ASTRONOMICAL REFERENCE FRAMES

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INTRODUCTION

The essential problem to be dealt with by the topic "Astronomical Reference frames" is to study what should be the involvment of IERS in the analysis, maintenance, and construction of celestial reference frames for all useful spectral domains. This should be done taking advantage of the competence of other groups or individuals, but respecting their areas of activity.

We note that the IAU Working Group on Reference Frames (WGRF) met in early October 1996. They discussed the key issues of this report and then, after some modification, agreed with the contents of this report.

We also note the completion of the first realization of the IAU International Celestial Reference Frame (ICRF). This catalogue of approximately 600 radio sources has now been finalized. As such, the future IERS involvement in this area concerns maintenance and upkeep.

An important proposal which affects several of the topics is that a Consultative Group should be appointed by the IAU to advise the IERS on matters concerning celestial reference frames. This Consultative Group is to begin its function at the time when the existing WGRF will have concluded its present work. It could be the successor of the WGRF.

1. MAINTENANCE OF THE ICRF

It is considered that the maintenance of the ICRF must be one of the three major objectives of IERS, together with the maintenance of the ITRF and their time-variable relations. Any decision on the definition of the system is of the sole responsibility of IAU, so that the reference system (ICRS) is to remain untouched. However, individual positions of the sources must continue to be improved. This means that:

i) All primary sources must be regularly observed in a coordinated manner as well as their structure.

ii) Other ICRF sources must also be occasionally re-observed and the evolution of their structure systematically analyzed, so that a stock of potential primary sources be updated.

iii) The list of primary sources must be modified whenever they are found to become inadequate, and new primary sources must be added accordingly, without modifying the representation of the system. This requirement will need some theoretical thoughts and possibly additional definitions.

iv) The number of sources of the ICRF must not be limited. A densification of the catalogue with new sources is very desirable.

The role of IERS should be to promote and coordinate observations, to decide upon their frequency, to update the various lists of sources, and to decide upon the time when such modifications become effective, according to the evolution of the requirements. IERS will be supported in these activities by the Consultative Group defined in the Introduction.

2. OPTICAL REFERENCE FRAMES AND THEIR LINK TO THE ICRS

The objective is to follow the accuracy with which the optical primary catalogue (now Hipparcos, later ...) represents the ICRS, to promote observations for its maintenance and, if felt necessary, to increase the quality of the link.

At present, the most significant contributions for determining the optical-ICRF frame tie are VLBI and MERLIN observations of Hipparcos radio stars with respect to the ICRS radio sources. A coordinated observation program should be promoted. Contributions from ground-based optical astrometry should also be considered and, if alternate methods are available, they should similarly be promoted.

In addition to the promotion of these programs, the role of the IERS should be to analyze the results and make a list of stars that are thought to be the best representatives of the ICRS in optical wavelengths (some kind of primary stars for ICRS). It should promote observation programs and either organize them or stay in close contact with the people responsible for them (e.g., in case of a new astrometric satellite). The IERS must be helped in this work by the Consultative Group.

3. OTHER OPTICAL CATALOGUES

It is important that other catalogues represent also the ICRS and that the accuracy be maintained into the future. There should be a continuous check on the most used ones (PPM, TYCHO as well as new ones that will be constructed using Hipparcos and other new or old data).

It should, however, not be the role of the IERS to provide the checks. It could do the comparisons between the catalogues, but the main task would be to centralize the results and give some kind of recognition to the links that would be considered as the most significant. At this level, the important parameters to be publicized are the accuracy and the biases of the link including their dependence upon time.

4. REFERENCE FRAMES BASED IN OTHER WAVELENGTHS AND UPON OTHER OBJECTS

It would be useful to investigate the necessity of extending the ICRS into the infra-red and microwave spectral domains. The Consultative Group should consider the analyses of catalogues of objects in other wavelengths (e.g., IRAS) and frames based upon other objects. In such cases, where there would naturally be other specialists involved, the Consultative Group should serve only to encourage and promote the establishment of the appropriate frame-tie, determined by the specialists themselves.

In general, other catalogues (such as IRAS) are nominally based upon an existing optical reference catalogue (e.g., FK4 or FK5) and would automatically be tied to the ICRS by an exisiting or future more accurate optical link (FK4 or FK5-ICRS). However, if such a link does not exist or if the accuracy of the other catalogue exceeds that of the catalogue to which it is referenced, then it would become necessary to establish a direct link to the ICRS (ICRF or its optical counterpart).

5. POSITIONS AND MOTIONS OF THE EQUINOX AND OF THE ECLIPTIC

The dynamical reference system, as realized by the ephemerides of the major bodies in the solar system, is no longer based upon the mean equator and mean dynamical equinox, nor upon the mean dynamical ecliptic. Instead, the most recent ephemerides are based directly upon the ICRF. However, the equinox and ecliptic do remain important concepts in a number of applications, such as analytical derivations of precession and nutation, etc. Therefore, it is necessary to make an effort to know the relation between the ICRF and the best determinations of the equator and ecliptic.

The instantaneous positions and motions of the equinox and ecliptic are inherent within the planetary ephemerides. The determination of their means at a given epoch, however, requires some later analysis. Further, there are two different definitions of the ecliptic. Therefore, uncertainties in the locations of the mean equinox and ecliptic arise from different ephemerides, different methods of analysis, and the differing definitions of the ecliptic itself. The IERS should analyze and monitor these differences, make available the different determinations, and present an estimation of the uncertainties of the results.

6. MILLISECOND PULSAR TIMINGS

Information from the timings of millisecond pulsars is useful for determining the Earth's orbit and for orienting the whole inner planetary system onto the ICRF. These objects have now been observed, measured, and analyzed for well over a decade by specialists outside of the IERS, and there is no reason to believe that their activity will not continue into the future. The IERS, however, can certainly encourage the observation of the millisecond pulsars in order to ensure their continued support.

In a lesser role, the IERS could assist in the collection and distribution of the analyses and results of those more actively involved in the studies of the millisecond pulsars.

7. IERS CONVENTIONS

All information present in the IERS Conventions is of interest to astronomy, This includes numerical standards, celestial reference frames, transformations between systems, and relativistic models. All should continue to be carefully followed and updated. The important point here is the availability to the astronomical community in a timely manner. The IERS is to establish and maintain coordination with the IAU WGAS (Working Group on Astronomical Standards) and, in particular, with SOFA (Standards of Fundamental Astronomy). Certainly, the IERS must maintain its own set of standards as it has done in the past. However, when possible without sacrificing accuracy or efficiency, these standards should be chosen to conform with those of the IAU WGAS. In all cases, they should be consistent with the IAU resolutions on reference systems (at present, the IAU and IUGG resolutions adopted in 1991).