Contribution to the history of astrometry No. 1A

Bengt Strömgren and modern astrometry

Development of photoelectric astrometry including the Hipparcos mission

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***ABSTRACT**: Bengt Strömgren is known as the famous astrophysicist and as a leading figure in many astronomical enterprises. Less well-known, perhaps, is his role in modern astrometry although this is equally significant. There is an unbroken chain of actions from his ideas and experiments with photoelectric astrometry since 1925 over the new meridian circle in Denmark in the 1950s up to the Hipparcos and Tycho Catalogues published in 1997.*

1. Introduction

This account follows a chain of actions beginning with an experiment on photoelectric astrometry in 1925 and culminating with the Hipparcos mission at the end of the 20th century, thus, in 1925 began a new era of positional astronomy comparable in significance to that of Tycho Brahe four centuries earlier. This brief account is far from being a complete history of Hipparcos, nor, of course, of the many other developments of photoelectric astrometry in the same period.

Note: ***This is a shorter text than to the proceedings of the IAU Symposium 254 where references are given; see*** www.astro.ku.dk/~erik/History.pdf.

5. Conclusion

Bengt Strömgren appears clearly at the root of my contributions to astrometry, including Hipparcos, and he was directly active before the mission approval in 1980 in order to ensure Danish and Swedish support. He would have seen the Gaia mission (to be launched in 2011) with astrometry, photometry and radial velocities as the ultimate fulfilment of his quest since the 1930s for comprehensive studies of our Milky Way. It seems from the unbroken chain of actions defined here that there would have been no Hipparcos, no space astrometry with a scanning satellite, if any of the five persons Bengt Strömgren, myself, Pierre Lacroute, Jean Kovalevsky or Lennart Lindegren had been absent from the scene before 1980.

2. Strömgren's experiments with photoelectric astrometry

Bengt Strömgren in 1925 at the age of 17 years reported about experiments with photoelectric recording of star transits. In the focal plane of the meridian circle in Copenhagen he had placed a system of slits parallel to the meridian, Fig. 1. Behind the slits was a photo cell which received the light from the star after it had passed the slits. As the star moved across the slits the variations of light intensity gave corresponding variations in the photo current, and these variations of current were amplified and recorded.

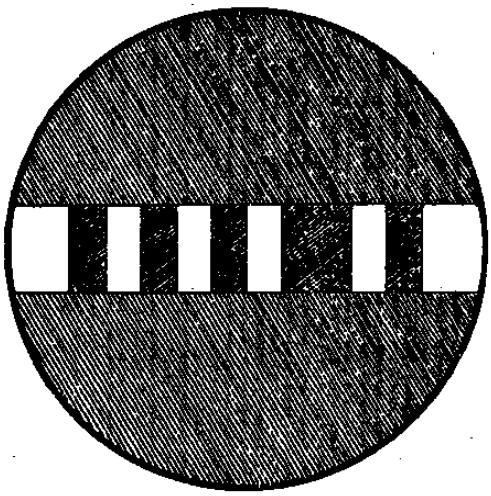

Figure 1. Slit system for photoelectric measurement of right ascension with a meridian circle (Strömgren 1925)

Strömgren, however, found a serious drawback of his initial method: For reasons of statistical noise, it would only allow recording of stars to 6th or 7th magnitude with a medium size meridian circle. He therefore proposed a method of integration (Strömgren 1933) which should allow observation of much fainter stars. A mirror was placed behind a system of equidistant slits. It was switched quickly at predetermined times between two positions. In one position the light hits one photo cell, in the other another photo cell, both of them able to integrate all the light reaching them.

The mirror and the whole operation of this “second generation” system posed technical problems and no further experiments have been reported. The author of these pages heard about the two proposals as a student and that bore fruit later on as I shall explain, but I probably never discussed them with Strömgren in those early days.

3. Developments in Denmark and Hamburg

In 1940 Bengt Strömgren succeeded his father, Elis, as director of the observatory, then located in the centre of Copenhagen. The same year he took the initiative to build a new observatory outside Copenhagen. A site in Brorfelde 50 km west of Copenhagen was selected. Ten years later the concrete for the foundation of the main instrument, a new meridian circle, was poured, and finally, in 1953 the instrument itself could be mounted. I then got the task as a fourth year student to test the stability of the new instrument by photographic observations of a star very close to the North pole. Strömgren did not intend to implement a photoelectric method at the new instrument, but preferred a method where a photographic plate is moved along with the star. This method was technically less challenging, and was in fact put into operation in Brorfelde in the 1960s.

Most important for me as a young astronomer, was to grow up in an observatory where a new meridian circle was the main instrument and where this course for the institute had been defined by an outstanding scientist. Bengt Strömgren gave everybody, not only a youngster as me, confidence about the future line of astronomy. How very different at most other places in the world where astrometry, the astronomy of positions, was being discarded as old-fashioned stuff. At such places I would probably have become an astrophysicist, since I certainly did not want to do old stuff.

In 1956 I finished my studies and became a conscript soldier. Most of the time I had the opportunity to work in a laboratory (Niels Finsen Institute) measuring radioactive decay of dust, collected to follow the nuclear weapon testing of the two superpowers. The measurements were obtained by radioactive counting techniques and my experience with this brand new technique I could later apply to photoelectric astrometry.

In 1958 I moved to the Hamburg Observatory where both astrometry and astrophysics were held in high esteem; Otto Heckmann was the powerful director. My interest went towards observational astrophysics, but soon I got the best idea I ever had (Høg 1960): I realized that Strömgren's method with the switching mirror could be implemented very elegantly by a photon counting technique. I do not think any other astronomers used photon counting at that time; I had the idea from the counting of radioactive decay.

Briefly, the technique was as follows: A photo multiplier tube is placed behind a slit system, the photo-electrons are counted in short time intervals,

e.g. 0.2 seconds, controlled by an accurate clock, and these counts are recorded on punched tape. Later numerical analysis of the counts in a computer gives the transit times across the slits. In principle, the transit time for individual slits could be derived, or the transit time for a group of slits. The latter method would be less sensitive to noise, and in the course of time both method have been widely applied.

The slits should be inclined to the stellar motion by 45 degrees in alternating directions. By such a "fishbone grid" a two-dimensional measurement of the star in the focal plane became possible (Fig. 2), corresponding to right ascension and declination.

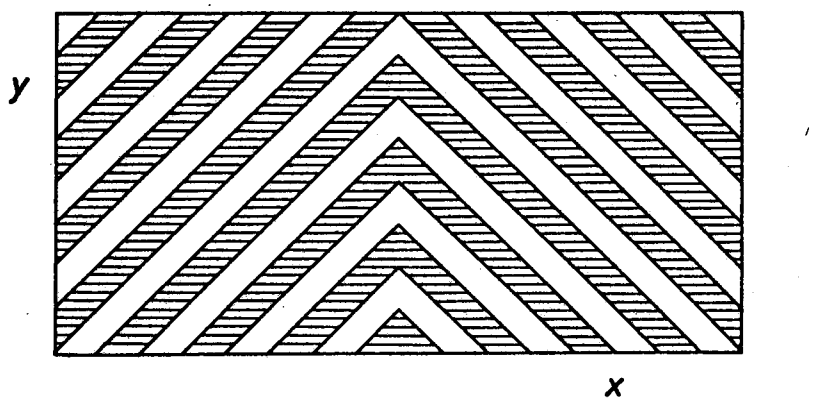

Figure 2. Slit system for two-dimensional photoelectric measurement in the focal plane of a meridian circle (Høg 1960)

Astrometry by means of accurate slits and photon counting was subsequently applied on meridian circles, on long-focus telescopes, and ultimately on the first astrometry satellite, Hipparcos. French astronomers became interested in the method, and I saw reports in the early 1960s from Lille and Besançon where they worked with "une grille de Høg", as they called the system of inclined slits, but I do not recall if they used photon counting. The method with the fishbone grid and photon counting was crucial in the proposal for space astrometry by Pierre Lacroute.

Heckmann was immediately interested in my proposal, and I recall that he helped me write the report in 1960. He wanted the method implemented on the Hamburg meridian circle for the planned expedition to Perth, Western Australia. That kept me busy for the next decade and resulted in the Perth 70 Catalogue of positions for 24,900 stars (Høg & von der Heide 1976).

4. Space astrometry

In 1967 I heard the presentation in Prague by Lacroute (1967) about space astrometry. This was the first time that such type of astronomy was proposed for a space mission. The potential advantages were clear, no atmosphere and no gravity, but the technical problems seemed utterly underestimated since a total mission cost of only 10 million French francs was claimed. The proposal did not start any activity outside France, and I was fully occupied with other matters; at that time I did not have any vision of space astrometry. But Lacroute's vision was fortunately shared by other French astronomers, especially Jean Kovalevsky. He supported the idea and finally had the project converted from being a French national project to become European through ESA.

In 1975 I was invited to be member of a small working group of astronomers and ESA engineers set up to make a mission definition study of space astrometry. I felt that I had to join the group in spite of my profound scepticism about Lacroute's proposals and also a lack of interest in space techniques. At the first meeting of the group on 14 October the ESA chairman urged us to be independent of previous ideas and to propose whatever space techniques could most efficiently achieve our scientific goals. With this encouragement in mind I designed in six weeks my vision of a scanning astrometry satellite, called TYCHO. From this design study many (seven) new features were adopted in the final Hipparcos satellite. The name seemed proper for the first satellite especially designed for astrometry. Several years later Kovalevsky introduced the name HIPPARCOS as an acronym for the final satellite, based on the TYCHO/Option A.

In a large team a few will often stand out; Andrew Murray, my old colleague and member of the Hipparcos science team, once said: "Erik, the best you have ever done for astronomy was to find Lennart!" and I agreed. I "found" Lennart Lindegren in 1973 while a 23 year old student at Lund Observatory (see Høg 2008b), and I have had the privilege to work with him ever since. I brought him into Hipparcos in 1976 and without his unfailing genius in all mathematical, computational and optical matters the project would not have been ripe for approval in 1980, and probably never.

The Hipparcos project won the competition with the EXUV project in ESAs Astronomy Working Group, but only barely so. - If Hipparcos had lost I was ready to quit the project for lack of faith that the astrophysicists would ever let it through. - ***See the conclusion on p.1!***

Further illustrations to the poster

The poster was shown with four large pictures (A4):

The Copenhagen meridian circle used by Bengt Strömgren
Courtesy Steno Museum, Aarhus

The Carlsberg Meridian Circle from Brorfelde, here on La Palma

The Hipparcos astrometry satellite launched by ESA in 1989

Astrometric accuracy through 22 centuries from Hipparchus to Gaia.