and isospin structure of the neutral weak current—another important test of the Weinberg–Salam theory. With present detectors and neutrino beams it is feasible to study the weak interactions and nuclear structure with neutrinos probing nuclei.

▶ Heavy ions. Recent deep-inelastic-scattering experiments with heavy-ion beams have revealed a new and unsuspected reaction mechanism, in which the projectile kinetic energy is almost totally converted to internal energy of the nucleus. For glancing collisions, on the other hand, states of very high rotational velocity have been observed, with consequent changes in the shape of the nucleus. At sufficiently high spins this leads to fission. The Committee's report points out that new phenomena and new surprises can be anticipated as the energy of the ion beams is increased. At about 12 MeV per nucleon, the ion velocity will exceed the velocity of sound in nuclear matter; the threshold for pion production comes at about 150 MeV/nucleon; at ultrarelativistic energies (10 GeV/nucleon has been proposed) proton–nucleus scattering results lead one to expect unusual phenomena.

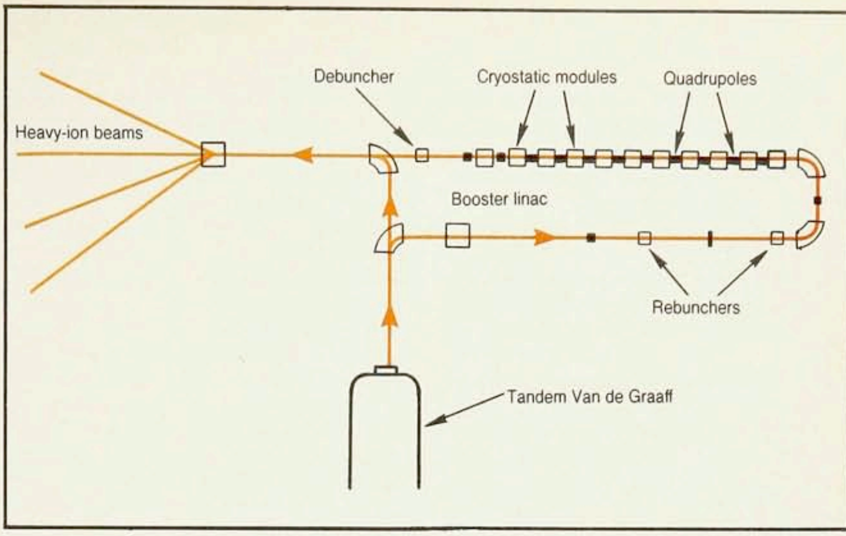
The report discussed other recent advances and the opportunities they offer for the next decade—in studies of nuclear charge and current distributions, "nuclear molecules," multiparticle correlations, tests of quantum electrodynamics, and the use of pions and light ions as nuclear probes. Applications of nuclear science for solid-state technology, radiochronometry and medicine are also surveyed.

Long-range plan. The Advisory Committee's report stresses the fact that experimental nuclear physics in this country is at present widely dispersed in university and government labs of differing sizes, using a variety of nuclear probes over a great range of energies. In contrast to elementary-particle physics, where low-energy facilities quickly become obsolete as higher energies are attained, the Advisory Committee feels that the current diversity of experimental facilities is appropriate for a broad attack on the most urgent questions in nuclear science. Experiments at low energies are expected to play an important part in this broad approach. Though the Committee does recommend the construction of some new national facilities, it urges that considerable attention be given to upgrading existing local and intermediate-size user laboratories.

The Committee's plan through 1986 includes the following recommendations for construction:

▶ A neutrino "horn" at LAMPF (Los Alamos Meson Physics Facility), to serve as an intense source of relatively low-energy neutrinos.

▶ A kaon channel at Brookhaven. This high-performance beam line and spectrometer system at the AGS synchrotron would provide increased K-meson intensity.



"Afterburner," to boost the energy of heavy ions from the Stony Brook tandem Van de Graaff, is similar to those recommended by the Nuclear Science Advisory Committee for upgrading several heavy-ion accelerators in the next five years. This superconducting linac has 11 cryostatic modules separated by room-temperature quadrupoles. The Stony Brook linac, to be completed in 1981, will boost the tandem's output energy by 18 MeV per unit ion charge.

▶ Upgrading three heavy-ion accelerators. Increasing beam energies, for example by installing "afterburner" linac segments on existing machines, would permit the exploration of the interesting region above 20 MeV/nucleon. It would also extend the range of heavy-ion masses that can get above the 5 MeV/nucleon Coulomb barrier. Ion sources should be improved to provide polarized ions, high charge states and exotic particle species. Design studies should begin for an ultrarelativistic heavy-ion facility.

▶ Upgrading three light-ion accelerators, involving among other improvements the raising of ion energies to the pion production threshold, and the provision of some heavy-ion capacity.

▶ Electron accelerators. Construction of an intermediate-energy continuous-beam electron accelerator is planned to begin in 1982. Continuous electron beams, as distinguished from pulsed operation, are important for correlation studies in nuclear physics. The long-range plan calls for construction to begin in 1985 on a high-energy (2-GeV) continuous-beam electron accelerator, which would be a national facility.

The construction budget envisioned by the Advisory Committee calls for \$17 million in fiscal 1980, rising to \$20 million (in 1979 dollars) in 1986. An additional \$10 to 14 million per year is strongly urged for new capital equipment such as detectors and electronics, which the Committee feels have fallen badly behind the state of the art and the needs of sophisticated experiments during the past decade of budgetary austerity.

With these construction and instrumentation plans and an operating budget rising from \$113 to \$132 million in 1986, the Nuclear Science Advisory Committee feels that the community can develop the minimum capacity necessary to attack the most important scientific questions "at a constant level of scientific strength." With one exception, the long-range plan calls for a roughly constant level of manpower in nuclear science. The Committee feels that funds must be provided to remedy what it regards as a serious shortage of nuclear theorists. It also recommends an expansion of computer facilities to support theoretical computation. —BMS

Mercury data show no Sun shrinkage

Last year when John Eddy and Aram Boornazian reported evidence that the Sun has been contracting about 2 arc seconds per century, the announcement was greeted with excitement tempered by skepticism. Their evidence, reported at the American Astronomical Society meeting last June (PHYSICS TODAY, September 1979, page 17) and still not published, was obtained by analyzing measurements of the Sun's transit made at the Royal Greenwich Observatory (from 1836 to 1953) and the Naval Observatory (from 1864 to 1953). Now Irwin Shapiro of MIT has published an old analysis of 23 transits of the planet Mercury in front of the Sun in the period 1736–1973. He finds[1] that the solar diameter cannot be decreasing more than 0.3 arc seconds per century, with a 90% confidence limit.

In 1973 Shapiro and Michael Ash (Draper Laboratory) had completed the analysis of the transit data along with other data to determine the general relativistic contribution to the secular advance in the perihelion of Mercury's orbit. Last summer when Shapiro heard about Eddy and Boornazian's analysis of solar transits, he dug out the computer printouts from that analysis of Mercury's transits. A transit of Mercury across the Sun occurs about 13 times per century and only in May and November, when Earth and Mercury are nearly aligned, on the same side of the Sun, along the intersection of their orbital planes. Each transit—the time for the disk of Mercury to cross the disk of the Sun, from internal contact to internal contact—that Shapiro used in his analysis was observed at many different places (because the transit is usually observed with a small telescope). If the diameter of the Sun does vary with time, the transit data should disclose such variations reliably unless some time-dependent, systematic change in the operational definition of instants of contact occurred.

Shapiro feels he has made a conservative estimate of the errors in the Mercury transits and concludes that any shrinkage of the solar diameter is less than 0.3 arc seconds per century with a 90% confidence limit. He points out that his result is consistent with that of Sabatino Sofia (Goddard Space Flight Center) and his collaborators, who reported,[2] on the basis of solar transit data, that any change in the solar diameter was less than 0.6 arc seconds per century. Eddy and Boornazian had reported, from Greenwich data in 1836–1954, an apparent shrinkage of 2 arc seconds per century in the horizontal diameter and about half that in the vertical diameter. They also cited evidence from Christopher Clavius in 1567 of an annular eclipse that was consistent with the Greenwich trend.

After learning of Shapiro's analysis, Leslie V. Morrison (Royal Greenwich Observatory) examined a more complete set of observations of Mercury transits. He too found no statistically significant change in the solar diameter—over the period 1723–1973 he obtained a change in diameter of (-0.14 ± 0.08) arc seconds per century (standard error).

Eddy feels Shapiro's analysis of the Mercury transit data effectively rules out the possibility of a persistent change in the solar diameter of the amount he and Boornazian had specified, lasting for many centuries, and that his own extrapolation of the Greenwich trend to the 1567 eclipse observation was not justified. Emphasis now, Eddy feels, should concentrate on tests of the reality of the decrease found in the Greenwich data set, between 1850 and 1954, on the possibility of changes in the solar diameter lasting for a century or less. He and Boornazian feel that the Mercury data for the period of overlap with Greenwich measurements are not sufficient to test the reality of a decrease during the period. They believe the Mercury data used by Shapiro suggest a decrease of about 1 arc second per century between 1850 and 1954; with error bars an even larger change is not excluded.

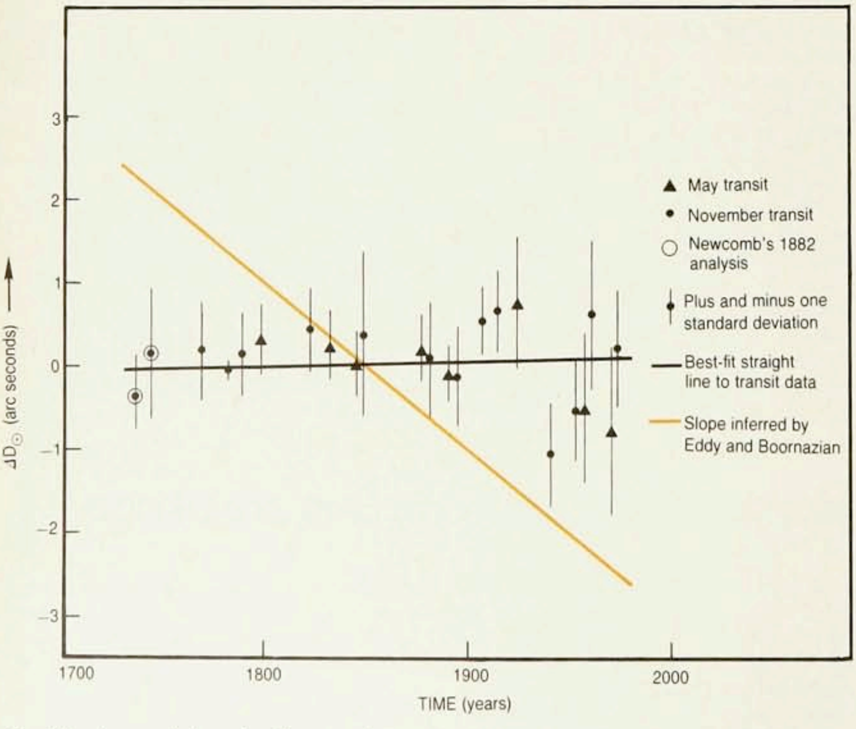
Shapiro has severe reservations about such a methodology of selecting a small portion of his data without any physical basis. Shapiro remarked to us, "Wouldn't it be a surprising coincidence if the Sun decided to shrink just when the new telescope started operating at Greenwich?"

Eddy and Boornazian also feel that individual measurements of times of contact of Mercury transits are subject to many of the same uncertainties that are found in the Greenwich transit data, due mainly to the difficulty of defining the boiling solar limb. An advantage that partially compensates for the small number of observations is that in the Mercury transit data, the observers were not constrained to look through the increasingly smoggy atmosphere at Greenwich.

Eddy and Boornazian are reanalyzing the Greenwich measurements in an effort to define systematic effects that could lead to an apparent decrease in solar diameter, including that of changing atmospheric transparency. Preliminary results reduce the unexplained change, leaving an apparent decrease of 2.0 ± 0.7 arc sec/century in the horizontal diameter and a statistically insignificant change of 0.2 ± 0.2 arc sec/century in the vertical diameter. Programs specifically designed to make more accurate, modern measurements of the solar diameter have been initiated by Henry Hill at the University of Arizona and by Timothy Brown, Peter Gilman and Eddy at the High Altitude Observatory in Boulder, Colorado.

At a meeting on the ancient Sun held in Boulder, in October, David Dunham (Computer Sciences Corp) reported on an analysis that he and his collaborators had done of a solar eclipse observed by Edmund Halley in 1715 in combination with recent solar eclipses in 1976 and 1979. They find[3] a shrinkage in the diameter over that two-and-a-half century period amounting to 0.7 ± 0.4 arc sec.

Shapiro, in his *Science* paper, warns that interpretations of old observations should be treated cautiously. "There are too many important questions concerning seeing, instrument characteristics, and observation techniques that are virtually unanswerable in the present era and that could bear strongly on the reliability of any interpretation." —GBL



Possible changes in the solar diameter, $\Delta D_\odot$. The residuals from Shapiro's analysis of Mercury transit measurements are plotted as triangles and circles (see key). The colored line is the slope inferred by Eddy and Boornazian from solar observations. Figure adapted from ref. 1.

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1. I. Shapiro, Science **208**, 51 (1980).
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3. D. W. Dunham, S. Sofia, A. D. Fiala, D. Harold, P. M. Muller, submitted to Science.