

Preface.

R. N. THOMAS

Boulder Laboratories, U. S. National Bureau of Standards.

1. - Background of the symposium.

The present symposium, fourth in the series of symposia on Cosmical Gas Dynamics sponsored jointly by the International Union of Theoretical and Applied Mechanics and the International Astronomical Union, actually represents the blending of two lines of attempt to focus attention on aerodynamic phenomena in stellar atmospheres. One is the evolution of the present series of symposia itself. This series grew out of collaborative efforts by J. M. BURGERS and J. H. OORT to study the properties of interstellar gas clouds, and their feeling that collaboration between aerodynamicist and astrophysicist might be extended to other problems of the interstellar medium and galactic structure, where large differential velocity fields are observed. The stimulating effect of three such symposia on the interstellar medium led to the suggestion that the aerodynamical-astrophysical collaboration be extended to other areas of astrophysics — such as the stellar atmosphere — where observed velocity fields suggested interest in aerodynamic problems. The second line of interest grew directly among astronomers interested in the structure of stellar atmospheres, under the dual impetus of an enormous increase in detailed observational data and of an associated refinement in interpretative theory. An informal gathering of a few astronomers at the 1952 IAU meetings in Rome considered the question of whether a more careful examination of the concept of « astronomical turbulence » might not be useful. The discussion led to plans for a more extended symposium, to last several days, at the time of the Dublin IAU in 1955; and for preparation of an extensive bibliography covering astronomical papers on aerodynamic phenomena in stellar atmospheres. These plans were considerably condensed: no bibliography was prepared, and a 2.5 hour session was held at Dublin (*Trans. IAU* 9, 727 (1955)), the curtailment apparently reflecting the attitude of most astronomers that the subject was not at that time of sufficiently wide-spread

interest to justify such extensive attention. Thus the present symposium may be viewed as the culmination of these earlier efforts, from the standpoint of astrophysical interest in a more complete view of the structure of stellar atmospheres; as well as an extension of the collaborative efforts between aerodynamicists and astrophysicists in the general series of symposia of which this is the fourth.

The preface to the Proceedings of the Third Symposium (*Rev. Mod. Phys.*, **30**, 905 (1958)) contains an historical-conceptual summary of the evolution of astronomical concern with aerodynamical problems and of the introduction of the concept of «astronomical turbulence». This summary serves as well for this symposium on the stellar atmosphere as it did for that on the interstellar medium, and there is little point in repeating it here. It is however useful to stress two points made in that summary. One is that historically most astronomical concern with velocity fields in stellar atmospheres has centered on phenomena concerned with stellar pulsation and on the various measurements of «astronomical turbulence» — a term loosely used to denote random velocity fields in the stellar atmosphere. The second point is that an astronomical concern with aerodynamical phenomena, rather than simply with velocity fields, came when astronomers began to ask the mechanical energy dissipation likely to be associated with these velocity fields, rather than simply their effect on the radiative absorption coefficient or on the momentum balance in the stellar atmosphere.

For a number of years in the postwar era, astronomers have debated whether demands for a more realistic appraisal of the relation between «astronomical turbulence» and aerodynamical concepts represented a point of semantics or one of physics. In a similar way, it has been a controversial question whether mechanical energy dissipation effects were sufficiently large to have appreciable influence on models and concepts used in analysing stellar atmospheres anywhere except in extremely tenuous regions such as gaseous nebulae and the solar corona. In the past few years, it appears that astronomical opinion has shifted sufficiently to include even the denser regions of the solar chromosphere within the category of being subject to appreciable influence by these mechanical dissipative effects — raising the densities admitted for such a category from some 10^8 to some $(10^{15} \div 10^{16})$ atoms/cm³.

This dual astronomical impetus arising from increase in detailed observational data and refinement in theory has stimulated concern with a third aspect of the velocity field-aerodynamic phenomena association, that of a more detailed interest in specific solar features. From one side, questions on the origin of the velocity field providing the mechanical dissipative effects in the solar chromosphere-corona led to more detailed interest in the observational properties and theoretical consequences to be associated with the observed solar granulation, and to investigations of the aerodynamic significance of

the observed solar spicules. From another side, extreme high-dispersion spectra of the solar surface (up to some 20 mm/Å) give strong evidence for small-scale, transient velocity features existing there.

Because this was the first symposium on aerodynamical phenomena in stellar atmospheres, and the possible breadth of the subject is so great, the program was planned to emphasize those points standing out in the manner just summarized. As a general preparation of background material for the Symposium, a number of astronomers collaborated in preparing a bibliography covering papers on aerodynamic phenomena in stellar atmospheres. In practice, the epoch that it seemed useful to cover went back to roughly 1920. A request was made by the aerodynamicist members of the Organizing Committee for some kind of a background-summary of astrophysical concepts and jargon, in the field covered by the Symposium. This was taken as an opportunity not only to present a background-summary from the standpoint of the conventional astrophysical approach, but also to look at the astrophysical methodology from a somewhat more critical standpoint, asking what effects could be expected if indeed aerodynamic dissipation effects had significant influence on the state of the stellar atmosphere. While such a discussion thus became strongly involved in the current controversy on the importance of including effects of aerodynamic dissipation, it was not thought useful to schedule as part of the sessions a discussion of the solar chromospheric studies referred to above. It was felt these were too specialized for this first Symposium.

The two topics already referred to as most studied in the astronomical literature were made the basis for the first two sessions on astronomical material proper: « astronomical turbulence » and pulsation phenomena. The scope of the latter session was widened, to include the subject of non-catastrophic mass-loss, to one of whose possible phases we must be led in studying the outer boundary conditions for the pulsation problem. Also a session was reserved under this heading for a more direct inquiry into problems arising from a shock propagating into a medium of decreasing density.

Attention was then directed at the more detailed studies of « localized » velocity fields that are possible by restricting attention to the sun. Considerable emphasis was placed on the solar granulation, and also an attempt was made to stimulate discussion, from the aerodynamicist's viewpoint, of the general problem of convective instability as it might be reflected by the granulation. It is hard to cover the wide range of material bearing on velocity fields in the solar atmosphere, and their possible association with other phenomena such as magnetic fields, as part of such broad sessions as this, so only a small sampling was included. There seemed to be a general feeling that one of the future symposia in the series might be confined to solar phenomena.

Finally, because of the general interest in energy dissipation mechanisms in those rarified atmospheres where magnetic fields occur, a discussion of collision-free shocks was included.

2. – Mechanics of the symposium.

The Fourth Symposium was held as one of the sessions of the 1960 International School of Physics «E. Fermi», under the auspices of the Società Italiana di Fisica, at the Villa Monastero, Varenna (Lake of Como), 18-30 August.

Like the three preceding Symposia, it was organized by the International Union of Theoretical and Applied Mechanics and the International Astronomical Union. The Organizing Committee consisted of: IUTAM: BURGERS, LIEPMANN and SEDOV; IAU: MINNAERT, RIGHINI, SEVERNY, UNSÖLD and THOMAS. MINNAERT served as president; LIEPMANN and THOMAS as the secretariat.

Arrangements at Varenna were prepared by RIGHINI. We are indebted to the staff of the Villa Monastero, the Mayor and City Council of Varenna, and to the Italian Physical Society for their role as hosts to the Conference.

The two International Unions, with the assistance of UNESCO, made available limited funds for the partial defrayment of traveling expenses of some of the participants. The Consiglio Nazionale delle Ricerche di Italia generously made available a grant to aid in meeting the secretarial and other expenses at Varenna. The US National Bureau of Standards aided in the secretarial problem on obtaining transcriptions of the meetings. To meet an unexpected crisis in the transcribing equipment, the U.S. Air Force kindly provided equipment and personel, Mr. F. SLATER, and Mr. D. TADDE. G. COLCHAGOFF and S. CELLERAI organized the obtaining and initial transcription, of the records: to Mr. SLATER and Mr. CELLERAI, we are particularly indebted for the functioning of the recording equipment under trying conditions of severe power failures occasioned by storms.

The detailed prior arrangements from the standpoint of the organizing secretariat, the transcription of records in Varenna, and the subsequent compilation and preparation of corrected transcriptions and manuscripts have been handled by Miss ANNE TAYLOR of the NBS staff; at Varenna she has been aided by Miss NANCY POTTER of NBS.

Arrangements for publication have been made by G. POLVANI, President of the Italian Physical Society and by G. RIGHINI. The Society has generously supported the publication of these Proceedings as a supplement to *Nuovo Cimento*. RIGHINI, LIEPMANN and COLCHAGOFF have, together with THOMAS, acted as an Editorial Committee on the Proceedings. Rough transcripts of the several sessions were provided to the participants for correction as they

were transcribed. These formed the basis from which an edited version of the proceedings has been prepared. Considerable condensation and re-ordering of material has been made in the editing process. Because the main use of such proceedings as these lies in the degree to which they summarize current thinking, the major concern has been to ensure their prompt publication. Because of this, no possibility has been given the participants to check the edited version; responsibility for errors and misconceptions thus fall on THOMAS, who offers apologies for these wherever they may occur.

The list of participants is as follows:

Aerodynamicists and Physicists. – C. AGOSTINELLI, Italy; G. K. BATCHELOR, England; A. A. BLANK, USA; G. F. CARRIER, USA; F. H. CLAUSER, USA; G. COLCHAGOFF, USA; A. CRAYA, France; L. DAVIS, USA; P. GERMAIN, France; S. GOLDSTEIN, USA; M. KROOK, USA; R. B. LEIGHTON, USA; H. LIEPMANN, USA; S. LUNDQUIST, Sweden; W. V. R. MALKUS, USA; N. MILFORD, USA; H. PETSCHKE, USA; V. S. SAFRANOV, USSR; L. SCHIFF, USA; V. D. SHAFRANOV, USSR; W. B. THOMPSON, England; M. S. UBEROI, USA.

Astronomers. – L. BIERMANN, Germany; K. H. BÖHM, Germany; E. BÖHM-VITENSE, Germany; A. BRUZEK, Germany; E. M. BURBIDGE, USA; G. BURBIDGE, USA; I. K. CSADA, Hungary; C. DE JAGER, Netherlands; A. J. DEUTSCH, USA; G. ELSTE, Germany; E. G. FORBES, Scotland; G. GODOLI, Italy; M. HACK, Italy; S. S. HUANG, USA; F. KAHN, England; K. O. KIEPENHEUER, Germany; P. LEDOUX, Belgium; R. LÜST, Germany; W. H. MCCREA, England; M. MINNAERT, Netherlands; E. A. MÜLLER, USA; A. G. PACHOLCZYK, Poland; B. E. J. PAGEL, England; E. N. PARKER, USA; C. W. PECKER, France; J.-C. PECKER, France; S. POTTASCH, USA; K. H. PRENDERGAST, USA; H. V. REGEMORTER, France; G. RIGHINI, Italy; J. RÖSCH, France; E. SCHATZMAN, France; M. J. SEATON, England; A. B. SEVERNY, USSR; E. SPIEGEL, USA; ZD. SVESTKA, Czechoslovakia; R. N. THOMAS, USA; J. TUOMINEN, Finland; A. UNDERHILL, Canada; A. UNSÖLD, Germany; J. WADDELL, USA; C. A. WHITNEY, USA.