CELESTIAL REFERENCE SYSTEMS
THE ASTROLAB CONTRIBUTIONS

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The reference system problems

The purpose of the astrometry is mainly to study and to quantify the positions and the motions of celestial objects. This may be done only if we can use a celestial reference system.

We can use, following the instrumental capabilities, dynamical or kinematical concept to materialise the reference system. The materialisation is effective and useful when we have the precise coordinates - or the possibility to compute them - of a set of celestial objects. With the high precision, the best celestial reference system could satisfy some properties as stability, density and accessibility.

A reference system is stable when it has no residual rotation .For example the FK4 system presents, relative to the dynamical system, a rotation practically around the z-axis, which induces variations of rihgt ascensions of about, in second of time:

$$(\text{FK4}/\text{dyn}) = 0.035 + 0.00085\ (T - 1950.0)$$

Since January 1, 1984, the correction are made (on α and $\mu\ \alpha$) and we are in the FK5 system, where this rotation is removed.

The accesibility means that objects of the reference system could be easy to observe and the density means that it is easy to find objects of the reference system in any part of the sky.

Everybody may understand that, because the techniques of observations are not perfect, the astronomers are obliged to use many different reference systems. The main problem is to connect these different systems to obtain a unique one. Since Newton theory, followed

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by General Relativity, the best system was the dynamical one based on the motion of the Earth-Moon gravity center around the Sun. Now, new techniques such as Very Long Baseline Interferometry (VLBI) and the future Hipparcos satellite, give us the possibility to construct an extragalactic system of high precision and a stellar one connected with the extragalactic system. The extragalactic reference system will be the fundamental system and the stellar system being, as it is always the case, an "interpolation" system.

There remains the problem of connection between the old and the new systems and particurlarly the connection between dynamical and extragalactic systems. This will be obtained, mainly, by observations of Sun and planets positions in the Hipparcos stellar system. Then the connection of stellar and extragalactic systems give the positions of Sun and planets in the new fondamental system: the extragalactic reference system. As the astrolabe is now able to give positions of planets and Sun in the FK5 system which will be a subset of the Hipparcos system, this kind of instrument may give in the future, an important contribution to connect the stellar and the dynamical systems.

The astrolabe: Newpossibilities and new programs

The principle of the astrolabe is well known. Let us only repeat that the main quality of this instrument is the compacity of the solid reference constitued by the prism and the mercury surface. The observation consists of obtaining the transit time of the observed objects at a constant zenith distance (about 30° in the classical model). This intrinsic precision is about 0".15 to 0".20 for one observation. Primitively the astrolabe was used to determine the parameters of the Earth rotation through the measurements of longitude and latitude variations. Since the begining, in 1956, many observers work to increase the precision and the possibilities of the astrolabe.

The precision is increased if we can give a greater stability to instrumental constant. Some of them are easy to measure and give no problem. The exact zenith distance is not in this case and remain as an unknown with time and latitude. As this zenith distance is defined by the size of the prism it is necessary to increase its stability. For some years we use in CERGA Observatory and now in Paris, prism built in ceramic with very low dilatation coefficient.

The possibilities of the astrolabe may be increased without big problem. In fact the main problem is to increase the field of declinaticn which may be observed. This, which was not easy to do with classical prism, is very simple with new prism. Now, we can easily obtain field of about 120° and more in place of the 60° that we have with the old system. For example, it is now possible in Paris Observatory to observe stars and planets for wich the declination is greater than - 11°.

Finally to observe the Sun, it is only necessary to add a filter to protect the instrument. This filter is a plate covered by a coat of chrome-nickel directed toward the Sun. In CERGA Observatory a great plate protect the entire astrolabe but it is not negligible in the definition of the zenith distance. To remove this effect we have, in Paris, put the filter in front of the objective. In this case, only a differential effect may appear.

We construct at CERGA Observatory the solar astrolabe to obtain solar positions. The diameter is also obtained with a precision of 0"5 for one observation and since 1978, we have detected variation in the value of the solar diameter of 0"5 amplitude and periodicity of about 1000 days. We are doing analysis to detect the oblateness of the sun and, eventually, its variations, which is very important for solar astrophysicists.

It is why we construct a new astrolabe in Paris Observatory: it is very important to confirm (or not) these results, and to contribute to the elaboration of the new celestial reference system.