Is the Sun Shrinking? Two Views

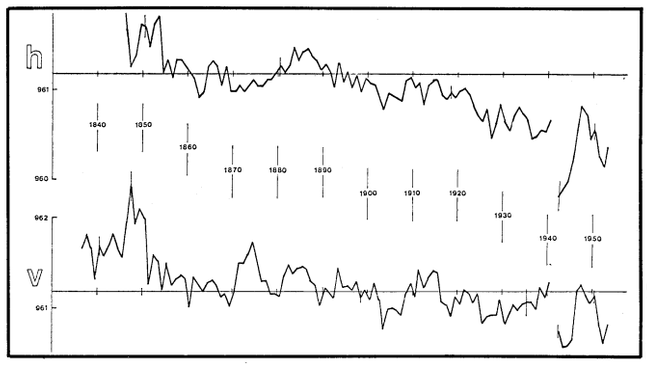
Astronomers of old were sticklers for detail. For more than two centuries they meticulously measured the diameter of the sun by observing how much time it took the solar disk to cross a fixed line of sight. The measurements originally were made to determine the exact position of the sun with respect to the stars, but modern-day scientists now find that the old data may give us a new understanding of how the sun works.

After analyzing solar diameter data recorded both at the Royal Observatory at Greenwich between 1836 and 1953 and at the U.S. Naval Observatory since 1846, John A. Eddy and Aram A. Boornazian conclude that the solar diameter has been shrinking for the past hundred years, perhaps for as long as 400 years. Eddy, a visiting scientist at the Harvard-Smithsonian Center for Astrophysics, and Boornazian, a mathematician with S. Ross and Co. in Boston, calculate the shrinkage to be about 2 arc seconds per century in the sun's horizontal dimension (approximately 5 feet per hour) and about half that vertically. The shrinkage does not apply to the entire solar mass, but rather to the sun's outer layers.

Since the rate of shrinkage is so fast, the two researchers believe it is only a temporary contraction phase. "It's unrealistic to assume this will continue," Eddy told SCIENCE NEWS. "It does seem to imply that the sun is oscillating in some way. However, going farther back into time to find an expansion will be difficult since the records get dimmer and dimmer."

The researchers were able to go as far back as the 16th century. The path of a solar eclipse passed over Rome in 1567. If the sun were the same diameter as it is today, the eclipse should have been total. But Clavius, an observer of the celestial event at the College of Rome, wrote that the moon "did not obscure the whole Sun ... but a certain narrow circle was left on the Sun, surrounding the whole of the Moon on all sides." Eddy and Boornazian say this leaves little doubt that Clavius observed an annular eclipse, the type that would have been seen if the sun were slightly larger four centuries ago.

Though still a matter of speculation, a shrinking sun could provide the solution to the great solar neutrino mystery (the fact that the sun gives off fewer neutrinos than predicted by current solar models). In a paper presented to the American Astronomical Society in mid-June, Eddy and Boornazian reported, "If only the outer 20 percent of the Sun's radius is involved — the convective zone — enough energy would be supplied to make up the deficit that falls when we take the presently measured neutrino flux as indicative of the real temperature of the solar core. The implication is that the Sun and presumably other similar stars could now be deriving a significant part of their energy from gravitational contraction."



Annual averages of the sun's horizontal (h) radius and vertical (v) radius in arc seconds from 1836 to 1953. A straight line fit to the data gives an apparent shrinkage of about 2 arc seconds per century in the horizontal.

Eddy and Boornazian

Bringing gravitational contraction into the picture dusts off an old 19th century concept used to explain the sun's energy output before nuclear fusion was known. "The deficit of neutrinos already shows that the nuclear model needs a change," says Eddy. "I won't be surprised to see a future model where the sun is getting its energy from several mechanisms." The solar astronomer speculates that the gravitational contraction may act like a governor. When energy from the solar core decreases, the contraction could make up the loss, thus modulating the sun's total luminosity.

But the final verdict is not in on the Greenwich observatory data. A group of scientists at the Goddard Space Flight Center have an interpretation that differs from that of Eddy and Boornazian.

After studying the solar diameter measurements made between 1850 and 1937, Sabatino Sofia, John O'Keefe and Janet R. Lesh, along with Louisiana State University physicist Andrew S. Endal, report in the June 22 SCIENCE that "there is evidence for a slow systematic decrease of the observed radius by about 0.2 arc second over this time." This is much smaller than Eddy's finding.

O'Keefe says the difference lies in the measurements each chose to use. While Eddy believes the horizontal measurements of the sun's diameter were more accurate, since they were done with a clock, the NASA researchers took the opposite view. "We confined ourselves to the vertical measurements," says O'Keefe, "since they were done with a micrometer. This was more precise at the time."

But a decreasing solar radius was not the main concern of the NASA group. Rather, it was whether the Greenwich data point to any large changes in the solar constant (a measure of the sun's energy output) over the last century. O'Keefe's answer: They don't.

To reach that conclusion, it was assumed that a fractional change in the sun's radius is directly proportional to a fractional change in the solar constant. A standard deviation of .25 arc second in the mean solar radius was considered the upper limit to the radius's variation during that 87-year period between 1850 and 1937. The trend toward a decreasing radius was included in this deviation. From their complex model of the sun's convective efficiency for periods of about 100 years, such a variation in the radius led to the conclusion that the solar constant could not have changed by more than .33 percent during that time.

"Our study definitely shows that ...1 to 2 percent change[s] in the solar constant over the last century did not take place," says Sofia. He would now like the SCLERA telescope in Arizona to make measurements of the solar diameter in order to provide a highly accurate monitor of future changes in the solar constant. □

Carter's solar program

President Jimmy Carter's new solar energy package, announced to Congress June 20, sets a goal of meeting 20 percent of all U.S. energy needs by the year 2000 using solar and renewable sources. The program's centerpiece is a $405 million Solar Development Bank. Some further incentives would include tax credits for domestic, industrial and agricultural designs using solar technology, tax credits for airtight wood-burning stoves, and a permanent federal excise tax exemption for alcohol fuels. Carter also plans to expand his proposed budget for solar energy programs to $1.1 billion to encourage international use of solar technology through the Agency for International Development.

Pivotal to Carter's proposal is the passage of his "windfall profits" tax that would

create the "energy security fund" intended to fund the Solar Development Bank and pay for the tax incentives. By linking the politically popular solar programs to the windfall profit tax, the White House may smooth the way for the tax bill, but in so doing may prevent implementation of the solar program until Sept. 30, 1980, too late, say many solar advocates, to benefit the delicate solar market.

Meanwhile, two similar bills have been introduced in the Senate by Robert P. Morgan (D-N.C.) and by John A. Durkin (D-N.H.). A third, by Rep. Stephen L. Neal (D-N.C.), would take effect this fall if passed. □

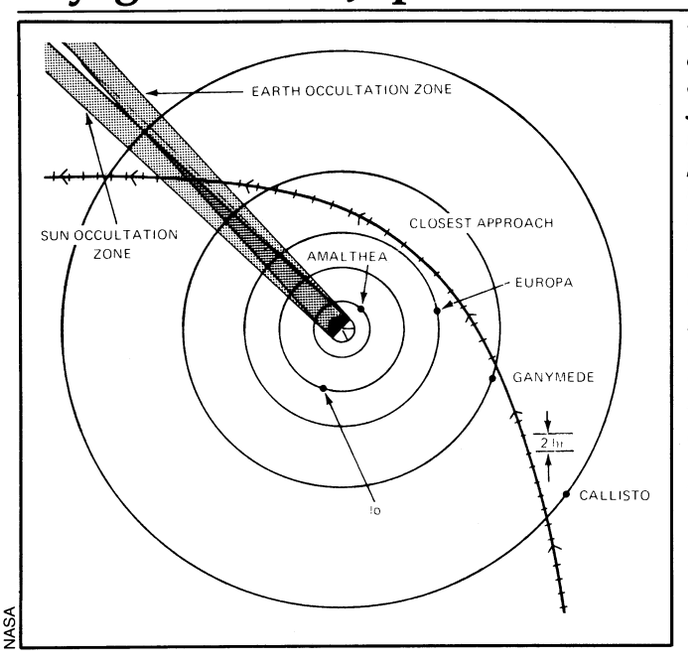
Neutrons not neutral about PLT plasma

In thermonuclear fusion experiments neutrons are the gauge of success. If the experiment is an attempt to produce the fusion of a deuterium nucleus with another deuterium nucleus, it is the neutron left over after formation of a helium-3 nucleus that comes away bearing energy. Thus it is the neutrons from which a practical reactor will somehow have to extract the energy; but meanwhile it is the neutrons that bring evidence that fusions have occurred and that the experiments are on track toward ultimately making enough of them for practical purposes.

In recent years one sort of fusion experiment, the kind that implodes pellets of deuterium fuel with laser light, has been having a kind of box score competition over the number of such thermonuclear neutrons it can produce. Now, in the June 14 NATURE, comes the first report of thermonuclear neutrons produced by the other kind of fusion experiment, the sort that confines a plasma (ionized gas) in a vacuum chamber with magnetic fields. The particular experiment is the Princeton Large Torus. Its success is reported by J.D. Strachan and nine others from the Princeton Plasma Physics Laboratory.

In the PLT experiment a plasma of ionized deuterium is held in a toroidal-shaped chamber. The experimental procedure is to try to heat it to the temperature at which fusions will occur between the deuterium ions. This is done first by electrical means and then by shooting beams of energetic neutral atoms, either hydrogen or deuterium, into the plasma. When the neutral beam was hydrogen, neutrons came out that showed, by their momentum characteristics, that they came from fusions by deuterium ions in the plasma. This is taken to indicate that the hydrogen neutral beam is indeed heating the bulk ions in the plasma. The neutral beam technique has been the beneficiary of much effort and money on the supposition that it would do just that, so the result is a heartening one. □

Voyager 2 nears Jupiter



NASA

The Voyager 2 spacecraft is alive and busy as it approaches its July 9 rendezvous with Jupiter and the planet's five innermost moons. It has already taken several thousand photos, and will soon be reexamining Jupiter's ring, Io's volcanoes and other phenomena discovered during the March flyby by its predecessor, Voyager 1 (SN: 5/5/79, p. 294). In the encounter trajectory diagram at left, the satellite positions are shown as they will be at the time of the spacecraft's closest approach to Jupiter.

VOYAGER 2 CLOSEST APPROACHES

Target	Date	Time (PDT @ spacecraft)	Distance (km to target center)
Callisto	July 8	0521	214,993
Ganymede	July 9	0014	62,233
Europa	July 9	1051	205,807
Amalthea	July 9	1301	558,531
JUPITER	July 9	1529	721,754
Io	July 9	1617	1,129,813

The sudden appeal of synthetic fuels

As gas lines slowly wend their way through Washington, a flurry of synfuel bills are being driven through the House and Senate in a race to beat the July 4 recess, when Congress goes home to face gas-hungry constituents. At last count there were 40 bills making the committee rounds. One has already been approved by the House.

Synfuels are produced from coal, oil shale and grain. The emphasis is being placed on coal because of its great abundance, but shale oil recovery and alcohol from grain are also being considered.

Price tags for some of these initiatives are high. The cheapest is the House-approved package sponsored by Rep. William Moorhead (D-Pa.), asking for $2 billion to produce 500,000 barrels of synfuel a day by 1985. Higher priced is the bill sponsored by Rep. Carl D. Perkins (D-Ky.), who wants $205 billion, almost twice the national defense budget.

The Moorhead bill provides loan guarantees to prospective investors and price subsidies (once the synfuel is on the market) to make up the difference, should gasoline prices be less than synfuel prices. If oil prices rise as they are expected to, the price subsidy may not be necessary, so any cost-cutting on the Senate floor will involve the loan guarantees. Meanwhile, House Majority Leader Jim Wright (D-Tex.) is pushing for a more ambitious goal: two million barrels of synfuel per day in ten years, costing $3 billion to develop.

In the Senate, Henry Jackson (D-Wash.) is backing a measure that would authorize almost $5 billion for synthetic fuel demonstration plants. But synfuel proponents particularly like his provisions to waive some environmental laws and regulations. This "fast track" approach is drawing support from industry and could become a part of the final congressional synfuel package.

During a hearing at the House Commerce subcommittee on energy last week, committee member Albert Gore Jr. (D-Tenn.) said, "I think that we've got to move very swiftly [on synfuels]... we need nothing less than an 'Apollo project' kind of commitment to it." But testimony from witnesses who would be potential synfuel producers indicated that although the technology is not new, the soonest a new plant could begin production is in five years. S. David Freeman, director of the Tennessee Valley Authority, said synfuel is "part of the long-term answer... and in my opinion, not the most important part." Conservation would be more immediately effective, he said.

Most witnesses agreed that two of the five years needed to put the first plant on line would be taken up in satisfying environmental regulations. Committee