on contact binary stars; and by R. E. Gershberg (Crimean Astrophysical) on activity in T Tauri and UV Ceti flare stars. Among the brief communications in this part of the volume are R. Pallavicini's (Arcetri) application to stellar flares of the chromospheric-evaporation process and nonthermal-electron effects detected on the sun during the SMM mission; Vogt and G. D. Penrod's (Lick) mapping of starspots; the outcome of a 20-year program to observe RS CVn optically at Catania (C. Blanco et al.); a 5-year radio study of RS CVn variables (P. A. Feldman, Ottawa); new data on the infrared companion of T Tau [T. Simon (Hawaii) et al.]; results for the chromospheres of T Tau stars as indicated by EUV spectra [A. Brown (Queen Mary College, London) and C. Jordan (Oxford)]; and optical patrols of five T Tau variables (W. Herbst, Wesleyan University) and four young, weak-emission variables [F. J. Vrba (Flagstaff) et al.].

In Session IV we find overviews by D. J. Mullan (University of Delaware), "Models of spots and flares"; E. R. Priest (St. Andrews), "Magnetic instabilities in stellar atmospheres"; D. S. Spicer (Zürich), "Flaring processes in stellar atmospheres"; K. Kodaira (Tokyo), "Empirical models of stellar flares"; and G. Belvedere (Catania), "Dynamo theory in the sun and stars." Short notes here include an interesting paper by H. U. Bohn (Würzburg), who has refined the value for the efficiency of acoustic-noise generation in red dwarf atmospheres and has sought to rehabilitate the acoustic theory for heating the coronae of such stars.

N. O. Weiss (Cambridge University) discusses in the final session the prospects for future theoretical work on active red dwarfs. L. Goldberg (Kitt Peak) contributes a summary of the Colloquium.

The material has been edited very carefully by Byrne and M. Rodonò (Catania), as is particularly apparent when one reads the discussion transcripts for many of the papers.

A real gap in the Colloquium program was the complete lack of any comments on the stellar-astronomy aspects of red dwarf activity. The Soviet reader, however, will have access to L. V. Mirzoyan's monograph, Stellar Instability and Evolution (Erevan, 1981), which gives a rather full account of flare-star statistics, so he should not find this gap in the Proceedings too serious.

The topics explored at IAU Colloquium No. 71 are attracting an ever wider group of researchers – observers and theorists, stellar and solar astronomers, specialists in plasma physics and in solar–terrestrial relations. A Russian edition of the Colloquium Proceedings would therefore be most desirable.

Translated by R. B. Rodman

# Understanding the Universe*

Reviewed by V. G. Surdin

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Recounting some of the benefits that spacecraft techniques have had for astronomy, this volume is based on five lectures given at the UN/IAU International Astronomy Seminar that was held at the Hofburg in Vienna on August 12, 1983, as part of the Second United Nations Conference on the Exporation and Peaceful Uses of Outer Space (UNISPACE 82). The scope is wide indeed, ranging from studies of the solar atmosphere to topics in cosmology.

Eminent astrophysicists from several countries have prepared the separate chapters, designed for the lay reader who wishes to learn about the goals and achievements of space astronomy. This survey aims to show how much more effectively certain classical astronomical problems can be handled if observations are made from spacecraft rather than from the ground. It is not direct probes of the planets that the authors are speaking of – such missions are outside the purview of the book – but the expanding of the wavelength range and the many other advantages that come about when instruments are lifted above the earth's atmosphere. Even so, here and there some interesting results from in situ sampling of the interplanetary medium are mentioned, as are various new tools available to ground-based astronomy. Appended to the volume is a biographical sketch of each author, some information about the UNISPACE 82 conference and the IAU, and, to guide nonspecialists, an annotated list of astronomical and physical constants.

In calling his lecture "The atmosphere of the sun and the stars," Jean-Claude Pecker (Paris) seeks to under score the fundamental changes in approach brought about by space technology. Gone is the day when studies of the processes on the solar surface formed a rather detached subject having a few points of contact with stellar physics. Today sensitive ultraviolet and x-ray telescopes are revealing chromospheres and coronae on many stars and enabling us to monitor their variable activity. As Professor Pecker remarks, "after a period when it was often said... 'the active sun is a star,' one could say now that 'stars are suns,'" in the sense that practically all the phenomena observed on the sun are now detectable on other stars as well. Even the 11-year solar activity cycle is no longer unique: a number of sunlike stars have been found to go through analogous cycles of chromospheric activity. Prospects are at hand for comparing a star's activity period against its other, physical parameters (especially its rotation, magnetic field, and intensity of convective processes); perhaps we may soon be able to solve the riddle of periodic activity in stars.

*The Impact of Space Astronomy. Edited by Richard M. West. D. Reidel Publishing Company, Dordrecht, 1983. xii + 249 pp.

One new field of solar research that has developed in the past few years may be called "helioseismology." It is concerned with effects whose characteristic period amounts to hours or minutes. The instability of the earth's atmosphere thus far has seriously inhibited attempts to extend the methods of helioseismology to other stars. Observations from above the atmosphere, even in the traditional optical range, might well yield valuable data on periodic stellar microvariability. Such information will be very useful for probing the subphotospheric layers, the structure of the convection zone, and the periodic phenomena taking place there. Still, if we want to understand the source of stellar energy—how a stellar thermonuclear reactor is built—then the sun is and will long remain a unique object of investigation, for an earthbound observer can record its flux of neutrinos. Solar neutrino astronomy is a rare example of how observing conditions can only be improved by taking out instruments not upward, away from the earth's surface, but downward, into the ground. In technical sophistication, neutrino experiments do not take second place to those in space, and in fact may surpass them in the importance of the information they can furnish. So although one can agree with Pecker that "solar and stellar physicists are indeed more and more speaking the same language," the sun will surely continue to be a prime testing ground for our ideas about the structure of stars generally.

Roger M. Bonnet (CNRS and ESA) devotes the next review to solar–terrestrial relations. The sun and earth interact through gravitation, solar-wind particles, radiation, and the magnetic field. And while some of these effects of the sun can be perceived directly on the earth's surface, the chief physical processes operate in the upper layers of the terrestrial atmosphere and in the magnetosphere. Space experimentation is therefore decisive in studying those processes. Notably, the high atmospheric layers are not only a subject of research in their own right, but they serve as a distinctive form of detector. Long before the space era, in fact in the late 19th century, physicists who studied geomagnetic and auroral phenomena were able to forecast the arrival of solar corpuscular radiation, tying its intensity to the level of solar activity. The initial rocket experiments of 1946 similarly were designed to investigate the sun. The Soviet Luna 3 probe was the first spacecraft directly to measure the solar-wind parameters. Ever since, much of space astronomy has been oriented toward the study of our daytime luminary. Apart from its purely theoretical interest this research has had a great deal of practical benefit, for it is the sun's influence that controls the climate and weather on the earth. But the interrelation is very complicated and in order to understand how it works one has to study the sun itself, away from the effects of the terrestrial atmosphere. By launching instruments into space it has been feasible to sharpen the 1% accuracy of the solar constant to 0.1%, so that one can at last detect the true fluctuations in this fundamental quantity. To be sure, we still do not know just how the changes in our climate are related to the variations of the solar constant, but prolonged series of measurements will help pin down the relationship.

R. Hanbury Brown (Sydney) addressed the conference on efforts to determine the size, shape, and surface temperature of various types of stars. He thoroughly reviews the history of stellar interferometry, from Michelson's classic work, which called for incredible precision in fabricating the mechanical parts of the instruments, to the modern long-baseline intensity interferometers which Hanbury Brown has done so much to develop. First built by radio astronomers and only later by optical observers, intensity interferometers place far lower demands on the opto-mechanical accuracy of the instrumentation, so that one can lengthen the baseline and enlarge the diameter of the telescope mirrors. The two light beams do not have to be brought to a single point and they do not undergo direct interference. Instead the light intensity is recorded at the focus of each of two telescopes and the fluctuations are then compared at frequencies as high as 100 MHz. They will either be correlated or not, depending on the angular size of the source and the telescope spacing. The interferometer operating at the Narrabri Observatory in northeast New South Wales has compound 6.5-m diameter mirrors whose separation can be made as wide as 188 m, a baseline that can furnish 0".0002 resolution. But accurate measurements require very long exposures: $100^h$ altogether if a $2^m.5$ star is to be measured to ±5% accuracy, or often a full month of observing time. In a seven-year program the Australian group measured angular sizes for 32 type O–F stars, hot objects whose earlier $T_{eff}$ determinations had been especially unreliable. From visual and ultraviolet fluxes recorded by the OAO-2 satellite and the angular diameters it was possible to set up new $T_{eff}$ scale for hot stars. An important feature of this method is that the stars's distance need not be known. For the first time the $T_{eff}$ scale has been grounded entirely on observational data, instead of relying on comparisons of stellar spectra against theoretical models.

Distances of fair accuracy (±25%) are available for half the stars measured, yielding their physical size. For example, Spica (B1 V) has a radius of 7.9 $R_\odot$; Fomalhaut (A3 V), 1.6 $R_\odot$; and ζ Puppis (O5f), 15.6 $R_\odot$. The intensity interferometer can distinguish double from single stars and even determine the shape of an individual star. Flattening has been detected for the first-rotating Altair, while the Wolf–Rayet star γ Velorum shows evidence of an asymmetric envelope. In due course it is hoped that the method can be made sensitive enough to record the changes in the radius of pulsating Cepheids. Such measurements, if combined with radial velocities of the stellar surface, would provide accurate distances for individual Cepheids— a technique of great promise for improving the interstellar distance scale. Soon an interferometer 100 times as sensitive, capable of measuring $7^m.5$ stars, will be under construction at Narrabri. When optical instruments are carried into space, the angular resolution will improve further still; even classical astrometry with the Hipparcos satellite should enhance the accuracy of parallaxes fivefold. And the opportunity of putting large mirrors in space, capable of measuring stars in the ultraviolet away from air turbulence, will make space interferometry much more effective even than on the ground.

If space platforms offer bright prospects for optical astronomy, in the case of x- and γ-ray astronomy space observations are a necessity. Walter H. G. Lewin (MIT) reviews some of the progress in this area, dwelling on the findings of rapid variability in the high-energy range.

Here information has to be utilized with remarkable efficiency: as observations can be made only from space, high-energy astronomers are severely limited in the amount of data they can acquire (in the $\gamma$-ray range each photon is precious). Hence in processing the observations one inevitably must involve all the resources of modern statistics. But the results are impressive. Not only have numerous hard-radiation sources been detected, but their physical nature can now be grasped.

Particularly fruitful have been the cases where a given object can be observed in different wavelength regions, say in both x-ray and optical radiation. Thus it is very important to make synchronous observations on the ground and in space. To be sure, that cannot always be done: the enigmatic $\gamma$-ray bursts have been recorded by near-isotropic detectors, so the direction toward a burster can be ascertained only after concurrent data from several spacecraft have been processed. Since $\gamma$-ray bursts are rare and aperiodic, they might not have been observed synchronously at all. Nonetheless, long years of systematic conventional photography of the sky have borne fruit. Once the position of the 1978 November 18 burst had been pinpointed to $\pm 5'$, Brad Schaefer, an MIT graduate student, inspected 5000 plates in the Harvard collection, and on one of them he found an optical flare that had occurred near the $\gamma$-ray burst site on 1928 November 17. The field had been photographed several times in a row on that night and the evidence shows that the optical flash lasted less than 45 min! Accordingly in 1982 the field was given a very deep optical examination ($21^h$ combined exposure) which disclosed a faint source at the site of the 1928 flash. Professor Lewin is confident that the nature of the $\gamma$-ray bursters will be deciphered in the decade to come.

Further along in his talk he mentions the relativistic jets from the nuclei of active galaxies and quasars, as well as supernova outbursts and the puzzling object SS 443. Common to all the objects being studied by x- and $\gamma$-ray astronomy is their capability of teaching us how matter and fields behave in physical environments that would be difficult or impossible to reproduce on the earth.

An extensive chapter by Malcolm S. Longair (Royal Observatory, Edinburgh) reviews the interplay between space research and cosmology. In language intelligible to nonspecialists he describes (and beautifully illustrates) the structure of the universe. There is a thorough account of the empirical facts that have molded our concept of a hot, big bang universe, as well as the nucleosynthesis problem, the riddle of the baryon asymmetry, the isotropy of the cosmic background radiation, and so on. One curious paradox: we think we have a reasonable idea of what events occurred in the remote past, when the universe was only a few years, minutes, or seconds old; but we cannot yet say what the universe looked like closer to our own era, at the time when the galaxies and systems of galaxies formed. Longair explains in detail the distinction between the adiabatic and the isothermal scenarios for the development of structure in the universe, he believes the observations best fit the former theory. But in order to decide once and for all which theory is valid, we will have to observe distant (and thereby young) galaxies and clusters, the background radiation in the far infrared, and the hot x-ray emitting gas in galaxy clusters and the primordial "pancakes" from which they originated. Every one of these experiments requires a telescope in space.

In her concluding remarks Alla G. Masevich (Moscow) stresses the hope that ground-based and space astronomy will continue working hand in hand. How beneficial such contacts can be is highlighted by the identification of the 1978 $\gamma$-ray burst with the 1928 optical flare source, or by the discovery on old Shternberg Institute plates that a certain quasar was optically variable. Underpinning the astronomy of the future, whether it flourish in space or on earth, will always be our classical astronomy with its rich heritage and invaluable store of observations.

Translated by R. B. Rodman