

the result of a lack of observations. Additionally, they review efforts to measure time variations in the misnamed solar constant. They show that the Sun is a variable star and that the sunspot number cycle is associated with variations in total solar luminosity. The book also discusses the lives and work of the people who made the important measurements. I was particularly entertained by the description of Samuel Pierpont Langley's 1881 expedition to measure the solar constant from the summit of Mt. Whitney in Southern California.

The second section of the book deals with the history of efforts to relate changes in climate to solar activity. The authors examine the difficulties that have plagued this field. The solar sunspot number cycle has a period of approximately 11 years. Climate measurements such as temperature have to be made in ways that permit precise comparison on time scales of a hundred years or longer. Subtleties such as changes in the brand of paint used on an instrument shelter can confound the most careful investigator. Hoyt and Schatten examine these issues in considerable detail and leave the reader with an excellent feel for the topic.

The two most important problems examined by the book concern the presence of sign reversals in the observed correlations and the fact that the climate variations that are observed are larger by a factor of ten than simple energy-balance calculations can account for. The book reviews the possible explanations for these problems and is quite successful in giving the reader a well-balanced picture of the field.

The authors have chosen to consider only variations in solar irradiance as possible drivers of climate change. They discuss the role of solar ultraviolet variations on the basis that the proportional change in irradiance in the ultraviolet is much larger than it is at visible wavelengths. They do not, however, treat the solar wind, which also has a very strong solar-cycle dependence; the amplification factor required to produce climate changes is much greater for solar-wind changes than it is for irradiance changes. The role of the solar cycle in driving changes in the atmosphere at altitudes above 90 km (the magnetosphere, ionosphere and thermosphere), which they also do not consider, is well established. This omission leaves the authors unable to account for the observed 22-year periodicity in climate, which corresponds to the 22-year Hale sunspot cycle. Readers interested in this topic should consult *Sun, Weather and Cli-*

mate, by John Herman and Richard Goldberg, (Dover, 1985).

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Shadow of a Star: The Neutrino Story of Supernova 1987A

▶ Alfred K. Mann
W. H. Freeman, New York, 1997.
210 pp. \$22.95 hc
ISBN 0-7167-3097-9

In *Shadow of a Star: The Neutrino Story of Supernova 1987A*, Al Mann provides an account of the events leading to the production of neutrinos by SN1987A and their detection by two large experimental teams: the IMB collaboration working in the Morton salt mine outside of Cleveland, Ohio, and the Kamiokande collaboration working underground near the small Japanese city of Kamioka.

Mann, a senior member of the Japanese-US Kamiokande collaboration, develops two parallel stories: the evolution and explosion of Sanduleak 202, the massive star in the Large Magellanic Cloud that was the progenitor of SN1987A, and the birth and evolution of the Kamiokande experiment. While there have been several notable articles and books about stellar evolution and SN1987A, Mann's book is the only one devoted to the most exciting result to come from that remarkable celestial event: the detection of a neutrino burst associated with the supernova explosion. The observation confirmed the idea, first proposed in the 1960s by Stirling Colgate and Richard White, that the bulk of the binding energy released in the transition to a neutron star is in the form of neutrinos. This confirmed the basic notion that a type II supernova signals the end of the life of a massive star. On the experimental side, the detection of neutrinos from SN1987A was the first detection of neutrinos from outside the Solar System. (Neutrinos from the Sun have been detected since the pioneering solar-neutrino experiments of Ray Davis.)

The best part of Mann's book is the glimpse it provides of the inner workings of the Kamiokande collaboration. While the detections of atmospheric neutrinos solar neutrinos and neutrinos from SN1987A have been the great successes of the experiment, the detector was originally built for another reason: The "nde" in Kamiokande is an abbreviation for "nucleon decay experiment," not "neutrino detection experiment." The story of the tempering of the bitter disappointment in the

negative results for nucleon decay by the sweet success in the search for neutrinos is an important one: It demonstrates the ability of an experiment probing a new, unexplored domain to make discoveries not envisioned in the program's original conception.

While Mann avoids the "merely personal" (as Einstein once put it) aspects of the inner dynamics of the large collaboration, he does recount experiences with one or another of the two dozen scientists working on the Kamiokande experiment at the time of SN1987A. Although a small collaboration compared to the number of people who might be involved in particle-physics experiments, there were all the familiar problems of trying to get large numbers of independent scientists to work together toward a common goal. The story of the growth of trust and cooperation between US and Japanese groups, despite their different cultures and traditions, is something that should be read by all scientists involved in large collaborations, as well as by the public.

Mann's book certainly dispels the myth that science is a dispassionate, emotionless pursuit. The story of the events surrounding the discovery of the neutrinos from the supernova has all the drama one could hope for in an important scientific discovery. Among its human touches is the description of data transport from the detector to the collaborators on the surface: Although the data acquisition system of Kamiokande was relatively sophisticated, the data did not make its way to the surface by Ethernet or Internet, but rather by "sneakernet," as a graduate student ran with the data tapes from the underground experiment to the surface.

Shadow of a Star is intended for a general audience, and it contains valuable insights into the dynamics of large international collaborations. The detection of neutrinos from SN1987A was perhaps the astronomical discovery of the 1980s. Mann captures its excitement.

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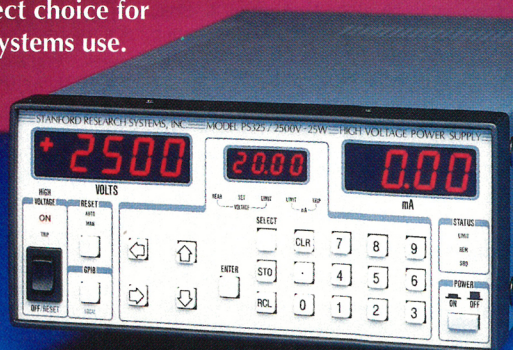
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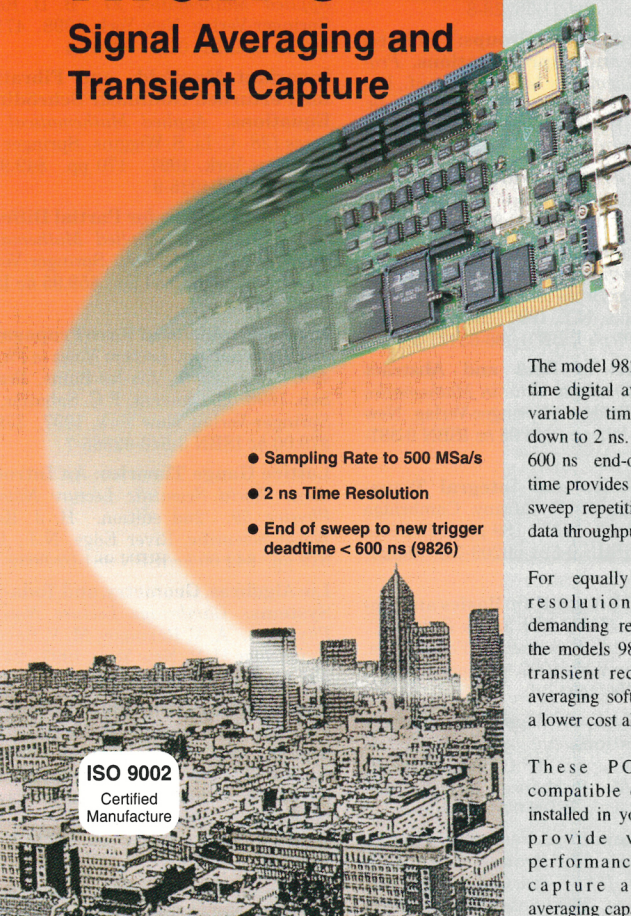
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