

PHYSICS and SOCIETY

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PHYSICS AND SOCIETY is a quarterly newsletter of the Forum on Physics and Society, a division of the American Physical Society. The newsletter is distributed free to members of the Forum and also to physics libraries upon request. It presents news of the Forum and of the American Physical Society and provides a medium for Forum members to exchange ideas. PHYSICS AND SOCIETY also presents articles and letters on the scientific and economic health of the physics community; on the relations of physics and the physics community to government and to society, and the social responsibilities of scientists. Contributions should be sent to the Editor: John Dowling, Physics Department, Mansfield State College, Mansfield, PA 16933, 717-662-4275.

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A MESSAGE FROM GORKY by Andrei Sakharov.

This is the text of the letter from Academician Sakharov (translated by Tatiana Yankelevich and Richard Lourie). It is his response to being awarded the 1983 Szilard Award of the Forum and was read at the Awards Session at the 1983 Baltimore APS meeting.

I am grateful and proud to accept this award, named for a remarkable man and scientist, Leo Szilard. I know of Szilard's outstanding scientific merits and of his public activity, which sprang from his innate, acute feeling of personal responsibility for the fate of mankind on our planet, and for the possible consequences of science's great victories.

In the years of Szilard's life and activity it became clearer than ever before how great the responsibility of scientists is to the society. And, to a large extent, it is due to Szilard that this awareness began to spread in the scientific community. Unfortunately, today, almost 20 years after Szilard died, the problems that disturbed him are not less acute or tragic.

Today, as then, the world is politically and ideologically divided into two opposing camps. Both sides are threatening each other with missiles and nuclear weaponry. Destructive capacity increases every year and has already reached a level at which its uses would cause the deaths of hundreds of millions of people and cause destruction unprecedented in the history of mankind; create chaos, devastation and suffering; and hurl human society back centuries. The total annihilation of mankind and life on Earth is not out of the question - perhaps even with the existing reserves of nuclear arms - and is even more probable with the further quantitative and qualitative development of the means for mass destruction.

Meanwhile, the confrontations are not static. One glance at the map of the world today and in the first post-war years is enough to realize that the line separating the areas of prevailing influence has been continuously moving in one direction - to the benefit of the socialist camp. One could call this a manifestation of the laws of history; some might say of historical justice. Others might call this a socialist expansion replacing one sort of social and legal problems with others, no less acute and tragic. The most important thing is the objective result, which is a further aggravation of the international situation and an increasing danger of local conflicts growing into a worldwide clash.

The problems of the underdeveloped countries are as acute as they were earlier. There is no doubt that unevenness of development creates enormous suffering for the greater part of mankind and poses a threat to world stability. Maybe that is the main source of danger. To decrease the unevenness is one of the chief tasks of our times, demanding coordinated action by all countries, developed and developing. Unfortunately, the division of the world produces

negative results in this matter as well. At present, the Soviet Union provides the developing countries with only very small amounts of technological and economic assistance - and only to those under its influence. Having practically withdrawn from participation in worldwide joint efforts, the Soviets have, however, become a major supplier of arms.

Since the late 1960's international terrorism, a sort of terrorist international of "left" and "right" groups, has become a serious destabilizing factor. Those states that directly or indirectly encourage these destructive forces are undoubtedly causing great harm to the entire world, their own people included.

One of the most tragic and dangerous events of recent years was the Soviet invasion of Afghanistan. Many tens of thousands of Afghans have died in the three years of war; according to some estimates, the number of victims exceeds 100,000. Many Soviet soldiers have died. Millions of Afghans have fled the horrors of war and left the country; about one-third of the population have become refugees. The Soviet invasion seriously aggravated the international situation, affected the rate of the arms race and, in particular, the fate of SALT II. If there are not changes for the better in the world, Afghanistan could become the Abyssinia of a new world war!

Today we ask ourselves once again: Does mutual nuclear terror serve as a deterrent against war? For almost 40 years the world has avoided a third world war. And, quite possibly, nuclear deterrence has been, to a considerable extent, the reason for this. But I am convinced that nuclear deterrence is gradually turning into its own antithesis and becoming a dangerous remnant of the past. The equilibrium provided by nuclear deterrence is becoming increasingly unsteady; increasingly real is the danger that mankind will perish if an accident or insanity or uncontrolled escalation draws it into a total thermonuclear war. In light of this it is necessary, gradually and carefully, to shift the functions of deterrence onto conventional armed forces, with all the economic, political and social consequences this entails. It is necessary to strive for nuclear disarmament. Of course, in all the intermediate states of disarmament and negotiations, international security must be provided for, vis-a-vis any possible move by a potential aggressor. For this in particular one has to be ready to resist, at all the various possible stages in the escalation of a conventional or a nuclear war. No side must feel any temptation to engage in a limited or regional nuclear war.

There are two specific problems. One is that the main part of the Soviet Union's nuclear potential is concentrated in gigantic land-based missiles. Essentially, this is a first-strike weapon. It is necessary to strive to eliminate these weapons or to reduce their number. There is little chance of this happening before the west has analogous missiles and is ready to eliminate them as well as the other means of nuclear war. The second problem is that the Soviet Union is not likely to eliminate its powerful medium-

range missiles, which have upset the nuclear equilibrium in Europe and which threaten China and Japan, before the West deploys analogous missiles.

Certainly the ultimate goals are international security, the elimination and demolition of nuclear weaponry, and rapprochement - convergence by countries with different political systems. In the long run, convergence is the only alternative to global destruction. This goal cannot be achieved without profound political and ideological changes - both in the relations between socialist and western countries, and within the countries themselves.

In the postwar years Nils Bohr, as well as Szilard and many other like-minded people, dreamed that open societies would provide an important and dispensable guarantee for international security. Since then, Stalin's tyrannical regime with its monstrous mass crimes has become a thing of the past in the Soviet Union. But the key features of the system formed under Stalin have basically survived. They are: the monopoly of the Party and the state in economics and ideology, which is even harsher in the political and military spheres; and the attendant violation of freedom of conscience and the free flow of information; of the right to choose one's country of residence and place of residence within the country; the unfounded persecution of dissidents and prisoners of conscience. Of course, the scale of persecution cannot at all be compared to that of Stalin's times. But to persecute people for their convictions, people who have not resorted to violence or advocated it, is in essence inadmissible. I am certain that the plight of the prisoners of conscience-many of whom are sentenced to seven and even 15 years of deprivation of freedom-cannot help but disturb us. It is very important to fight for each prisoner as an individual. Universal amnesty for prisoners of conscience in the Soviet Union and throughout the world would not only be an act of humanity but an important step on the path of strengthening international trust and security.

I would like once more to remind you of the profound alarm felt by our great predecessors - Einstein, Bohr, Russell, Szilard - for the fate of mankind, and of the ideas they left us. These ideas - about peace, about the importance of mutual understanding and tolerance, about the openness of society, the respect for human rights, the convergence of states with different political systems, the responsibility of scientists are as important today as when they were expressed for the first time.

Андреи Сахаров

WHAT'S WRONG WITH A NUCLEAR FREEZE?

by Lewis A. Glenn, L-387, Physics Dept.,
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Advocates claim that a nuclear freeze will

- Put an end to an arms race that otherwise can end only in holocaust
- Ensure that there will be no future generations of nuclear weapons.

The freeze proposal would ban the manufacture, testing, and deployment of any new nuclear weapons, while allowing the maintenance of existing nuclear forces **only** until reductions could be agreed on with due deliberation. What's wrong with this idea?

The main problem is verification. Most proponents of a freeze agree on the importance of verification by prefacing their proposal with the adjectives **mutual** and **verifiable**. The reason for this is that, without adequate verification, one side could clandestinely acquire and deploy new weapons while the other does not. The problem is aggravated if this happens while both sides are supposedly reducing their arsenals since, in this case, the numerical superiority of the evader is quickly magnified. The risk of nuclear confrontation is then very much enhanced because the evader may perceive that a surprise strike would eliminate any possible counter-strike by the victim. The possibility of a successful first strike becomes a reality when the aggressor has the task of only locating the few remaining weapons of the victim (the main body having been dismantled by agreement) and can target each with several of his own to ensure their complete destruction. Conversely, the risk of confrontation is much less with large numbers on both sides. Even with multiple targeting, the aggressor is assured by the laws of probability that at least a small fraction of the victim's arsenal will remain after his onslaught. If the initial arsenal is large enough, the remnant will be sufficient to wreak havoc on the aggressor's homeland - thus serving as an effective deterrent to any nuclear exchange.

Freeze advocates generally react to this MAD (for Mutual Assured Destruction) scenario with the claim that it is too dangerous and that adequate verification is possible with "national" methods. By this they mean methods that can be managed independently, without cooperation of the other party - an especially important consideration in view of the closed nature of a totalitarian society like that of the Soviet Union. In fact, there are three items that need to be verified in the event of a freeze: testing, manufacture, and deployment. The detection of nuclear weapons testing is relatively easy, at least up to a point. Neither the Soviet Union nor the United States is currently testing in the atmosphere, such testing having already been proscribed by the Limited Test Ban Treaty of 1963: satellite surveillance and extra-territorial atmospheric sampling virtually ensure that no violations have occurred. Underground testing is still permitted, however, although by mutual agreement (the unratified Threshold Test Ban Treaty of 1974) testing is limited to explosive yields not exceeding 150 kilotons.

Extra-territorial seismic monitoring has guaranteed the acceptance of this limit, although the Soviets have been accused of a few isolated violations. Moreover, the state-of-the-art is such that seismic monitoring could detect underground explosions with yields in excess of only a few kilotons. This would require the installation of a number of "tamper-proof" instruments **within** the national frontiers of both sides, as well as the provision for periodic maintenance, and perhaps occasional on-site inspections. It is important to note, however, that weapons with yields equivalent to those dropped on Japan could probably still be secretly tested by a determined evader, even with the best currently-available seismic equipment in place. Some have argued that satellite surveillance would be effective in detecting any nuclear testing since a great deal of surface activity is involved in conventional underground experiments. It goes without saying that such activity is easily avoided - at very moderate cost increases - in the event that it matters.

The detection of the manufacturing and deployment of nuclear weapons is infinitely more difficult. Again, it is claimed that production plants and transportation routes are well-known and can easily be kept under satellite scrutiny; new ones can be similarly identified. Our satellites are far from infallible, however, as has recently been demonstrated anew by the "discovery" of hundreds of previously unaccounted for new Soviet T-80 tanks, the production facilities for which were supposedly under constant surveillance. Moreover, it is tacitly assumed that facilities to assemble and transport new nuclear weapons must resemble the present, "well-worn" plants and routes. Unfortunately, the state-of-the-art has advanced considerably in the past few years. Much less special nuclear material (SNM) is required in modern, compact weapons systems and world inventories have increased dramatically. Those few facilities - such as uranium enrichment plants - that were large, specialized, and therefore highly visible, can now be replaced with much smaller and concealed operations. In the case of uranium enrichment, for example, gaseous diffusion can be substituted for by either mechanical centrifuging or laser isotope separation, both of which would require far less space. Warhead fabrication would require even less subterfuge, since nuclear and conventional warheads are now interchangeable on many weapons. Nuclear warheads could be assembled right alongside conventional explosives. Once so assembled, they could be transported just as ordinary missile components or munitions. Moreover, a clever evader would design his systems to be highly modular. Components would be separately transported to disparate locations and stored for rapid assembly at a later date. The genesis of such a program is probably already in place in the Soviet Union, with the appearance of the mobile, solid-fueled ICBM designated the SS-16.

Nuclear freeze proponents concede the possibility - even the likelihood - of some cheating. They claim, however, that the "number of weapons that could be produced clandestinely would be very small (some tens or hundreds) with respect to the size of current arsenals...". Whether or not these low estimates are accurate, even they are most disquieting. If the

Soviets could secretly stockpile only two weapons per week, while both sides had supposedly first frozen production and then staged "verified" reductions at the modest rate of, say 10% per year, in ten years time they would be left with 1000 and we with none!

Finally, we come to the important question of motivation. It is claimed that the Russians do not want a nuclear war any more than do we. In a recent speech, George Kennan is quoted as saying: "There is no issue at stake in our political relations with the Soviet Union - no hope, no fear, nothing to which we aspire, nothing we would like to avoid - which could conceivably justify the resort to nuclear weaponry". While we must agree with this homily, there is good reason to suspect that the same view is not held by the other side. When one reads Kennan's remark, there is a great temptation to substitute **German government for Soviet Union and armed conflict for nuclear weaponry**. The result is virtually a transcript fragment from Neville Chamberlain's speech to the Commons just prior to his departure for Munich in 1938. If the communist leader, like his national socialist counterpart 45 years ago, perceives that political advantage can be derived by agreeing to a nuclear freeze, there is no doubt that he will make the most of it; there is considerable doubt whether he will live up to it. And just as in 1938, there is an upswell in public opinion in the democracies, especially amongst the "better-educated" contingent, that decries any dissent from these views and labels as a warmonger any dissenter.

Some will read these words and recoil in horror. They will cry out about an endless arms race, with ever increasing numbers of missiles and megatonnage. Endless it may be, but unbounded it will surely not be. Competition for increasingly scarce federal funding is the viscosity that will put a lid on our strategic arsenal, and this process is already underway. New weapons systems are coming under increasing scrutiny (witness the MX and B-1 programs) and these will have to compete for limited funds with other defense needs, as well as with social programs. Still, it is vital that we continue nuclear weapons research if we wish to minimize the risk of a surprise attack. In the real world of today perhaps an endless arms competition is a necessary component of eternal vigilance which, as Jefferson would have it, is the price of liberty.

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MINUTES of the EXECUTIVE COMMITTEE Meeting at the FORUM on Physics and Society, April 17, 1983 at the Baltimore APS Meeting.

The Executive Committee meeting was called to order by William Chinowsky at 11:30 a.m. on Monday, April 17, 1983, in the Convention Center in Baltimore, MD. Executive Committee members present were Nina Byers, William Chinowsky, Bernard R. Cooper, Carol Jo Crannell, John Dowling, Eric Fawcett, Kenneth W. Ford, Ernest C. Hammond, Natalia Meshkov, Leo Sartori, and Dietrich Schroeer. Other interested persons attending included Earl Callen, David Hafemeister, Chuck Hebel, Brian Schwartz, and Peter Zimmerman.

1. Forum Arms-Race Studies

Leo Sartori reported on the progress of the Forum-sponsored arms-race studies. Starting early this year five groups had been formed to look at problems of missile survivability, EMP, proliferation, verification, and civil defense. All the groups had reported that morning on their progress. The present studies are more in the nature of self-education, asking what the major problems are that might be addressed by a larger-scale study. The next step is a small workshop to plan possible big studies. The Panel on Public Affairs under Tony Nero is reviewing a request for \$5K to \$7K to hold that conference later this summer. (Will there be a problem with classified data?) Millie Dresselhaus (future APS President) is supportive of this idea. Bernard Cooper felt that the Ford Foundation might be approached to fund this meeting, with the APS as guarantors. Nina Byers believed that APS funding might give the planning workshop greater credibility. Brian Schwartz wanted to use the APS money as leverage to get Ford funding for a larger topical conference. David Hafemeister thought one could do this meeting cheaply, but most felt that travel money, etc., would be required. Peter Zimmerman argued the APS should carry it as far as possible. Brian moved, and John Dowling seconded:

Motion No. 1: Leo Sartori should encourage arms-race studies over the summer, using APS funding. He should use his own judgement, based on progress, whether to approach the Ford Foundation, etc., for money to run a larger topical conference on the topic to push such studies further.

The motion passed unanimously. Nina Byers moved that

Motion No. 2: POPA and the APS Council are to be thanked for their support of the Forum arms-race studies.

This motion passed by acclamation, Willie Chinowsky will write such a letter of thanks. Each of the subgroup chairmen will send a summary of their progress to John Dowling for the Newsletter.

2. International Contacts

Eric Fawcett suggested the Forum might send copies of the Newsletter plus descriptions of these arms-race studies to physical societies throughout the world, e.g. to Japan, Canada. The Forum would thereby discover not only what others are doing, but also could ask whether they might want to participate in these studies in some way. Would the Forum want to contact also other organizations like Pugwash, NAS, etc.? It was suggested that the Forum should be very careful about such organizational contacts on this potentially politized issue. Eric will circulate all letters and names of potential recipients before sending anything out. Nina moved and Leo seconded:

Motion No. 3: A foreign-relations committee should be established for contact with Forum equivalents of foreign physical societies.

The motion passed unanimously, Willie Chinowsky will appoint this committee.

3. Topical Conferences

Bernard Cooper moved and Nina seconded:

Motion No. 4: Planning shall be initiated for a topical conference on arms-race issues, going beyond the workshop of this summer.

This motion passed unanimously. Willie will appoint Joe Lach to be chairman of this committee. Lach should talk to Leo, Bernard, and the studies directors. June 1984 sounds like a good time. A note from Willie on this proposed conference should appear in the Newsletter.

4. Forum/AAPT Publications

Kenneth Ford reported on the progress of publications by the AAPT of Forum symposia: the proliferation session is published, the nuclear-war symposium is to appear, the summer session on women in physics may be published, the symposium on alternative energy sources is still limping along. Could these items be published in the APS Bulletin? Who would pay the costs of \$100 per page? Ken will pursue that question. Comments were made about the refereeing, reprinting and copyability of these publications.

5. Freeze

There is an international move to endorse a freeze, saying "We call for an agreement to the testing, production, and deployment of nuclear weapons and nuclear-weapons delivery systems. Meanwhile, no further nuclear weapons or delivery systems should be deployed anywhere." Should the Forum circulate this petition? Brian felt the Forum should not do this. The APS Council statement has had sufficient impact, coupled with the May issue of *Physics Today* in which Keyworth and Marshak square off. There is no need

for the Forum to stick its neck out further at this point. Considerable debate about this proposed Forum involvement ensued. In the end Nina simply asked for help of anyone who cared to assist in circulating this petition.

6. Report of the Council Representative

Since the resignation of Barry Casper, Brian Schwartz has been acting as an unofficial Forum Representative to the Council. He reported on the most recent Council meeting:

a. He discussed reactions to the Council's nuclear-arms statement. Presidential Science Advisor Keyworth was very unhappy about it, a letter exchange will be printed in **Physics Today**.

b. The AIP issued a statement in favor of science education, the Council worried whether that statement was properly issued on its behalf - the AIP Governing Board will review how such statements should be issued.

c. The APS treasurer handles \$10 million each year; some money is "surplus" as the APS wants to have a reasonable cash reserve. The costs of APS journals to libraries are going up, in exchange the size of the pages is going up by 20%. A discussion followed about charges to the third world - it is pretty liberal already.

d. The Nuclear Regulatory Commission proposed the APS might want to undertake a study of "Radionuclide Release from Reactor Accidents." POPA was not too enthusiastic, liking neither the short time schedule nor the idea of a NRC observer. The APS Council would approve if it could be properly done, if the right chairman and group members could be found.

e. The APS Council strongly favored continuation and expansion of the APS Washington Office of Public Affairs: it is receiving \$50K this year, \$100K next year. A report by Bob Park (the "chairman of the office") on the office might be put in the Newsletter. Does he know anything about funding sources? He does know about matters of international security and scientific information, even though the APS recommendations on that issue were not accepted by the Administration. He is continuing to let the press know about difficulties with such policies as an early-warning system.

Willie moved to commend Brian for taking over this "temporary" position, the commendation was seconded by acclamation.

If the Forum can get the election of a new Council Representative completed by November 20, then she/he could attend the fall meeting of the Council.

7. Newsletter Report

The Newsletter Editor John Dowling reported on the

state of the Newsletter. That state is satisfactory, and the Forum membership is growing. John pointed out that if necessary for financial reasons, three issues of the Newsletter could be made to suffice -but everyone urged him to continue with four. He suggested that Krystal Hathaway be asked again to design questions for the APS candidates. Ballots will be included as part of a newsletter issue. The committee nominating candidates for Forum offices should think about student candidates.

8. Treasurer's Report

Dietrich Schroeer reported on Forum finances. His best guess is that \$1500 may be left in the Forum treasury at the end of FY-1982-3, including \$1000 from the 1982 short course on the arms race. He suggested that the chairman again ask for a \$3500 subsidy from the APS Council like last year. It was recommended that he redo the budget to set aside the short-course income as a reserve for conferences, etc.

On behalf of the ad hoc travel committee Dietrich proposed limitations on travel expenses paid by the Forum, seconded by Willie:

Motion No. 5: Travel funds for one trip per year for the chairman, vice-chairman, and secretary/treasurer shall be assured; this would probably be to the April meeting. If hopefully - these funds are not used, or if only some partial expenses are paid, then other members of the executive committee may ask the chairman for travel support of no more than transportation and two day's expenses. Travel expenses for speakers at Forum sessions must be approved by the chairman in advance, preferably there will be no such expenses, but if there are any then they are very unlikely to be approved if they exceed \$200. It is recommended that no sessions be planned where a significant number of speakers might need subsidies - unless the APS can be persuaded to fund it directly.

The chairman should seek additional budget contributions beyond the \$3500 to expand such travel funds. Earl argued that the Forum was set up to allow such travel pay for speakers. The motion passed.

Earl suggested the Forum institutionalize "Forum Contributed Sessions." But then one must watch out for co-authorship problems for people who want to contribute both to this session and to a "real" physics session.

9. Secretary's Report

The Minutes of the January 1983 meeting of the Forum Executive Committee were approved.

10. APS Fellowships

Peter and Dietrich suggested that a committee be appointed to nominate candidates for APS Fellowships under the sponsorship of the Forum. ½ %

of the Forum membership can be nominated in any one year.

11. The Technology Export Issue

Chuck Hebel reported on the state of the technology export act. The Corson committee report was not followed by the Administration in setting up guidelines. Instead more hardline guidelines have been proposed by the Mantulle committee. Some physics items may be controlled - e.g. solid-state devices. A new study of the problem is in progress. Some unclassified items/ideas could come under export controls. Should a summary of the Corson report be put in the Newsletter? Research fares well in the FY-1984 budget; but increases come mostly in the DoD, which may be moving some money into areas that could be controlled. Continued vigilance is needed to keep the debate in the goldfish bowl.

Submitted by Dietrich Schroerer, Dept. of Physics and Astronomy, U. of North Carolina, Chapel Hill, NC 27514.

deter or contribute to the threat of nuclear war, 2) are studies of Soviet CD germane to the discussion, 3) does CD treat only the symptoms, 4) what is the impact of CD on peacetime diplomacy or crisis stability, and 5) what problems arise if CD plans are inadequate or unworkable when the public has been led to believe otherwise.

So far the Forum Study Group on CD has started an examination of the above issues and has volunteers for special items such as a computer code for nuclear explosion effects, and a search of RAND and FEMA reports. Finally, a bibliography containing over 250 articles, reports, books and films has been compiled.

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Planned Study on Electromagnetic Pulse and Its Implications Including Effects on Command, Control, Communications and Intelligence. By Bernard R. Cooper, Dept of Physics, West Virginia University, Morgantown, WV 26506.

A nuclear explosion generates an intense electromagnetic pulse (EMP) likely to cut off communications and power. As a consequence, a central factor in current plans for designing U.S. war capabilities is the strengthening of the communications and control system. The key question is whether such "hardening" to the necessary technical level can be achieved. Does EMP of itself eliminate the possibility of limited nuclear war involving "controlled" retaliation? The Forum sponsored study will attempt to delineate and characterize various effects that define the quantitative basis for the credibility of the EMP threat. Insofar as is possible through the use of unclassified information, we will also attempt to gather information on differing perceptions of the EMP threat held by various armed services, contracting companies, committees, government agencies, and countries.

The disruptive effects of EMP resulting from a nuclear explosion give rise to a grave element of uncertainty about the U.S. power and communications system. For example, the July, 1962 test of a 1.4 megaton bomb 248 miles above the earth and about 800 miles southwest of Hawaii caused multiple electrical problems in Hawaii.

EMP is characterized by an electric field of approximately 50000 to 100000 volts/meter. W.J. Broad in the Jan.-Feb. Science articles on EMP claims that pulses may be as high as 1,000,000 volts/meter! The risetime of the pulse is about 10 to 20 nanoseconds which is 100 times faster than for lightning, and hence too fast for standard lightning protection devices. This electric field results from the outgoing pulse of gamma rays from the explosions interacting with molecules in the air between 40 and 20 km above the earth's surface. These gamma rays travel long distances and can interact with the system. Free electrons are ejected which produce secondary electrons. Enough of these electrons persevere and spiral along the geomagnetic field lines and hence create an electric field. Thus there can be systems-generated EMP, internal EMP,

FORUM STUDIES: Progress Reports from the Baltimore APS Meeting.

The Forum Looks at Civil Defense by John Dowling, Physics Dept., Mansfield State College, Mansfield, PA 16933

Civil Defense (CD) presents the Forum with an interesting paradox: since CD obviously has the potential to reduce both casualties and economic damage in the short term and speed up recovery in the long term, why does it suffer such a lack of credibility, or worse, such apathy?

The Forum can contribute to a CD study in the following areas: 1) what real physics applies, 2) what is practical, and 3) what is needed to make CD work.

The "practicality" deals with the extent to which people and structures can be protected from the blast, heat and direct radiation of nuclear explosions and the extent to which crisis relocation can be executed. Correspondingly, the limitations of expense, national resources, and common sense have to be applied to the above. Finally, we will examine what steps are most appropriate to initiate the study.

The Forum can also help in determining what is needed to make CD work, e.g., what steps are necessary for general public education and to establish a trained cadre of workers. The Forum may also contribute by examining present plans for stockpiling, shelter plans, and the crisis relocation plan.

It is not clear how much the political questions which surround CD can be or should be examined. CD is intimately tied up with such issues as 1) does CD

cavity EMP, and Compton charging unique to each particular system. Other factors may enter in, e.g., rate of change of E and H fields, polarizations, and pulse shapes.

Although electronic components can be acted on directly by an EMP, the main threat to electrical components is the induced transients generated by EMP-system interaction. The large electric field from an EMP pulse causes avalanche breakdown at a p-n junction. Thus there is a large energy to be dissipated at the junction which gives rise to extreme localized heating. Because semiconductor thermal diffusion time constants are long compared to EMP pulse times, great heating changes the conductivity at the junction. The result is short circuit and permanent damage to most very vulnerable solid state devices.

Vacuum tubes have thick metal parts, and hence much better protection (whether this is a deliberate or inadvertent Soviet advantage is arguable). Regardless, it is very difficult to avoid the use of solid-state devices in modern communications technology. Shielding communications lines and centers is very difficult since wires, pipes, and metal objects penetrate shielded structures. Electromagnetic energy must be transmitted as well as received, therefore antennae and input couplings are vulnerable sections. Long distance ground communication lines and fiber optics lines are fine. But switching centers still use solid-state circuitry and require large expenditures to shield. Airplanes used as control centers in the atmosphere can be shielded at great expense, but whether pulses of 100,000 volts/meter can be handled is uncertain. Satellites are vulnerable with regards to both the shell and to the devices within.

A system can be hard enough for one application and yet fail in another. For instance, a low-frequency radio transceiver might be adversely affected by EMP when operating alone as a relay station atop a remote hill, whereas it might not be affected at all by EMP when used as part of another system inside operational headquarters.

Several new technologies may be of use to reduce EMP effects. While shielding does not work well to protect satellites, special circuits (filter antenna inputs) and cables from low atomic number metals (Al not Cu; so electrons are less readily released) may be of help. Emergency communications systems can be set up using ground wave signals. Finally, EMP pulses can be clipped by new fast-acting types of Zener diodes. While this may not work for power grid or long communications lines it may be all right for small things like field radios. C.N. Vittitoe of Sandia National Labs is working with me to direct this study. The probable goal is pedagogical review. The three stages of the study are 1) self education, 2) selection of individual areas to write on and individual writing, and 3) a coherent review article.

The basic topics to be examined are

High-altitude EMP:

Of the many general types of EMP (ground-burst, air burst, dispersed, magnetohydrodynamic...), this is the most widespread in its influence and has generated the greatest alarm.

Inputs to EMP:

Air chemistry, weapon gamma-ray and x-ray (and perhaps neutron) outputs, models for the atmosphere, interactions between the photons, electrons, atmospheric parameters, resulting conductivity and current density that serve as drivers for the EMP.

Direct system interaction with EMP:

Photon interaction with a system and subsequent alteration in conductivity, current density and boundary conditions, breakdown effects.

EMP threats:

To C₃I systems, to power systems, to civil defense.

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VULNERABILITY: Some Questions for an APS Study on the Future of Land-Based Strategic Missiles by Peter D. Zimmerman, Physics Dept., Louisiana State Univ., Baton Rouge, LA 70803.

- I. Are land based missiles presently vulnerable?
 - A. Absolute missile/MIRV accuracy
 1. Bias errors
 2. Applicability of CEP as figure of merit
 3. Use of MARV and terminal homing.
 - B. Likelihood that an attack can be executed
 1. Reliability
 2. Fratricide
 3. Adequacy of the offensive C-3 system to initiate the attack under conditions of peace, nominal peace and high tension.
 - C. Possibility of a satisfactory point defense
 1. Adaptability of existing types of systems (Sprint/Spartan)
 2. "New" or "novel" systems (Swarmjet, guns, pebble screens, etc.)
 3. Impact on the ABM treaty as seen by both sides.
 - D. Structure of likely attacks
 1. EMP precursor shots and effect on C-3 of any system
 2. Likelihood of disarming first strike vs protracted exchanges
 3. Cost of knocking out ICBMs in terms of MIRVs not available for other purposes.