program to teach accelerator science. Wiedemann hopes to develop a course in accelerator science and perhaps to write a textbook on the subject. He sees the lack of textbooks as a major problem facing physicists who wish to launch accelerator-science teaching programs.

Fermilab. In Fermilab's new program, student applicants are expected to have passed all graduate qualifying exams and to be ready to select a thesis topic. A sponsoring faculty member at the student's university monitors the student's progress, working with the Fermilab Accelerator Science Committee. A Fermilab staff member approved by the sponsor and the committee supervises the student's thesis research.

Fermilab provides housing for students accepted into the program and pays them stipends comparable to what they would get at their own universities. The laboratory hopes to maintain about six students in the program.

When the laboratory initially contacted about 20 universities in the Midwest, the response was uniformly favorable, but some department representatives expressed concern about recruiting students. It is no secret that many physicists have been inclined to view accelerator science as "second-class physics." And partly because so few physicists do research on accelerator science at universities, students have found it difficult to get interested in the subject.

As it happens, Fermilab has now sent a poster announcing its new program to some 100 universities, and applications are likely to exceed the acceptance limit of six the laboratory has placed on the program, Fermilab's Roy Rubinstein reports. Two students have been accepted into the program, one from MIT and one from the University of Illinois, Chicago. Serious negotiations are being conducted with several more.

Texas Accelerator Center. Student interest in accelerator physics also turns out to be lively in Texas. The Texas Accelerator Center, a joint project of Texas A&M, the University of Texas at Austin, Rice University and the University of Houston, currently has about a dozen doctoral students from the four universities, and the aim is to boost the number to around 20. Two of the students have finished their course work, and another six or so will be that far along by the end of the summer.

In addition to training PhD students, the center brings about 20 juniors, seniors and beginning graduate students to the lab in The Woodlands to expose them to accelerator science. The students spend three months at the center, during which they get free housing and a stipend of $1000–$1500 per month. The center has applied to DOE, NSF and private industry for funds to support the summer program.

TAC's current budget comes to about $5 million a year, according to its director, Russ Huson. It receives some of its funding from the Baylor College of Medicine for the development of a 4-tesla magnet for use in magnetic-resonance imaging, and another portion of its funds from the SDI program, Huson says. Most of its money, however, comes from the Department of Energy, and most of it goes for design work on SSC.

Huson was the head of the accelerator division at Fermilab for five years and left, he says, partly because he feels that national laboratories are not ideal for teaching accelerator physics. They tend to be too isolated from the academic world, he thinks, and students tend too often to get sucked into established and inflexible projects.

Huson anticipates that the Texas Accelerator Center will send students to visit national laboratories but that most will do the bulk of their thesis research at the lab, working mainly on design and computer work for an advanced-technology, multi-GeV proton linac with a 15-MeV/m gradient. Peter McIntyre, a physicist at Texas A&M who serves as spokesman for TAC, says that TAC has submitted a proposal for the linac to the Department of Energy and is anxiously awaiting a reply.

Other programs. It is of course nothing new for the major national laboratories to accept an occasional graduate student to do thesis work in accelerator science, and a few physics departments have encouraged students to study accelerators. At Cornell University there usually are about six to eight physics-department faculty members specializing in accelerator science, supported by about a dozen accelerator specialists. The number of students working for doctorates in the field generally ranges from six to eight.

The Cornell accelerator group is generally recognized as the premier team in the academic world and includes luminaries such as Maury Tigner, chairman of the SSC central design group; Boyce McDaniel, head of the SSC board of overseers; and Robert R. Wilson, who designed the Cornell Electron Storage Ring.

The State University of New York at Stony Brook, the University of Maryland, the University of California at Berkeley, the University of Wisconsin and Caltech also turn out an occasional PhD in accelerator physics, according to Cornell's Siemann. It is Siemann's impression that accelerator science is a substantial part of the physics program only at Cornell and Maryland.

Asked for examples of the kind of doctoral work a student might do in accelerator physics, Siemann mentioned three Cornell dissertations ranging from the purely theoretical to the purely technological: "Statistical method for nonequilibrium systems with applications to accelerator beam dynamics," "Multibunch instabilities and current-dependent phenomena in the Cornell Electron Storage Ring" and "Injection process of the Cornell Electron Storage Ring."

Siemann notes that a great many accelerator physicists started out in other fields and were retrained as accelerator physicists while doing postdoctoral work or later. Brookhaven has a formal Accelerator Technology Fellow Program, run by Paul Reardon, to provide postdocs with such training.

In addition Melvin Month of Brookhaven conducts a regular summer school in accelerator physics at varying locations. These summer sessions provide established accelerator physicists with refresher courses, give young postdocs an opportunity to learn something about accelerator physics and yield useful conference proceedings that are published by AIP. Month has just established an APS topical group on particle-beam physics.

—William Sweet

Britain and Germany sign SDI-research agreements with US

The Strategic Defense Initiative has gained some ground among US allies, though opinion about SDI in allied countries remains deeply divided. The US government has concluded agreements with the British and West German governments permitting companies in the two European countries to bid for work supported by the SDI Organization, and it is anticipated that other major US allies will sign similar memoranda of understanding in the coming months.

When the US government invited friendly countries to join in research on missile defenses early last year, there was a lively response from European and Israeli companies, especially those in the electronics and aerospace industries. The initial reaction from most government leaders, however, was wary. The most prevalent first reaction from Europeans was that a missile-defense system would not be in their interests even if it worked, because it might enable the United States to protect itself in a nuclear war while leaving the Europeans vulnerable to attack from missiles stationed just across their borders. The French government promptly dissociated itself from the SDI enterprise and proposed an alternative joint European research program it dubbed EUREKA. Only the Israeli government expressed almost unalloyed interest in getting involved in missile-defense research, though Portugal, Italy and Luxembourg also expressed interest early on.

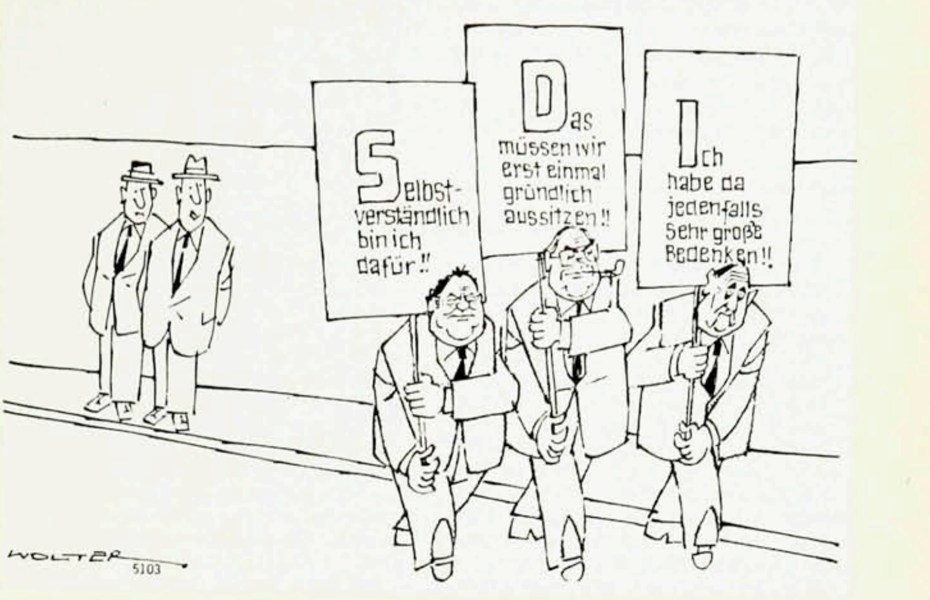
In the United Kingdom and West Germany, where opposition parties strongly oppose SDI, mainly on the supposition that it will escalate the arms race and impede arms control efforts, government leaders felt they were being asked to make a dangerous political commitment in exchange for very uncertain military, scientific and economic returns. Last December, when negotiations were entering a crucial phase, US officials implied that billions of dollars in SDI money might go to Europe, but there were good reasons to be skeptical.

For one, Congress was cutting the Reagan Administration's requests for SDI funds, and in reaction the SDI Organization decided last November to reallocate its money to emphasize rocket interceptors and free-electron-laser systems—areas in which foreign companies can scarcely be expected to play much of a role (PHYSICS TODAY, January, page 53). By far the most advanced work on free-electron lasers is being conducted at US laboratories; work on rocket-interceptor systems is even more advanced, and it is unlikely that Europeans would have much to contribute at this late stage of development.

Even so, observes Lieutenant Colonel Simon Worden, free-electron lasers and interceptors are being emphasized primarily as potential boost-phase intercept systems. Worden, a personal assistant to SDI chief Lieutenant General James Abrahamson, says that there is a lot of room for European participation in mid-course and terminal defense systems.

Other barriers to European contracts include ABM Treaty limitations on transfers of ABM components, the limited capabilities of European industry in crucial areas and the improbability of the US selecting foreign companies for work with potentially large economic spinoffs, John Pike believes. Pike, a space-weapons specialist with the Federation of American Scientists in Washington, testified to Congress on 10 December 1985 that one could realistically expect at most $300 million, or 1% of the SDI budget, to go to European contractors.

The British approach in the negotiations was to demand a guarantee of $1.5 billion in SDI contracts as the price of signing an agreement that would officially involve the United Kingdom in the program. The British failed to win that guarantee, and when US Defense Secretary Caspar Weinberger and British Defense Minister Michael Heseltine finally concluded an agreement on 6 December, the details were declared secret. Within weeks Heseltine was out of office, an apparent victim of an intricate cabinet fuss over whether to favor a European or a US helicopter firm. Naturally rumors soon flew that Heseltine really was out because he opposed and resented Prime Minister Margaret Thatcher's decision to conclude the SDI agreement. While there is little or no evidence to support that suspicion, his departure fortified the perception that taking a position on SDI can be dangerous to one's political health.



Three political heavyweights in the current West German coalition government are portrayed in this cartoon walking in step on SDI—but the words on their signs belie the image of unity. Carrying the "S," Franz Josef Strauss, leader of Bavaria's right-wing Christian Socialist Party, is saying, "Naturally I am for it." Carrying the "I," Foreign Minister Hans-Dietrich Genscher says, "I in any case have serious reservations." Chancellor Helmut Kohl, in the middle, is saying, "First of all, this is something we have to fundamentally sit out."

The Federal Republic. By this time, early 1986, the West German government appeared to be dragging its feet. Heinz Riesenhuber, minister of research and technology, publicly stated that participation in SDI could not be justified on the basis of its alleged usefulness to civilian research. Foreign Minister Hans-Dietrich Genscher was known to oppose participation in SDI because he feared it would wreck arms control and damage German–Soviet relations. Chancellor Helmut Kohl was considered insistent that an agreement had to be concluded, but even he seemed inclined to stall (see cartoon).

By late winter, commentators in the United States were beginning to wonder whether there would ever be an agreement, while in Germany the press was reporting that the Kohl government was under intense US pressure to sign by Easter. A memorandum of understanding was in fact finalized the week before Easter, a traditional day (since the 1950s) for peace marches in Germany and the UK. Weinberger signed the memorandum for the US government, Economics Minister Martin Bangemann for the Federal Republic. The German government insisted on making Bangemann the signatory of the agreement to stress that it puts priority on the economic rather than the military aspects of SDI cooperation.

Reaction to the agreement in the German press was lukewarm. As a press review issued by the German government put it, "While available comment seemed to prefer success at the disarmament talks to the creation of a new generation of weapons, it also supported cooperation in the SDI project as long as it will also serve to protect European security interests."

Assessments. According to one school of thought, stated last December in *The Wall Street Journal* by one of the paper's Europe editors, the Reagan Administration's campaign to drum up European participation in SDI was a mistake because the Administration "let Europeans behave as though they'd be doing America a favor by participating."

R. V. Jones, a leading British expert on air-defense systems, supports the idea of defenses against ballistic missiles, but he feels that US Defense officials engaged in an "awfully hard sell." Jones felt that the British government should have raised tough questions about the feasibility of certain missile-defense systems in the negotiations with US officials; his views about SDI are summarized in the box below.

The campaign to win European support for SDI would appear in a dim light if it were to end up costing the supporters their jobs. That could hap-

Jones, British air-defense expert, discusses SDI outlook

R. V. Jones, a leading British expert on air defenses since the mid-1930s, is consulted frequently by governments on defense issues. He supports SDI "as a vigorous effort to explore what can be done to counter nuclear missiles" but is "very skeptical about the application of directed-energy weapons at long range."

Background. Educated at the University of Oxford, Jones took up the study of infrared detectors at the Clarendon Laboratory in the mid-1930s, which brought him into contact with the closely related radar technologies. When the war broke out, Jones was quick to emerge as a leading figure in efforts to counter the German Luftwaffe. His first major accomplishment was to figure out that the Germans were using systems of intersecting radio beams to guide their nighttime bombers. After winning the so-called "battle of the beams," Jones went on to conduct studies of German radar systems, the V-1, the V-2 and other major technological programs. A few months before D-day, Jones was able to convince Deputy Allied Commander Arthur W. Tedder of the crucial importance of locating and knocking out Germany's coastal radar. An anti-radar effort was authorized, and on the eve of the invasion the Allied forces succeeded in knocking out all but six or so of Germany's 47 radar stations on the Channel coast.

Jones has been on the faculty at the University of Aberdeen since 1946, except for the years 1952–53, when Winston Churchill brought him back into government to serve as the chief of scientific intelligence in the consolidated defense ministry. Jones has described his wartime activities in *Most Secret War* (1978), which appeared in the United States as *The Wizard War*, a phrase Churchill coined to describe the operations Jones and his colleagues conducted. In an interview conducted on 1 April, Jones discussed his views about SDI with PHYSICS TODAY.

Radar vs. directed energy. In his book, Jones notes that the British first began to think about radar when a committee on air defenses was set up in 1935 and immediately took up the question of "death rays"—"the idea being the creation of a sufficiently strong beam of electromagnetic waves which would heat up anything in their path." It was quickly calculated that the power needed was far beyond contemporary technology, but having brought up electromagnetic waves, the committee got to thinking about radar. By the time the war broke out, it was apparent to specialists such as Jones that development of effective radar would depend on finding means of getting wavelengths down into the centimeter and millimeter regions and of increasing output power. Now, with directed-energy weapons, we are back to death rays, with the key problems being to increase the power and to focus the beams.

Jones sticks to the very skeptical assessment of directed-energy weapons at long range that he outlined in an article published in June 1985 by the Centre for Policy Studies in London. Jones believes that any directed-energy device placed in geostationary orbit would have to have a precision at least ten times better than the space telescope's, which he does not consider achievable in the foreseeable future.

Low-orbit lasers. Turning to laser or particle-beam weapons put on patrol in low orbits, Jones considers the technical possibilities somewhat more interesting. He thinks it might be possible to use a laser beam as its own optical radar by sending out a broad beam and then using the reflected light to focus the beam sharply on a region of the enemy booster. He is especially interested in recent work on phase-conjugation techniques. Jones reports that Lieutenant General James Abrahamson, head of the SDI Organization, is trying to get top security clearances for him so that he can be briefed about the latest advances in methods of overcoming atmospheric distortion and of switching beams from target to target without having to move or refocus mirrors.

Jones remains worried that a laser of plausible specifications would have to be able to make a beam "dwell on a spot of just under 1 meter diameter on a booster at a range of 3000 kilometers for seven seconds in order to produce sufficient disruption." Overall, he wrote last year, "it is hard to differ from the opinion of Edward Teller, who, although he supports SDI, is quoted in *Commentary* for March 1985 as saying, 'Lasers in space won't fill the bill—they must be deployed in great numbers at terrible cost, and could be destroyed in advance of an attack.' "

JONES

Jones himself supports the SDI research program on the simple moral ground that if there is any possibility at all of defending populations against the danger of nuclear extermination, then one must explore that possibility. But he is inclined to think that it would or will probably take until the middle of the next century to develop and deploy an ABM system that would require us to change the doctrine of mutually assured destruction.

Rocket interceptors. Looking to the decades immediately ahead, the technology that makes sense to Jones is the type of infrared homing interceptor being developed as an anti-satellite weapon by the Air Force and as an ABM system by SDI. "This is the part of the program I would support," Jones told PHYSICS TODAY. It might be worth deploying such a system to defend missile silos, as permitted by the ABM Treaty, Jones said, but "whether or not it is worth it has to be thought through by the policymakers." He said that "in a way you already went through this with Sentinel and maybe it would go the same way again."

Asked about his "feel" for the types of inventions that would be required to make directed-energy weapons work, as compared with his feel in 1938–39 about the inventions that would be needed to make radar work, Jones became cautious and self-deprecating. He was "much closer to the front line then," he said, and "I couldn't guarantee my grasp on the current situation as I could then."

Pressed, he conceded that when he wrote a report in 1937 saying that it would be necessary to find ways of shortening radar wavelengths drastically and boosting power substantially, he felt very confident that the required inventions would be made. He does not feel the same way about directed-energy weapons at long ranges today.

"Of course the big difference between those days and now is that if you knocked out 10% of the enemy bombers, offensive operations became unsustainable and damage could be managed. Now you have to come up with such a fantastically effective defense, and you know how many things can fail once you are committed to operations," Jones said.

He went on to say he felt it was unfortunate that President Reagan couched the SDI research program in such dramatic terms. He felt that this had "interrupted the smooth course of ABM research and polarized scientists so that now you get people on both sides saying silly things, for example, the Union of Concerned Scientists statement that SDI is 'morally repugnant.' "

—WS

pen if negotiations with the Soviet Union came to a total deadlock over SDI, the United States were widely blamed and the conservative governments in the United Kingdom and Germany were driven from office because of their support for President Ronald Reagan.

It already is apparent that the European peace movement, which has been disoriented since its defeat in the effort to block the deployment of US missiles in Europe at the end of 1983, is seizing on SDI as its next focal issue. The Campaign for Nuclear Disarmament, the largest peace organization in the United Kingdom, voted at its annual conference last November to launch "a major campaign against SDI." In West Germany, anti-SDI demonstrations took place at 150 places on Easter, with support from a coalition of 40 peace groups, the Social Democratic Party, the Greens, the Federation of German Trade Unions, the German Communist Party and a variety of Catholic and Protestant groups.

Despite the breadth of the anti-SDI coalition in Germany and of a similar coalition in the UK, few political analysts would bet that either will succeed anytime soon in building an alliance capable of gaining electoral majorities. In both countries, the opposition is deeply divided—in the UK between the Labor and Social Democratic parties, and in Germany between the Socialists and the Greens.

In all, Reagan seems to have gotten what he wanted. With Germany aboard, several more significant memoranda of understanding will be concluded. Agreements with Italy, Israel and Japan are considered near certainties, and even France may reconsider and join. In March the French returned a conservative majority to Parliament, a conservative prime minister and cabinet now are "cohabiting" with socialist President François Mitterrand, and the defense minister in the new government is reported to be an enthusiastic supporter of SDI.

—WILLIAM SWEET

AAS elects Burke and Dupree to top offices

Andrea K. Dupree of the Harvard–Smithsonian Center for Astrophysics has been elected 1986 vice-president of the American Astronomical Society. Bernard F. Burke, William A. M. Burden Professor of Astrophysics at MIT, who was elected AAS president last year, will remain in office until 1988. Marc Aaronson of Harvard, Robert D. Gehrz of the University of Minnesota and Joseph S. Miller of Lick Observatory have been elected AAS Councilors.

DUPREE

Burke received his BS from MIT in 1950 and his PhD from MIT in 1953. He worked at the Carnegie Institution's Department of Terrestrial Magnetism in Washington, DC, from 1953 to 1965, serving as chairman of the radioastronomy section from 1962 to 1965. His research interests have included radioastronomy, galactic structure, microwave interferometry, microwave spectroscopy, antenna arrays, low-noise electronic circuitry and quasars.

Burke served on the advisory committee to the National Radio Astronomy Observatories from 1958 to 1962 and the astronomy advisory committee to NSF from 1958 to 1963. He has been a trustee of Associated Universities Inc since 1972.

Dupree received a BA from Wellesley College in 1960 and a PhD in astronomy from Harvard University in 1968. She stayed at Harvard as a research fellow from 1968 to 1974, a research associate from 1974 to 1975, and a senior research associate in astronomy and astrophysics from 1975 to 1979. She has been a lecturer in the Harvard astronomy department since 1970, a senior astrophysicist at the Smithsonian Astrophysical Observatory since 1979 and associate director for solar and stellar astrophysics at the Harvard–Smithsonian Center for Astrophysics since 1980. She works on stellar astronomy, the interstellar medium and high-resolution spectroscopy.

BURKE

Aaronson received his PhD from Harvard in 1977 and works mainly on stellar populations and stellar cosmology at the Steward Observatory. Gehrz received his PhD in 1971 from the University of Minnesota, where he now teaches. His research involves infrared astronomy, interstellar and circumstellar material, regions of star formation, mass loss, novas, astronomical instrumentation and telescope construction. Miller received a PhD from the University of Wisconsin in 1967 and currently works on extragalactic astronomy, active galaxies and quasistellar objects at Lick Observatory, where he is assistant director.

New Ewald Prize will honor leading crystallographers

The International Union of Crystallography has announced the establishment of the Ewald Prize for outstanding contributions to the science of crystallography. The prize was named with the consent of the late Paul Peter Ewald in recognition of his contributions to crystallography and to the International Union of Crystallography (see obituary, page 104).

The Ewald Prize is expected to be the "foremost award in crystallography," according to Robert F. Bryan, a chemist at the University of Virginia, Charlottesville, who is secretary for the US National Committee for Crystallography. Bryan says that the award should "greatly help to increase awareness of our discipline in the scientific community, building on the recognition afforded it by the 1985 Nobel Prizes in chemistry to Jerome Karle and Herbert A. Hauptman, both noted US crystallographers" (PHYSICS TODAY, December, page 20).

The Ewald Prize consists of a medal, a certificate and a financial award. It will be presented once every three years during the triennial International Congress of Cyrstallography. The first prize will be presented at the 14th congress, to be held in Perth, Australia, in 1987.

Nominations for the Ewald Prize are invited and should be submitted in writing, accompanied by supporting documentation, to the Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, United Kingdom. The deadline for nominations is 30 September 1986. □