Krumhansl says NSF underfunds physical sciences

An across-the-board 25 to 30% underfunding in NSF support of university-sited basic research in the mathematical and physical sciences and engineering currently exists. So stated James A. Krumhansl, the new assistant director in charge of NSF's directorate for those fields. Krumhansl, who was sworn in on 21 December 1977, also sees a serious underfunding for modern instrumentation—a problem that he feels may take five or more years to overcome. He told PHYSICS TODAY that NSF sees a bright future for synchrotron radiation, and that support by the agency for solid-state theory will be more certain through the recent formation of a separate program for condensed-matter theory.

Krumhansl, a physicist, received his PhD in 1943 from Cornell University, where he has taught during three separate periods (1943–44, 1948–54 and since 1959, when he was named full professor). Krumhansl's research interests have been primarily in the fields of theoretical solid-state physics, materials science, applied mathematics and electrical engineering.

Krumhansl told us that the underfunding situation had developed from "the integrated accumulation of terminations of basic research support going back several years." If NSF had available

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the funds to remove the shortfall that he perceives, he is certain that there would be "no concern whatever that it would support high-quality research." He applauded the sympathetic attitude that President Carter and his scientific adviser Frank Press have taken toward establishing a policy that recognizes the need for renewed support of basic research. But he warned that the present situation, having come about through several years of underfunding, is going to take a while to correct.

He added that "a significant part of our problem is not only being able to support people, but also to provide those people with modern instrumentation and equipment that they need. This is an on-going need and one that is particularly susceptible to obsolescence, normal depreciation, and so forth." He sees this component of the problem as being particularly significant with respect to international competition, and suggests that it might take as much as five years for the US to just come even in replacing obsolescent equipment.

Krumhansl is enthusiastic about the work presently being done in synchrotron radiation. He noted that "both the breadth of application and the unique capabilities to do certain kinds of experiments in this area are developing on even a more significant scale than we had expected, and it will be a thrust that we shall support—not simply as a machine thrust, but also because of its broad role as an underpinning of many basic research areas in physics, chemistry, biology and materials. I look forward to seeing much good coming from it." Through its materials-research division NSF currently supports synchrotron-radiation facilities

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Source of East Coast booming noises still a mystery

They may come as a series of sharp, explosive cracks, or as a rumble like distant thunder. They occur most often during the day, but they can strike in the middle of the night as well. Flashes of light, high in the sky, sometimes accompany them.

The mysterious booming noises heard along the East Coast of the US and Canada, from Nova Scotia to South Carolina, first reported in December, have provoked official investigations and scientific controversies. Hundreds of booms are now on record, but their origin is still a mystery.

Some of those who have studied the boom phenomena blame them on supersonic aircraft—either the Concorde, flown by British Airways and Air France, or US military planes on maneuvers—but the mechanism by which the booms (and flashes) are generated and carried over long distances remains the subject of speculation. Meanwhile, others maintain that natural causes account for at least some of the events.

Is Concorde the culprit? Early in March the Naval Research Laboratory reported, after a two-month investigation, that military aircraft were producing some of the booms during brief supersonic sprints; such craft have flown supersonically while on maneuvers for years, but NRL explained that unusual weather conditions had allowed the mystery booms to propagate. Close approaches of Concorde to Nova Scotia might be causing some booms there, the report said. Then Jeremy J. Stone, director of the Federation of American Scientists, also concluded that the Concorde had a role and claimed that its approaches to and departures from East Coast airports were also generating "superbooms" heard more than a hundred miles away.

Stone has found correlations with Concorde arrivals and departures for hundreds of reported booms, mainly from the Cape Sable region of Nova Scotia. Incoming Concorde flights make a slight turn about 50 miles off Cape Sable in their approach to John F. Kennedy International Airport on Long Island, and Concordes departing from JFK turn about

0031-9228/78/3106-0061$0.50

BRITISH AIRWAYS

Concorde flights have been implicated as the cause of some booming noises heard off the East Coast of the US, according to Jeremy Stone (Federation of American Scientists) and Richard Garwin (IBM). A recent Naval Research Lab report attributes some of the booms to military aircraft.

150 miles off Nantucket Island. (Planes bound to and from Washington's Dulles Airport fly straight paths.) These turns at supersonic speed, Stone said, may be providing multiple opportunities for the generation of shock waves, which then somehow produce the superbooms. Accelerations and decelerations and supersonic speeds may also be generating far-travelling booms, according to Stone.

Are booms felt, not heard? The superbooms identified by Stone are a type of "secondary" boom. Primary sonic booms are detected where the cone-shaped shock wave dragged along by aircraft moving at supersonic speeds intersects the ground to form a "boom carpet." Secondary booms, refracted from thermal-inversion layers in the atmosphere, generally are weaker than the primary type. Like the booms reported along the East Coast, secondary sonic booms are chiefly infrasound, low-frequency vibrations that are not directly heard but which may create audible reverberations in building and other objects. (About 94 percent of the reported mystery booms were detected by persons inside buildings.)

Stone told us his claims about the Concorde are supported by investigations of mysterious booms that occurred in Europe last year, before significant Concorde traffic reached the US. The British, Stone said, identified the Concorde as the source of their "bumps in the night" in an interim report of the Undersecretary of Trade that explained the unusual noises as the bouncing of secondary booms between the Earth and atmospheric reflection layers at altitudes of 30 and 60 miles. "Booms reflected from the upper layer," said the report, "are of very low frequency and tend to be felt rather than heard. Those reflected from the lower layer retain the characteristic double bang of the primary boom, but at a much lower energy level . . . ."

The British and the French have since joined in a joint investigation into the relation between the mystery booms and the Concorde, but both nations have refused to send representatives to a meeting called by the US Navy to consider the question, Stone said.

The legal problem. What difference does it make whether it is the military planes or the Concordes that are producing the booms? Proposed new Federal Aviation Administration regulations would permit no measurable sonic booms from civil aircraft on US territory or seas out to the three-mile limit. If the Concorde is proven to be the source of some of the East Coast booms, and if those events are sonic booms covered by FAA regulations, then the plane may have to use different flight paths for its US routes.

Any major change in flight paths could injure severely the viability of Concorde cross-Atlantic travel, according to Stone, because the planes can barely fly the present routes. "The Concorde carries only a 30-minute fuel reserve," he said, "and high headwinds have already forced it to land in Newfoundland when it was bound for the US." The aircraft's payload, already very small compared to the mass of the plane and the even larger mass of the fuel necessary each trip, can be reduced hardly at all if the flights are to be profitable.

FAS opposed American efforts to build commercial supersonic transports but offered no opposition to the landing of British and French Concorde flights at US airports. "We are not trying to put the Concorde out of business," said Stone. "We just want to explain these events."

"We know," he says, "that the Concorde is causing the booms, over considerable distances, in England and Nova Scotia." As for the rest of the mystery booms, he believes that some mix of Concordes and military aircraft, with contributions from unusual meteorological conditions, is responsible. The NRL is investigating Stone's findings.

Hyperbooms. Stone also found some correlation between Concorde flights and booms in New Jersey and in Charleston, S.C. He asked Richard L. Garwin, a physicist at IBM's Watson Research Laboratories, if sonic booms could explain these events. In response, Garwin has postulated Concorde-induced "hyperbooms" that may travel thousands of miles and reach the ground ahead of the planes that spawned them, if the aircraft lands or goes subsonic towards the end of its travel. And he can possibly account for the luminescence associated with some of the booms.

Garwin suggests that shock waves radiated from the Mach cone of supersonic aircraft, as they propagate upward through the atmosphere, bend in accordance with Snell's law for refraction between different media (because the speed of sound is dependent on temperature, which varies with altitude). At about 100 miles above the Earth, the waves enter the hot, rarefied thermosphere, where their paths become horizontal and then gradually bend downward again in an arc symmetric to the rising path. For an aircraft moving at Mach 2 in daylight hours, Garwin estimates that the distance between sea-surface bounces for the hyperboom waves would be approximately 1000 miles.

The hyperboom shock travels most of the distance in the thermosphere, at supersonic (aircraft) velocity, and can strike points extended along the plane's great-circle path. Such a phenomenon might explain correlations between Concorde flights and booms reported from Charleston, S.C., which lies 800 miles away from JFK on a great-circle path.

Sonic booms of the magnitude generated by the Concorde, Garwin calculates using the hyberboom model, conceivably could produce a temperature change of 10 000 K in the thermosphere, thus giving rise to light emission. He also predicts that thermospheric sonic booms should be double, with a two-minute separation in arrival time between shock waves emitted upward and downward from the Mach cone initially. Charleston observers have noted such intervals between events.

Why have hyperbooms not been detected long ago? Garwin answers that hyperbooms would occur only for large aircraft in level supersonic flight for a considerable time: Military aircraft, he says, typically spend only minutes at a time at supersonic speeds, whereas the Concorde travels at such speeds about six hours per day. "Another thing that lets the military craft out," he says, "is that they don't fly the same routes every day like the Concorde, so you don't know where to expect booms from them." Garwin's 14-page paper, in which he develops his hyperboom explanation, may

be obtained by writing to him at the IBM Watson Research Lab, Yorktown Heights, N.Y.

Doubts and disclaimers. William L. Donn, an atmospheric-wave researcher at the Lamont-Doherty Observatory in Palisades, New York, disagrees with Garwin's hyperboom hypothesis. He argues that no one has shown hyperbooms to exist, and at the observatory "we are listening all the time and have detected none." Donn told us that he and his colleagues have observed Concorde booms—"a strong component against the ordinary infrasound background, but nothing that will shake houses."

Donn holds that the best explanation for the East Coast booms is that offered by the NRL, military aircraft flying too close to shore. He suspects that such booms have been going on for a long time, but that people are more inclined to report such things now than in the past.

An FAA spokesman claims that the Concorde flights have from the beginning obeyed the law about overflying the US at supersonic speeds. Only one incident, a boom produced in June 1976 when an Air France plane approached within some 20 miles of the coast while flying supersonically, has been recorded by the FAA, and the agency made that occurrence public. FAA is continuing to monitor the Concorde as well as other craft for sonic booms.

The spokesman denied that the secondary booms attributed to the Concorde are the Garwin hyperbooms or that they are audible. He also noted that several US military aircraft, including the FB-111 and the FR-71, typically sustain supersonic flight for long periods in their maneuvers.

Nature's way. Before the Concorde loomed large in the mystery-boom case, Cornell University astrophysicist Thomas Gold and geophysicist Gordon J. F. MacDonald (consultant to Mitre Corp) were ready to announce that some of the booms and flashes might be natural phenomena of a sort sometimes related in the past to major earthquakes. They consulted Stone about holding a press conference to publicize the suspected connection. Stone, after investigating their ideas on his own and becoming aware of the possible Concorde role, advised Gold and MacDonald not to go ahead.

Gold thinks that natural phenomena have caused some of the booms and should be taken seriously as possible earthquake heralds. His theory is that methane and hydrogen from deep within the Earth, possibly prebiogenic in origin, are being vented from the ocean floor and ignited by electrical sparks generated in the gases' passage through the atmosphere. Booms and flashes at sea were noted in Charleston in 1886, shortly before an earthquake flattened the city.

One of the strongest arguments against the Gold–MacDonald view is that most of the booms have occurred during the day while one would expect natural phenomena originating deep below the Earth's surface to be independent of the diurnal cycle. Gold points out that several booms *have* been reported between 10:00 pm and 5:00 am, including a large one heard in New Hampshire in the middle of the night, when records showed no supersonic aircraft in the area.

Gold likes to observe that well-documented booms of the last century heard in the Ganges delta region, in the Mediterranean and elsewhere, are not explained easily by supersonic planes. He agrees that many of the booms detected recently may be artificially produced, but he worries that a real "background" of natural booms may be ignored if people accept supersonic aircraft as the sole explanation.

Gold told us that he and MacDonald did not hold their intended press conference because they had trouble obtaining a copy of the NRL report initially ("We didn't want to go in unarmed"), and later they felt there was insufficient interest. Of the NRL study, Gold says, "They belittle the role of natural phenomena and leave out the events for which they cannot account. The record of booms associated with explosions and lights in the past cannot just be swept away."

Floyd Carse Bennett

Krumhansl and NSF

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at the University of Wisconsin and at Stanford University (PHYSICS TODAY, March 1978, page 103).

For solid-state theory Krumhansl conceded that there might have been a period in which NSF's support was uncertain. This uncertainty may have arisen when in 1972 NSF's solid-state physics program was transferred from the physics division. Accommodation was made in subsequent years. Now, however, that NSF has just begun a separate program in condensed-matter theory, under the direction of John Connolly, in the materials-research division, he expects further clarification of the support in this area.

We asked Krumhansl if his directorate supported any work in applied physics. He suggested that there might be a few programs in the materials research and engineering divisions that are close to applications, "but they are quite long range in character, and that is in significant distinction from ASRA." NSF's Applied Science and Research Applications directorate, the successor to the old RANN (Research Applied to National Needs) program, now handles most of the agency's applied research activities. Krumhansl related that he has strong encouragement from Congress and other governmental areas to maintain a role of support of basic research within his directorate. In addition, NSF has just announced a joint university–industry program across the Foundation.

NSF has occasionally been criticized for allegedly trying to influence the direction of research in various fields, rather than letting the scientists do it, so we asked Krumhansl for his views in this area. He expressed great confidence in NSF's system of advisory panels. He pointed out that these panels "are staffed by a broad distribution of very highly qualified scientists, and one of their main concerns is to examine the balance of support in various fields. I believe, from the reports of the advisory panels that I have seen since coming here and from questions that have been raised and answered, that there is no significant evidence that anyone but the scientific community is determining the direction of research. I don't foresee any significant organizational changes. I think that the way in which we make decisions about programs to support is in the best traditions of determining merit and scientific quality."

In the materials-research area, several scientists, whose research interests are relatively narrow-focused, have complained that funding for their work from NSF has been hindered by the presence on their campus of an NSF-supported Materials Research Laboratory. Krumhansl noted that it is indeed NSF policy to emphasize support at these laboratories (located on 15 US campuses) for research that has an interdisciplinary character or thrust, but he pointed out that the materials-research division now has separate sections for metallurgy and materials and for condensed-matter sciences. "As far as NSF is concerned," he argued, "this doesn't represent a closeout of possible support for any individual investigator."

Krumhansl indicated that the newly formed Department of Energy has taken over nearly all of the research that the Energy Research and Development Administration had previously supported, and thus saw the NSF as gaining no new responsibilities in basic research as a result of that reorganization. He did tell us that he looks forward to an across-the-board liaison with DOE. One example of this liaison is the recently formed Nuclear Science Advisory Committee (PHYSICS TODAY, February 1978, page 77), which, he noted, has recently made a long-range recommendation to DOE and NSF regarding priorities in low-energy and intermediate-energy nuclear physics with respect to facilities and machine development.

Krumhansl perceives the greatest challenge of his job as being one of communication—to provoke it not only among scientists but also between the scientific community and the public. He argued that "the greatest need is thoughtful communication by scientists