject in this issue. This instrument, together with other techniques, has given a new lease on life to the Van de Graaff accelerator. Once an indispensable tool in the weapons program for studying low-energy nuclear reactions, its continued importance for this purpose is under discussion. In the meantime it has given birth to a new and very sensitive tool for materials analysis. The nuclear microprobe uses the ions from the Van de Graaff to probe the subsurface region of geologic, biological, and synthetic materials. Interpretation of the data, which depends, of course, on the vast body of low-energy nuclear data collected at the Van de Graaff by nuclear physicists, is leading to greater understanding of the formation of geologic materials, the operation of technological devices, and the synthesis of new materials.

The third subject is an intriguing experiment to measure the solar neutrino flux over geologic times as a test of the standard models of stellar evolution. The experiment entails isolating and counting very rare isotopes of technetium produced by the interaction of solar neutrinos with deeply buried molybdenum. The commercial molybdenum recovery process goes a long way toward isolating these isotopes. The final counting, however, will require drawing on and adding to analytical techniques developed over the years for weapons diagnostics.

These tales of synergy are common at Los Alamos and are appreciated by the new leader of our Life Sciences Division, Mark Bitensky. With bold vision Mark has outlined an astounding array of exciting opportunities in biological and biomedical research made possible by the unique combination of talent and facilities in the Laboratory's forte—the *physical* sciences. What combination of boldness and caution can see through the present tight budgetary climate to the realization of these dreams of synergy?

Necia Grant Cooper

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Errata: Los Alamos Science *apologizes for the misspelling of Roy Feber's name (Volume 3, Number 1, page 34) and for omission of credit to Sheila Satkowski for black and white photo laboratory work in the same issue.*

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On the Cover.

Artist's conception of the source of a gamma-ray burst. In this hypothetical model a neutron star ejects a fountain of plasma whose base, at a temperature of several billion kelvins, emits gamma-rays. Typically, neutron stars are about the size of a small town whereas the plasma fountain may extend the length of the state of New Mexico.

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LOS ALAMOS NATIONAL LABORATORY
MAIL STOP M708
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THE SOURCE TERM ISSUE

I write to bring you and your readers up-to-date on some recent developments in reactor safety. The iodine issue discussed in Volume 2, Number 2 of *Los Alamos Science* has been enlarged to include careful consideration of all fission products created in a nuclear reactor. This broadened matter is known as the source term issue.*

Briefly, it is now generally conceded that the predominant chemical form of iodine when it escapes from very hot fuel is iodide and probably cesium iodide (CsI). This conclusion immediately raises the question of the chemical form of the remaining cesium, as there are about 11 times as many cesium atoms created by fission as there are iodine atoms. The answer is cesium hydroxide (CsOH), since water (or steam) is always present in a light-water reactor and CsOH is thermodynamically the most stable form after CsI. Thus, the two most important fission products in terms of their threat to the health and safety of the public are in the form of chemical compounds that are not especially volatile (compared to I_2 or Cs) and that are very highly soluble. Once in solution these remain in solution, and little or none is ever again airborne. These fission-product compounds will accumulate in the water and wet steam and on the wet surfaces invariably present in the primary system and containment of a light-water reactor following an accident that ruptures the primary system and allows the escape of fission products from the fuel.

Examination of the behavior of some other less abundant or significant fission products is yielding comparably reassuring results.

These and other studies (for example, on containment integrity) suggest that the WASH-1400 source term estimates for the most dangerous fission products may be too high by a factor of 10 and possibly by a factor of 100 or more. If the new estimates are correct, their use in consequence models of even the worst accidents (including containment failure) would lead to predictions of no early fatalities. Thus, the importance of the source term issue and its resolution is evident. It may be the case that the worst reactor accident is less severe than serious accidents in other industries.

This issue has attracted the attention of the entire nuclear reactor community, both nationally and internationally. Both the NRC and the DOE have investigations underway. The Electric Power Research Institute (EPRI) and an industrial group known as the Industry Degraded Core Rule Making Program (IDCOR) are working on the problem. Abroad, West Germany has analyzed aspects of the issue, and the IAEA has held one meeting on the subject and has scheduled a second. Most recently, the American Nuclear Society has created an ad hoc committee** to prepare a comprehensive document on the source term issue. All of these efforts should be completed in about a year. Clearly, exciting times are at hand in this important technical area and major changes in our perception of the hazards of nuclear power stations are in the making.

W. R. Stratton
Los Alamos, New Mexico

Editor's Notes:

**By source term is meant the fraction of fission products that is assumed to escape from overheated fuel and move to the containment as volatile species should a major coolant pipe rupture and the ECCS fail and then to escape to the atmosphere should the containment be breached. The predicted consequences of a reactor accident depend strongly on the assumed source term.*

***W. R. Stratton has recently been appointed chairman of this committee.*

RADIATION PROTECTION SPECIALISTS LEAD THE WAY

The article entitled "Low-Level Radiation—How Harmful Is It?" in Volume 2, Number 2 of *Los Alamos Science* gave a good general summary of our current understanding on the risk of health effects resulting from low exposures to ionizing radiation, and it also described the various regulations developed to keep exposures to workers within safe levels. The description of the current radiation limits, however, was not correct for DOE contractor workers, such as Los Alamos National Laboratory employees. The annual limit in the current DOE regulations is 5 rems per year, not 12. By approval from the Deputy Assistant Secretary for Environmental Safety and Health, the contractor may get permission in special cases to exceed 5 rems in a year—an administrative procedure that will surely not be tried often. The point is that the DOE regulations are more restrictive than those discussed in the article. That the actual exposures in the workplace are much less than the regulations permit was properly pointed out in the article. Among all Laboratory workers monitored for external radiation for the past 5 years, 98 per cent had annual exposures under 1 rem and 99.4 per cent were under 2 rems.

Radiation effects have been the center of considerable controversy. Why? In my opinion, it is because the risks after typical exposures are so low that there is no way of observing health effects, principally cancer, as compared to the much larger number of cancers from all causes. This leads to multiple models, theories, and speculations without benefit of data at these low exposure levels. There is also the philosophical hurdle of deciding when one is safe. Safe is usually considered being free from harm or risk. There is nothing we do in life that is truly safe. For example, even sleeping for longer periods, like 10 hours, results apparently in a small increase of strokes and blood clots. In radiation matters, scientific committees recommend exposure guidelines that they judge will result in no greater risk after lifetime exposures at the maximum values than the risks for other serious injuries or illnesses in safer industries or occupations. These are experienced judgments that are always open to challenge; hence, controversy.

It is generally not appreciated how unique it was that radiation protection specialists felt that these small, undetectable health risks should be estimated and be used in setting standards. This was new for health protection—that is, to provide protection for levels of exposure that may produce potential effects or disease although these were not observable directly by scientific methods. In contrast, exposure regulations for other toxic materials were set at levels somewhat below those that produced acute or subacute effects, that is, recognizable symptoms or signs of toxicity. The concept of protecting against possible unrecognized injury, such as the small risk of induction of cancer years later, was new with radiation protection. In the past decade or so, this same philosophy of protection is beginning to be applied to regulations on exposure to toxic metals and chemicals in a manner similar to those used in radiation protection for more than 30 years. In effect, radiation protection specialists have led the way. As shown by the swirl of controversy, trail blazing is not an easy task. I believe radiation protection specialists in the formative years of the nuclear industries should be recognized for their foresight and concern.

George L. Voelz, M.D.
Assistant Health Division Leader
for Health and Research
Los Alamos National Laboratory
Los Alamos, New Mexico

PEDAGOGY IN REACTOR SAFETY

I have been giving a series of lectures for IAEA to a group of scientists and engineers from developing countries on the subject of PWR safety. For my main reference in discussing emergency core cooling I used your fine article, "Accident Simulation with TRAC," in the latest issue of *Los Alamos Science.* You provided a clear and vivid picture of the accident and recovery and I believe the students benefited greatly. I was much interested in the pedagogical virtue of your modeling of reactor components as variants on a pipe.

I'm working on a set of simple educational modules in nuclear engineering that include theory, calculation method, computer program, and illustrative example. They are intended to demonstrate concepts and allow the student to vary parameters and modify or expand the program. For the preparation of one on LOCA/ECCS I need to go one step further than the article, to the issue of the model used in TRAC. It would be too big a job for me to learn all the great detail that I know is involved in such a comprehensive code. Can you suggest a program of reading and study that would put me in good position to prepare such a module? Any written material would be helpful. Many thanks and best regards.

Raymond L. Murray
Professor of Nuclear Engineering
North Carolina State University
Raleigh, North Carolina

Editor's Note: In response to this letter, addressed to the authors, John C. Vigil sent the manual for the latest TRAC version to Professor Murray and recommended the references it contained as additional helpful material.

I was delighted to receive a copy of *Los Alamos Science,* Volume 2, Number 2, on Reactor Safety. This is a superb collection of articles on one of the most important technical issues we are faced with.

The timing couldn't have been better as my upper-level graduate course, Two-Phase Flow and Boiling Heat Transfer, is rapidly heading toward application topics which include thermal-hydraulic issues in nuclear reactor safety. I may use *Los Alamos Science* as class notes for this important part of my course.

Arthur E. Bergles
Distinguished Professor and Chairman
Department of Mechanical Engineering
Iowa State University
Ames, Iowa

THANKS FROM AGNEW

I'm finally getting around to thank you (Barb Mulkin) for the idea of the interview. In such articles one always wonders afterwards why one said this or that or why one didn't say something else. I believe that you did a great job and I appreciate your endeavors very much. Suggest if you reprint it that the picture on page 155 should carry the caption, "You mean I have to spend another year in San Diego?" Actually it isn't all that bad and each year Beverly and I have a harder time trying to decide what to do.

Keep up the good work and please tell Necia the magazine continues to be a smashing piece of work. Really impressive!

Harold M. Agnew
President
General Atomic Company
San Diego, California

Your comments on articles appearing in Los Alamos Science are welcome. Please address them to Editor, Los Alamos Science, Los Alamos National Laboratory, Mail Stop M708, Los Alamos, NM 87545.