

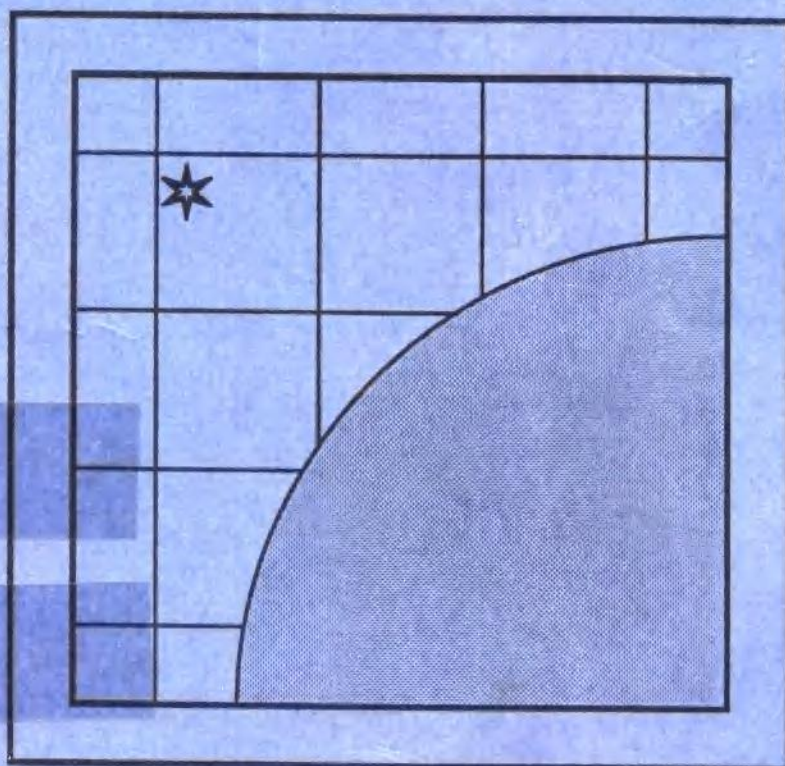


Proceedings

of the

127th Colloquium of the
International Astronomical Union

Reference Systems



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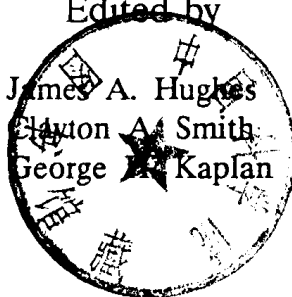
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Proceedings of the 127th Colloquium of the International Astronomical Union *Reference Systems*

held in Virginia Beach, VA, USA
14-20 October 1990

Edited by

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United States Naval Observatory
Washington, D.C.
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INTRODUCTION

Colloquium 127, *Reference Systems*, was proposed by the U.S. Naval Observatory during the XX General Assembly in Baltimore. The proposal was accepted by the IAU Executive Committee and the dates, 14-20 October 1990, and the venue, Virginia Beach, were given in the First Announcement mailed in February 1990.

This Colloquium was somewhat unique in that its primary purpose was to serve as a meeting opportunity for the IAU Working Group On Reference Systems (WGRS). In conjunction with this pivotal animus however, the meeting also provided an excellent forum for the presentation and discussion of matters essential to the concerns of the WGRS by individuals whether members of the WGRS or not. Thus both invited oral and poster papers were presented on topics ranging from theoretical relativistic considerations to new observational programs and results. The oral contributions are printed here in the order in which they were presented at the meeting. The poster papers are given in alphabetical order by the first author's name.

The Colloquium was characterized by the inclusion of several discussion periods. Some of these were closed sessions of the WGRS, but most of the discussions were open to all participants. The final recommendations of the WGRS evolved from these discussions. The starting points for this evolution are contained in the opening papers given by the four leaders of the sub-groups of the WGRS, namely, B. Guinot, J. Kovalevsky, T. Fukushima and D. McCarthy. It is interesting to compare these papers with the final form of the recommendations as they appear in the Appendix of these Proceedings.

Recordings were made of the exchanges which took place after the presentations of the oral papers, and the original intention was to publish this material as is usually done. However, due to the high level of interest and the associated disinclination to curtail discussion, the length of the transcription was overwhelming. Straightforward question and answer exchanges were rare, with long commentaries being more the rule. Thus, to keep these Proceedings to a reasonable size, it would have been necessary to severely edit the commentary. The first editor made a few attempts at such a procedure, but it soon became clear that such editing, without detailed discussions with the speakers, was not likely to faithfully reproduce the ideas expressed. Therefore, with some reluctance, it was decided to forego printing this material.

In general, it is fair to say that the meeting has been deemed a success by the vast majority of the attendees. Certainly from the point of view of the SOC and the WGRS it may be said that the objectives of the Colloquium were well met. It is equally true that the LOC did an admirable job, and the thanks and appreciation expressed by so many are repeated here. Thanks are also due those who refereed papers both at Virginia Beach and subsequently.

Attention is drawn to the final Recommendations of the WGRS which, together with a copy of the letter forwarding them to the IAU, appear as an Appendix to this volume.

James A. Hughes
Chairman, SOC, WGRS

ACKNOWLEDGEMENTS

Attendance at the Colloquium was greatly increased and many miscellaneous expenses were covered due to the generous financial support of the International Astronomical Union, the National Aeronautics and Space Administration and the Office of Naval Technology. It is a pleasure to acknowledge this support which contributed so much to the success of the Colloquium.

Thanks are also due to the U.S. Naval Observatory for hosting the meeting, and in particular for providing administrative and logistic support. Not only the institution, but many of its professional and clerical staff, rendered assistance where and when needed. Such contributions addressed many of the critical needs of the Colloquium and of its participants.

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PART 1. ORAL PAPERS

REPORT OF THE SUB-GROUP ON TIME

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1. Introduction

The report of the Sub-Group on Time (SGT) of the IAU Working Group on Reference Systems (WGRS) is divided as follows.

Sections 2 to 4 recall the scope of the work of the SGT and briefly describe its activity.

Section 5 summarizes the discussions on several topics which form the background of the draft recommendations and notes of Section 6.

2. Scope of the work

This has been defined in a letter of 1 June 1989 by the chairman of the WGRS, Dr J.A. Hughes, : "Define time- scales and time-like arguments and their interrelationships within the framework of General Relativity. Provision must be made for projecting these time scales into the past. The consequences of adopting any time-scale, when viewed in the context of a relativistic space-time continuum, must be carefully considered. The need for theoretically acceptable transformations meeting the accuracy requirements for all the diverse applications must be considered. The practical difficulty of defining and determining appropriate units of time as well as the precise transfer of time must also be addressed with reference to protocols already established."

3. Historical background

The atomic definition of the unit of time, in 1967, and the availability of atomic time scales since 1955, with accuracy requiring a relativistic treatment, generated new problems in dynamical astronomy. These problems were considered by a Working Group on Units and Time-Scales, created in 1970, chaired by G.A. Wilkins. The activity of this SG led to IAU Recommendation 5 (1976) on "Time-scales for dynamical theories and ephemerides", defining the time-scales which were designated in 1979 as the Terrestrial Dynamical Time (TDT) and the Barycentric Dynamical Time (TDB).

The 1976/79 recommendations raised much controversy (Guinot and Seidelmann, 1988) for reasons which are essentially:

- the lack of a correct definition in a relativistic framework encompassing space and time,
- the ambiguity between the ideal form of atomic time and the time-like argument of dynamical theories.

4. Development of the work of the SGT

The list of members of the SGT is given in Annex I. The necessity of receiving a wider range of opinions and advices, especially from experts in relativity, appeared in the course of the discussions. Annex I also gives the list of persons who were consulted. In the following, all these persons are usually designated by the initials given in Annex I.

The development of the activity of the SG on Coordinate Frames and Origins (SGFO) made clear the need of a strong interaction between the SGFO and the SGT. This led to frequent contacts with J. Kovalevsky, leader of the SGFO, and to common draft recommendations, as will be seen later. The work was performed almost entirely by correspondence, but I had the privilege of fruitful meetings with J. Kovalevsky and T. Damour.

The documents I received from my correspondents have been circulated. In the following abbreviated presentation, it is not possible to refer fully to the opinions which have been expressed : I rather concentrate on controversial topics. In the subtle problems which were encountered, opinions may diverge, even if based on correct scientific reasoning. In such cases, I followed the majority, at least when it is well marked.

5. Background of draft recommendations and notes

5.1. SPACE-TIME (DRAFT RECOMMENDATIONS G1 AND G2)

The necessity of a global treatment of space-time coordinates was unanimously recognized: "We must resolve the complete question of space and time transformations" (I quote L). In such a treatment there appears "the necessity of defining and using on an equal footing several systems of space-time coordinates, especially the systems centered at the barycenter of the solar system and of the Earth" (D). Brumberg and Kopejkin (1990) give a comprehensive study of "a set of reference systems mutually superimposing and covering altogether the whole of space-time" and advocate the use of non-rotating systems with the harmonic condition on the metric tensor; their work offers a complete and self-consistent set of coordinate transformations for the four space-time coordinates.

However, the choice of the coordinate conditions is still a domain of theoretical researches (Damour et al., 1990) and no particular solution can be recommended officially, at present.

It is in the nature of our work on recommended references and constants that the IAU recommendations often cannot meet the requirements of the most