Content:

Only about work leading to Hipparcos/Tycho

- Photoelectric effect, Bengt Strömgren
- Meridian circles in Brorfelde, Hamburg and Perth
- Hipparcos mission, including the Tycho experiment

Erik Høg – 2012

Niels Bohr Institute - Copenhagen

2012: Beijing at IAU Comm. 8 - General Assembly
Copenhagen meridian circle
Photoelectric astrometry begins in 1925

Bengt Strömgren (1957)
Bengt Strömgren 1925
Experiments with photoelectric recording of transits

Courtesy: Steno Museum, Aarhus
New meridian circle
initiated by Bengt Strömgren 1940
installed in Brorfelde 1953

Høg - Soldier 1957
Atomic bombs
Counting techniques
Idea 1958:
“... general principles of a new type of automatic measuring machine ...
...to magnetic tape ...
...to high speed digital computer...”
Hamburg 1960: Recording on punched cards

Scanning spectra

My innovations were much used but did not give me many publications. I won, however, the director Otto Heckmann’s sympathy and his confidence that I had even more to offer.

Otto Heckmann

Iris Photometer
**Slits + Photon counting vs. Time**

=> Astrometry + Photometry

Light intensity
= Photons per second

B. Strömgren 1933: slits + switching mirror

1930s: Photomultiplier Tube (PMT) and Image Dissector Tube (IDT) developed

Atomic bombs 1957: Counting techniques

E. Høg 1960: Slits + counting >>> implementation on meridian circles

In France called: *Une grille de Høg*

Ideas 1960

Otto Heckmann
Hamburg – **First slit micrometer** on a meridian circle 1966

**Semi-automatic:**
Manual setting of telescope
Photoelectric measurement of declination circle and star
Recording on punched tape
Photon counts of the star are accurately synchro’d to UT.
Therefore Crab pulsar 1969
Hamburg 1966
The Repsold meridian circle
Ready for Perth

**Semi-automatic:**
Manual setting of telescope
Photoelectric measurement of declination circle and star
Recording on punched tape
Perth Observatory – 1967-72-80

The GIER computer room
GIER was transistorized
RAM: 0.000 005 Gbytes
Drum: 0.000 07 Gbytes
0.000 0007 Gflops

Frau Ilse Holst

8-channel punched tape:
0.000 1 Gbytes
Perth – meridian pavilion

~260 star obs. per night, incl. 40 FK4s
~22 000 per year !!!

Fantastic for 1970
Final catalogue in 1976 by E. Høg and J. von der Heide

ABHANDLUNGEN AUS DER HAMBURGER STERNWARTE

BAND IX

5 years observing by a staff of 10

PERTH 70

A CATALOGUE OF POSITIONS

OF 24900 STARS
Denmark – automatic meridian circle
Feb. 1979
Space astrometry in France

- Ideas and work in France 1964-74 Nice, Grasse, Paris, Lille: Pierre Bacchus, Strasbourg, and CNES in Toulouse; there was no space astrometry activity outside France in this period

- Pierre Lacroute 1967: Presentation in Prague

- Jean Kovalevsky 1974: European project

Pierre Bacchus & Pierre Lacroute (1985)

Jean Kovalevsky (2005)
Design of a scanning satellite

- Lacroute 1974:
  - Expected 300,000 stars \( \sim 3 \) mas
  - with 40x40 + 30x30 cm apertures
  - Two-dimensional measurement
  - 6 Photomultiplier tubes

Frascati 1974 in ESRO SP-108
Beam combiners and mission

Features later adopted for Hipparcos are in red

• Lacroute 1965-1974:
  Scanning satellite
  with a beam combiner
  Two-dimensional measurement
  Beam combiner of 16, 5 or 3 parts
  Slit systems
  Only photomultiplier tubes (PMs)
  Passive attitude control
  Spin axis related to orbit

  Lacroute also considered
  a Spacelab option

  First meeting of the study group in Paris on 14 October 1975

• Høg 3 Dec. 1975:
  One-dimensional measurement
  Beam combiner of 2 parts
  Change its angle from 45 deg
  Modulating grid
  Image dissector tube
  Active attitude control
  Spin axis revolves around sun
  Star mapper with one PM
  Input catalogue
  Perhaps the best I ever did for astronomy
Design of a scanning satellite

- Høg 1975-1976:
  Expected 100,000 stars ~4 mas
  with 16x16 cm aperture
  One-dimensional measurement
  One image dissector tube + one PM

IAU GA 1976, Highlights of Astr., p.361
B. Strömgren 1933: Slits + switching mirror
E. Høg 1960: Slits + counting

P. Lacroute 1967: Go to space
J. Kovalevsky 1974: European project
E. Høg 1975: New design of mission
L. Lindegren 1976: Data reduction

Studies during 4 years led to:
ESA 1980: Hipparcos approval
Ed van den Heuvel in ESAs AWG

Hipparcos mission: 1989-93
Final results 1997:
16 volumes + 6 CD ROMs
Tycho-2 in 2000:
2.5 million stars

www.astro.ku.dk/~erik/History.pdf
Hipparcos and Tycho 1975-2007

- Focal plane of Hipparcos – Tycho:
  - New mission design Høg 1975
  - Mission approval Feb 1980
  - Tycho proposal Høg 1981
  - Launch 1989
  - Catalogues 1997 & 2007
  - Tycho-2 Catalogue in 2000
  - 2.5 million stars
  - 900 citations by 2012
## Number of stars with accurate distances

1% and 10 % maximum std. error

<table>
<thead>
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<tbody>
<tr>
<td>Year of publication</td>
<td>1950</td>
<td>1995</td>
<td>1997</td>
<td>2007</td>
<td>2021</td>
</tr>
<tr>
<td>1 %</td>
<td>1 =Sun</td>
<td>1 =Sun</td>
<td>168</td>
<td>719</td>
<td>11 million</td>
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<tr>
<td>10%</td>
<td>500</td>
<td>940</td>
<td>20870</td>
<td>30580</td>
<td>150 million</td>
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<td>Luminosities, M_V (mag)</td>
<td>+17 to -1</td>
<td>+14 to -4</td>
<td>+14 to -4</td>
<td>+20 to -8</td>
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</tbody>
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**Gaia will give will give us over 5000 times as many accurate distances as Hipparcos**

1997-2021: Numbers from Jos de Bruijne in July 2011, based on Luri, Babusiaux & Lindegren for Gaia

2011 Erik Høg
How Gaia began

- August 1989: Hipparcos launched
- Data reduction occupied us all, also me, but a visit to USSR in 1990 gave me impuls:
- 1990-91 dialogue with Russian colleagues
- Proposal Høg 1992:

  Scanning mission with **CCDs**: Roemer