Reference systems: What are they & what's the problem?

Chairman & Editor: *J.A. Hughes*

https://doi.org/10.1017/S1539299600008819 Published online by Cambridge University Press

Presentation of WGRS Recommendations I to V

B. Guinot

I start by general remarks on the background of the recommendations on space-time references which are submitted to you.

The need to consider time scales in a relativistic framework appeared more than 20 years age following the progress of atomic time standards. After long discussions, this led the IAU to define, in 1976, time scales which were designated, in 1979, as Terrestrial Dynamical Time (TDT) and Barycentric Dynamical Time (TDB). But soon afterwards difficulties in the interpretation of the definitions of TDT and TDB arose. It appeared that the source of these difficulties was the lack of a global approach to space-time reference systems. This point of view, first voiced by J. Lieske, gained acceptance. At the very beginning of the work of the WGRS Sub-Groups on Frames and Origins (SGFO) and on Time (SGT), it became clear the the primary mission of the SGFO and SGT was to jointly prepare general recommendations on space-time references on which they could base their specific recommendations.

Thus, Recommendations I to VII, prepared at Colloquium 127, Virginia Beach, in October 1990, that will be presented by J. Kovalevsky and myself, are organized as follows:

I and II:	General recommendations on space-time, (I, concepts, II, physical constraints),
III, IV, V:	Time,
VI, VII:	Space.

I shall present Recommendations I, III, IV, V and partly II.

I show the list of persons who contributed to the work of the SGT (see Proc. IAU Coll. 127). We should also add the contribution of the attendees of Coll. 127, especially of M.H. Soffel who helped to draft the Recommendations and the notes.

As all of you have the text of these recommendations and notes, I concentrate on the main points, especially those which led to objections in Virginia Beach.

Let us begin with Recommendation I. In the General Theory of Relativity, there is no priviledged coordinate system. Nevertheless a good choice of coordinate system may facilitate the treatment of the problem at hand, It is clear that the "good" coordinates should have their spatial origin at the barycenter of the masses which exert the main action, therefore we need

J. Bergeron (ed.), Highlights of Astronomy, Vol. 9, 117–119.

several coordinate systems. Recommendation I indicates, in a general manner, how to establish these coordinate systems.

I would like to draw your attention to Note 3 of Recommendation I. The metric form of Recommendation I is at a very low degree. It is nevertheless sufficient, considering the observational accuracy, with the exception of geodesic precession. This metric has been proposed because it is a common approximation to higher order theories. It will therefore be possible, when called for by progress in observational accuracy, to refine the metric form by adding more terms without changing the rest of the recommendations.

In Recommendation II, item 2, which recommends the realization of the time scales by atomic clocks, is only justified pragmatically; that is the best we can do. Item 3 and Note 5 have important consequences which appear explicitly in Recommendation III.

Recommendation III is a simple application of Recommendations I and II. It states the unit of measurement and the origin of the various coordinate times defined in accordance with Recommendations I and II. In fact, the unit of measurement is already defined in Recommendations I and II, but a certain amount of redundancy was found useful, so that the recommendations on time can be read independently. Recommendation III also designates two particularly important coordinate times: the Geocentric Coordinate Time (TCG) and the Barycentric Coordinate Time (TCB).

The notes of Recommendation III make clear that TCB differs from TDB in rate, by an amount of about 50s in a century. They give the relation between TCB and TDB and between TCG and TCB.

Recommendation IV defines a time scale, the Terrestrial Time (TT), which appears as an exception to the general rule for establishing coordinate times, but is necessary for measurements made on the surface of the Earth. The possibility of cancelling the "historical" offset of 32s.184 was considered in Virginia Beach, but rejected by a vote, therefore TT is identical to the TDT of the 1976/79 recommendations. Nevertheless, a large majority was in favor of changing the designation of TDT, by removing the adjective "dynamical", which was a source of misunderstanding.

Recommendation V is justified by the importance of some ephemerides based on TDB.

In conclusion, I would like to stress that we are officially introducing the General Theory of Relativity into the IAU activities on reference systems and constants. This is an important event. The conviction of a large majority of attendees at the IAU Colloquium 127 is that this introduction must be made as clearly, as openly, as neatly as possible. We must accept the theory in all its consequences, without trying to accomodate it by more or less artificial conventions, which sooner or later will be a cause of difficulties. We must

accept also its usual vocabulary. However, we have not forgotten the user who does not care about sophisticated theory; his needs are satisfied by the definition of TT, which, in most cases, can be replaced by TAI + time offset, TAI being available.

DISCUSSION

Kaplan:
Perhaps this would be better deferred to this afternoon, but I, and I suspect some other people, might like a little bit of background into actually how TAI is formed from ensembles of clocks that are separated on the surface of the Earth. That might help us a little bit conceptually in understanding the various time scales.

Guinot:
Yes, maybe that could be discussed this afternoon, but in brief what I can say is that TAI has the same relativistic definition as TT, and therefore combining the data of the clocks on the Earth and for disseminating TAI we use a concept of coordinate synchronization. Maybe this afternoon we could develop this point, but this is clearly stated anyway in the documents of the Comite Consultative por la Definition de la Second and in the CCIR documents.

Hughes:
Some of these documents are mentioned in the notes for some of the recommendations as well.

Christensen:
I would like to know the sign of the capital U in the metric, it is called the Newtonian potential, but isn't it the force function?

Guinot:
The sign of U is given in the notes for Recommendation I. The algebraic sign of the potential in the formula giving ds^2 is to be taken as positive.

https://doi.org/10.1017/S1539299600008819 Published online by Cambridge University Press