range. The principal uncertainty in the constant of precession is due to uncertainties in the planetary masses and hence in the planetary precession; the constant should therefore not be changed until an improved system of masses has been adopted.

Vicente also suggested that it would be better to adopt $20''.50$, rather than $20''.496$, for the rounded value of the constant of aberration, but *O'Keefe* pointed out that the recommended rounded values of the solar parallax and of the constant of aberration are self-consistent to a higher precision than is apparent from the number of figures given.

Finally, at about $17^h\,45^m$, the Chairman put the main resolution to the meeting and it was carried unanimously by the 50 Members of the Union that were still present.

2. ARGUMENTS IN FAVOR OF THE REVISION OF THE CONVENTIONAL SYSTEM OF ASTRONOMICAL CONSTANTS

W. Fricke

The system of astronomical constants conventionally used in the computation of ephemerides rests upon observations made in the nineteenth century. At the international conferences held in Paris 1896 and 1911 a set of values of various constants was adopted, and agreement was reached about the procedure for their introduction into the national ephemerides. The adopted values of the constants resulted from measurements of the maximum accuracy possible at the time of their adoption.

Several of the constants are not independent of each other, and it has always been known that the adopted values do not form a consistent set. If one keeps in mind that the main purpose of the ephemerides is to enable the comparison of observed positions of celestial objects with those predicted by theory in order to contribute to the improvement of the theories, then inconsistencies are only tolerable in so far as they do not obscure the comparison between theory and observation. At the time of Newcomb, the inconsistencies in the system of constants were harmless in this respect, since the accuracy of the observed positions of the stars and of the bodies of the planetary system did not seem to require more accurate values of the basic constants. Consistency for itself, however desirable it is from the logical point of view, appears to me not to be an indispensable condition for a system as long as no discrepancies arise in the discussion of observations. On the other hand, consistency becomes indispensable when the accuracy of the observations is sufficiently high to reveal discrepancies caused by an inconsistent set of constants.

I consider the fact that no changes have been made in the most important astronomical constants for many decades as a great advantage, because frequent changes in the foundations of the ephemerides may render the analysis of the differences between observed and computed values difficult or even impossible.

Some arguments put forth in the past in favor of a revision of the conventional system of constants seem to me not strong enough to justify a change. These are, first, the inconsistency of the system under the condition mentioned above, and second, the availability of improved values of certain constants. I would like to give an example of circumstances under which one is better advised to continue using an adopted incorrect value of a constant than to make a change in the foundations of the ephemerides. One of the best examples is probably provided by the constant of precession. It has been realized for a long time that Newcomb's constant of precession needs a correction of the order of plus 1 second of arc per century, and the reasons for Newcomb's error are known. However, it has also turned out to be extremely difficult to determine the correction itself with a better accuracy than 25 per cent. Now, the mistake in the adopted value of precession

is without effect on the computed ephemerides of the stars, since the error produced in the reduction from one equinox to another by Newcomb's precession is strictly compensated by the corresponding error in the proper motions of the fundamental stars which are derived by the application of Newcomb's precession. For the purpose of ephemerides and for the reduction of all observations it is therefore advisable to maintain Newcomb's value until the amount of an improved value is more definitely known. There is good reason to believe that the correction can be determined with higher accuracy in the near future.

Not quite such a favorable but a similar situation exists concerning the constant of nutation. Modern determinations based on numerous observations lead to a value which is smaller than Newcomb's ($N = 9''.21$) by about $0''.01$ with a mean error of only a few units in the third decimal place. Again, the errors caused by the error in Newcomb's constant of nutation appear to produce no such serious effects in the computed positions that a change would be justified at the present time.

It should also be mentioned that at present there exists no theory of the internal structure of the Earth sufficiently reliable for the derivation of the constants of precession and nutation from parameters of the Earth.

The Working Group, in following the recommendations of IAU Symposium no. 21, has decided not to propose a change in the values of the constants of precession and nutation.

The considerations presented above demonstrate that obviously certain necessary and sufficient conditions must be fulfilled to justify a change in the adopted constants. My personal view is that, in general, the necessary and sufficient conditions for a change are provided by unchallenged evidence that the ephemerides no longer fulfill their intended purpose, and that better values of the constants, providing a foundation for more accurate ephemerides, are available.

Thus, the most essential arguments in favor of the introduction of a revised system of constants at the present time are the following: first, the improved accuracy of observations since the time of the introduction of the current system, and the necessity of making available more accurate ephemerides to meet the requirements of the observers; second, the availability of improved values of several constants; and third, the occurrence, in the discussion of observations, of errors which later cannot be eliminated and which are caused by certain incorrect values of the constants.

As an example of the validity of the third argument may be mentioned the effects which arise from the use of an incorrect value of the constant of aberration in the ephemerides. It is impossible to eliminate from the results of observations errors due to incorrect aberration, unless each individual observation were to be re-reduced. In practice, this is obviously not feasible.

All three arguments have never before had quite their present strength. I reviewed recent developments at the Paris Symposium last year, and the papers presented there provided overwhelming evidence that the revision of the conventional system of constants cannot longer be postponed.

May I summarize very briefly the progress made during the past decade. The parameters of the figure and gravity field of the Earth have been determined with unprecedented accuracy. The measurements of interplanetary distances by radar methods have contributed essentially to the determination of the A.U. in meters. The mass of the Moon in units of the mass of the Earth has been determined with high accuracy by means of a space probe, and this new technique has superseded the questionable and difficult method of determining the Moon's mass from the lunar equation. More accurate theories and ephemerides of the planets have been developed, and improved techniques of astronomical observation have resulted in higher accuracy of the measurement of positions.

It is not too surprising that our knowledge is still insufficient to reconcile diverging results of different methods of determining the constants, in particular, if one compares older results with very recent ones. There exist also discrepancies between the values of some constants as determined by direct measurements and as derived from the values of other constants. The most outstanding example is the value of the A.U. in meters. The determination by radar echoes from Venus involves mean errors which are far smaller than the corresponding errors of all other astronomical determinations. The radar values for the A.U. lie just in the middle between the values obtained by the dynamical method and the best trigonometric determination. If one derives the A.U. from the most recent astrometric determinations of the constant of aberration, then its value lies outside the interval between the trigonometric and dynamical result. All determinations, however, of the constant of aberration, whether direct or via the astronomical unit, indicate that the *conventional* value of this constant is too small.

The Working Group has decided to recommend for adoption a value of the A.U. in meters which is a rounded value of recent radar determinations, and to treat the constant of aberration as a derived constant.

There exists very little hope that the trigonometric determination of the solar parallax, carried out by Sir Harold Spencer Jones from numerous observations during the years 1930–31, could be redone with any prospect of higher accuracy, since there are too many sources of systematic errors inherent in this method. The situation is different for the dynamical result which could conceivably be reconciled with the radar results in the near future.

One could argue that the radar results are still too fresh to deserve full confidence. My personal distrust of them in so far as it originates in their newness has a counterpart in my distrust of the dynamical result obtained from the discussion of the observations of Eros. As a rule the residuals between observed and computed values of the positions of the planet are taken as a criterion for the quality of the resulting solar parallax. It should be pointed out that the observations of Eros contributing to the normal positions rarely fulfilled the requirements of full astrometric accuracy and that it is not impossible that serious systematic errors may have affected the normal positions.

There is general agreement that with the adoption of a value of the constant of aberration derived from the proposed value of the A.U. a noticeable improvement will be achieved in the discussion of astrometric measurements.

The objections which can be made against the revision of the conventional system of constants on the basis of still existing discrepancies between various determinations are no longer compelling enough to counterbalance the agreed advantages of the revision. Discrepancies between measured quantities will continue to exist at any time, and the improvement of the values of the constants will be a lasting problem.

No further arguments appear to be necessary in favor of the recommendation that the 'new system shall be defined by a non-redundant set of fundamental constants, and by explicit relations between these and the constants derived from them'. The demand for consistency has been fulfilled as far as the relations are concerned which are explicitly set forth in the proposal and which form an inherent part of the system together with the primary and derived constants.