Concluding Remarks

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We started this meeting with a discussion of Vassily Yakovlevich Struve. I would like to mention again this great founder of the Pulkovo Observatory. Vassily Yakovlevich directed the determination of a constant of precession which is almost identical to the modern value determined by VLBI. How did he and his son Otto do that? They observed and reduced their own data, thereby avoiding the pitfalls of using data compiled by others without a full understanding of what went into such compilations. Can we still do this? I think this excellent symposium has taught us that, with difficulty, we can; that there are many who do not recognize the pitfalls; but that the reward is unprecedented accuracy and worldwide recognition.

What else did we learn? There is a need for a common approach to reference frames. Several speakers discussing relativistic frames tried to get the audience to understand their approach and pointed out inconsistencies. We must have our house in order before the high accuracy data come in. Here is an example: the mean place calculation controversy has now raged for six years. It was made crystal clear during this meeting by Soma and Aoki that Murray is erroneous and by Murray that Soma and Aoki are erroneous! People are reporting "errors" in the FK5 and we don't even know yet how to transform from B1950 to J2000! And by-the-way, the basic FK5 is now in print, a very happy occurrence!

We heard about HIPPARCOS, and the encouraging news that some very important reference frame data may emerge. Even with only six months of operation HIPPARCOS can yield considerable optical reference frame improvements. And we encourage the ESA to construct a second HIPPARCOS with minimum delay. The old ground-based catalogs are now even more important than they were before, as they will carry great weight when used with HIPPARCOS data to provide very accurate proper motions.

The Hubble Space Telescope, hopefully to be launched next year, promises galactic-extragalactic connections (quasars-HIPPARCOS Stars) and other relative astrometry with great precision.

We heard about three proposed USSR astrometric satellites, AIST, Regatta, and Lomonosov, and one proposed USA satellite, POINTS, all projects aimed at achieving very precise global reference frame data in the next ten to fifteen years. We hope that at least some of these projects will be brought to completion in this highly competitive field of space research, as they will bring a major advance to astrometry.

An example of the wide-ranging importance of the field of astrometry to other parts of science is the advance in the area of nutation. The accuracy of the astrometric (VLBI) data now available is well beyond what can be achieved by current theory and provides an entirely new set of data for geophysics.

J. H. Lieske and V. K. Abalakin (eds.), Inertial Coordinate System on the Sky, 5–6.

In VLBI we now have 1-2 milliarcsecond agreement between reference frames based on entirely independent sets of observations, with the promise of better accuracy using general relativity refinements. This is fifty times better than the current optical reference frame. In local frames, i.e., fields 10 degrees or smaller, accuracies down to a stunning 0.2 milliarcseconds have been achieved. And in VLBI relative astrometry even higher precisions are anticipated with the ambitious plans for the USSR Space VLBI project QUASAT.

VLBI catalogs and the FK5 are representations of reference frames from entirely different techniques. We need to understand these techniques better before we try to improve the optical reference frame by connecting it to the radio frame. A very large amount of effort is going into tying the optical and radio frames, both here in the USSR and abroad. But a warning needs to be sounded. The radio frame contains only a few hundred objects, one for every ten FK5 stars. Current work in connecting the frames is certainly useful, but we have to await new techniques, such as ground-based optical interferometry and the space-based astrometric systems, to get the optical frame to the same accuracy as the radio frame.

Please note the comment that the dynamical frame is defined by the ephemerides, which are only as good as the observations to which the physical models are tied.

George Wilkins presented a list of definitions. I have to admire the wisdom and courage of the organizers of this symposium for placing the definitions at the end, so there would be no cluttering up the discussions with facts! The definitions are complex. I saw several heads nodding vigorously during Wilkins' talk, both YES (agree) and NO (disagree) at the same time. Clearly, there is a need for some major decisions in reference frame building, and the reference frame meeting organized by the USNO next year in Virginia Beach (IAU Colloquium 127: Reference Frames, October 14-20,1990) comes none too early. We must iron out our differences, and a lot of preparation and correspondence is still necessary if we want to achieve a consensus at IAU Colloquium 127.

There is a great amount of optimism for reaching unparalleled accuracies both on the ground and from space. Only with optimism can we succeed. We can learn from HIPPARCOS. Without its optimistic predictions it would not have been built, but even if it cannot now reach its ambitious design goals, it will still provide a major step forward. The same holds for the many astrographic photographic surveys now being undertaken.

Vassily Yakovlevich was a master in international cooperation, using a web of personal friendships and open sharing of data necessary to further international goals. Let us continue in his footsteps and continue the close international cooperation that has always characterized astrometry, so that duplications do not occur and the field advances at the fastest pace possible. This symposium has contributed immeasurably to this goal.

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