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Minutes of the Fourth Meeting
of the
HIPPARCOS SCIENCE TEAM
ESTEC, 29-30 June 1982

Attendance

HST: Dr. M.A.C. Perryman, Chairman
Dr. P. Brosche
Dr. C. Coleman
Prof. F. Donati
Dr. M. Grenon
Dr. E. Høg
Prof. J. Kovalevsky
Dr. L. Lindegren
Mr. C.A. Murray
Mr. R.S. Le Poole
Dr. C. Turon
Prof. C.G. Wynne

ESA: Mr. L. Emiliani (part time)
Mr. R. Bonnefoy
Mr. M. Schuyer
Dr. S. Vaghi (part time)
Dr. R. Wills

1. Adoption of the Agenda

The agenda as shown in Annex I was adopted.

2. Report by the Project Manager

Emiliani reported that a three week delay in the SDR activities had occured following agreement between ESA and MESH. The importance of the HST's contribution to the evaluation of the SDR documentation was stressed.

The status of the project was briefly presented. SSDR would take place in the mid-October timeframe.

3. Report by the Project Scientist

Perryman thanked all HST members who had contributed to the success of the Strasbourg Colloquium. Murray congratulated the organizers and ESA on the prompt production of the proceedings. HST members were invited to bear in mind the possibility and value of organizing a "workshop" on HIPPARCOS activities in late 1983 or 1984.

Following the SPC's approval to release the Invitation for Proposals to non-member state scientists, copies had been distributed to institutes on the IAU and A & A mailing lists. An announcement had appeared in a recent American Astronomical Society Newsletter; some 50 requests had subsequently been received from non-ESA state scientists, so that the 1 October 1982 deadline was considered satisfactory.

The ESA SSAC (meeting of 3 June) and SPC (17-18 June) had recommended that HIPPARCOS should not be delayed because of current financial problems within the Agency.

Following the kick-off meeting between ESA and the Data Analysis Consortia, the consortia leaders had been invited to submit a formal proposal to ESA covering the additional reduction of the TYCHO data. This response would be submitted before 1982 November 30.

As a result of further studies by the Project Team on the hardware impacts of the TYCHO 3-filter option proposed by Høg (i.e. U_T in addition to B_T and V_T), and on the scientific impact of the TYCHO U_T data compared with possible ground-based data (based on the work of Grenon) Perryman recommended that the 3-filter option should no longer be considered. This position was accepted by the HST.

4. ICC/DRC Activities

The 3-monthly reporting to ESA of the activities and status of the three scientific consortia would commence with a first report to be submitted to ESA by 1982 October 31. Coinciding wih these reports from the consortia, Perryman would distribute to the three Team Leaders selected documents received by the Project Team, as well as a selected list of documentation of possible interest to the consortia. Responsibility for distribution within the consortia would lie with the Team Leaders. Distribution of all such documents would be subject to the same conditions as for the documentation distributed at the time of the SDR.

5. Comments on the SDR Documentation

a) Attitude Jitter and Dynamical Smoothing

Donati asked for a clarification of the term "jitter" which was used to describe both (i) deviations from the nominal motion, and (ii) errors in the attitude estimation. The latter definition was considered preferable (the phenomenon affecting the accuracy is the motion which cannot be assessed observationally).

HST approved the selection of attitude control by cold gas jets. Le Poole asked whether the limit cycle duration was not being restricted by the fixed size of the thrust and whether larger cycles could be achieved using a variable thrust.

Donati expressed some concern on the analysis that MESH had made on the jitter amplitudes in the case of wheel control. With the proposed gyro frequency band of 5Hz, dynamical smoothing with wheels would not be feasible; a smaller band ($\sim$ 0.5 Hz) should have been considered. Nevertheless, the main conclusion of the trade-off studies would probably not change.

Donati suggested that the inclusion of an accelerometer (e.g. piezo-electric transducer or an inertial-grade accelerometer) to measure the vibrations around the z-axis in the frequency band 0.5 - 50 Hz should be considered.

Kovalevsky agreed that any information that could be provided on jitter amplitudes at $>$ 0.1 Hz would be very useful. MESH presented values of 2 marcsec amplitude in the range 0-5 Hz but it was not clear what fraction of the power was expected at frequencies below 0.05 - 0.1 Hz - frequencies at which jitter could be assessed observationally. The intermediate frequency range (0.05 - 0.5 Hz) would be hardest to account for, and a more quantitative expression of the power spectrum in this range should be provided in due course. Sources of jitter in this range should be identified, since peaks in this range may have a bearing on the chosen observing strategy.

It was agreed that the need for magnetic torquers had not been demonstrated; until better estimates of the achievable limit cycles could be provided it was not possible to recommend either the inclusion or exclusion of a magnetic torque control. Le Poole noted that the magnetic torque control could ultimately provide a larger satellite lifetime as well as longer limit cycles. Donati expressed concern on the frequency and effects of magnetic storms. Coleman stated that studies of the interaction of such a torque actuator with the IDTs and PMTs would be needed. Interaction of the detector fields and of the earth's magnetic field should also be studied, independently of the presence of a torque actuator.

b) Modulating Grid

Bonnefoy reported on the CEH (EBL) and RAL (holographic) grid activities. Bonnefoy and Le Poole reported on the alternative grid proposed by TPD. This appeared an attractive possibility but is considered an expensive option.

The MESH approach to the LSI + MSI + SSI analysis was discussed. Lindegren argued that the on-ground calibration of MSI was not satisfactorily addressed, and in-orbit calibration of the MSI was considered unfeasible. The presence of the MSI and of the uncalibrated SSI was in danger of limiting the value of dynamical smoothing.

Kovalevsky presented FAST's concern about the stitching error. It was important for MESH to appreciate that it is not the size of the MSI correction matrix itself that is of concern. The problem is due to the discontinuities. These discontinuities had not been addressed in the ITT, which had been formulated before the patched scan field technology had been considered.

Le Poole questioned the validity of the assumption of SSI at the level of 13 marcsec being uncorrelated between adjacent grid lines.

The medium scale discontinuities of the CEH grid were, in conclusion, considered as highly undesirable for the overall mission.

c) Geometric Transformation

The transformations considered in the payload specifications (pp 33-36) were not fully understood by most Members of the HST or by the Project Team. Points of concern were as follows:

- the number of coefficients in the large scale transformation, given by MESH as a polynomial of order $p \leqslant 7$, was considered unacceptable by Kovalesky (FAST) and Lindegren (NDAC). It was not likely that $p>3$ could be handled in the reduction process;

- the definition of the relation between $H(\eta,\xi)$ and $H_N(\eta,\xi)$ using a polynomial of order 3 to an accuracy of only 1 arcsec is apparently inconsistent with the requirement of the attitude determination in the ξ direction to 0.1 arcsec. An accuracy of 0.05 arcsec should be specified;

- the transverse component cannot be independently determined on a 24-hr basis to this precision;

- the relation between the SM coordinate system and the main grid system is not specified;

- the origin of (G,H) is fixed on the grid, whereas the origin of (η,ξ) is fixed with respect to the beam combiner. The 1 marcsec requirement on the $(\eta,\xi) \rightarrow G$ transformation implies an impossible stability of the grid with respect to the beam combiner (0.01μ m). Some reconsideration of the transformation requirements are needed;

- the form of G_N, H_N are not considered.

Finally, Høg suggested that reversal of the satellite spin direction should be considered as a method of verifying the absence of short-term variations in the basic angle.

d) Grid Optimization

Kovalevsky presented a summary of results from FAST's investigation into the grid optimization. For the grid ratio, good agreement was found between the results of MESH (0.38 proposed) and those of FAST (0.37). It was noted that different phase extraction algorithms gave rise to different values of this ratio (e.g. autocorrelation gave rise to an optimized ratio of ∿ 0.25).

For the grid period, preliminary simulations revealed an inconsistency between the optimum value derived by FAST (∿ 0.55 arcsec) and that proposed by MESH (1.2 arcsec). Schuyer distributed to both FAST and NDAC copies of the papers MAT-HIP-512 ('Signal Model for Instrumental Parameters') and DM.56/BF/JP/0083.82, so that MESH's approach to the optimization problem could be appreciated. Kovalesky would clarify the inconsistency as soon as feasible.

Lindegren asked that MESH should study effects of polarization and diffraction by the grid.

e) TYCHO

The star mapper grid configuration proposed by MESH, (essentially the Phase A grid with a larger grid period) was considered unacceptable. The non-periodic grid should be given serious consideration.

Grenon emphasized the problems of optimising the scientific return from TYCHO, and asked that before the HST approves a given grid design a more detailed trade-off study should be performed so that the photometric precision as a function of limiting magnitude could be assessed. Similarly the selection of the S20 photocathode should not have been frozen before results of the trade-off were made available. Grenon emphasized the desirability of knowing the TYCHO spectral bands before the end of 1982 for the purposes of planning the supporting ground-based observations.

Lindegren asked that the ITT requirement of 0.1 arcsec knowledge of the satellite attitude be clarified with MESH. The 0.1 arcsec refers to the position of the z-axis, not to the motion about the z-axis. Both Høg and Kovalesky believed that a relaxation of the 0.1 arcsec requirement (perhaps by a factor of 2) was feasible. Confirmation may avoid the need for the vertical SM slits, and could avoid that the requirement on attitude drives the number of slits needed for the SM operations.

Both Høg and Kovalevsky would provide further confirmation of these ideas by the end of July.

f) Scanning Law

The values of the scanning law parameters proposed by MESH ($K = 6.4$, $\xi = 43°$) were approved by the HST. It was noted that a change in the value of K after a period of 2-2.5 years should be allowed for.

g) Coefficients of Improvement

The analysis of the great circle reduction and of the derivation of the coefficients of improvement performed by MESH was appreciated by the HST. In view of the error sources not presently fully analysed in the Technical Report (e.g. the grid contribution, veiling glare etc.) the ITT formula for the great circle reduction should be retained for the purposes of assessing the final accuracy achieved.

Schuyer summarized the history of the coefficients of improvement. MESH's identification of an inconsistency in the value of the coefficient of improvement for the parallax determination was confirmed by Schuyer and Lindegren.

Schuyer proposed that the ITT parallax coefficient be brought into line with the other values by adopting $C_i = 0.75\ R^{-\frac{1}{2}}\ (\sin\xi)^{-1}$. This was accepted by the HST, while a lower figure was not considered acceptable. This figure should now be accounted for by MESH.

h) Observing Strategy

Kovalevsky did not believe that the cyclic strategy proposed by MESH was necessarily the optimum one. He asked that the preliminary investigations of MESH into alternative strategies (e.g. pseudo-random strategies) be pursued. At the same time, allowance should be made for observations of empty fields for magnitude calibrations, and a more detailed specification of the strategy with respect to star distribution (e.g. across the field, and between the two fields) should be studied. The final strategy should be selected in conjunction with the eventual grid structure. A note "HIPPARCOS Dwell Time and Observing Strategies" (Kovalesky 1982 June 15) was distributed.

i) Chromaticity

Concern on the problem of chromaticy was expressed by all HST Members.

Turon and Grenon stated that some 30000 stars in the Input Catalogue would have accurate photometry, and a total of some 50-60000 would have a precision in (B-V) of better than $\sim$ 0.4 mag. A requirement had not benn placed on the ICC for a priori star colours, and it was not realistic to consider that colours for the remaining stars could be provided, within the framework of the ICC, before 1987.

Kovalevsky explained that the data reduction effort would be very inconvenient and quite different from that presently envisaged if star colours were not available at the time of the first stage of the reduction process. In this respect it was not of great help to postulate that colours would eventually be known through the TYCHO analysis. TYCHO would not contain all of the programme stars, and the timescale for the photometric reduction was not yet established.

Grenon emphasized that many of the high parallax star would typically be very red, with (B-V)$>$ 1.25. The chromaticity problem would be especially severe for such stars.

Høg noted that a narrower bandwidth and an S11 instead of an S20 photocathode could reduce the size of the chromaticity effect.

Lindegren had proposed to MESH a more efficient method of determining the in-orbit chromaticity map with filters placed in the relay optics train.

Both consortia (Kovalevsky and Lindegren) were not confident that a constant chromaticity component could be satisfactorily allowed for in the reduction process. Lindegren believed that this could be performed in principle, but the effects of the constant and variable components of the chromaticity would probably result in a much degraded solution.

Bonnefoy would ask MESH for a more detailed assessment of the sources of chromaticity, the expected form of the chromaticity map, and the timescales of variability of the various components.

It was agreed that MESH should be encouraged to remove the constant component through in-orbit adjustment. Concerning the remaining variable part of the chromaticity, no satisfactory solutions were presently foreseen by the scientific consortia.

j) Detection

Wills presented the results of assessment of the effects of veiling glare. On average, for a B = 9 mag star there was approximately 2 per cent probability of disturbance by more than 3 marcsec on a single measurement. For a B = 12 mag star this value increased to some 30 per cent. (Further details are given in Annex II).

It was noted that in many cases the effect is much larger than 3 marcsec, although the phase shift will differ between scans. Some allowance could be made in the Input Catalogue for the brighter stars, although generally this would be an impossible task. Neither of the Data Analysis Consortia would seriously consider attempting to calibrate such effects.

Le Poole drew attention to the possibly large number of resulting great circle interruptions. Dynamical smoothing may help to close the circles.

Grenon expressed concern that information could be lost on astrophysically interesting stars; Kovalesky agreed with the concern, especially for the case of double and multiple star systems where nearby pairs of comparable magnitude stars would suffer seriously from the veiling glare phenomenon.

Coleman suggested various lines of investigation that should be followed up by MESH, for example blackening the grid and the inside of the tube, and even investigating alternative dissector tubes.

There was general concern about the problem, and more precise information on the effect was requested.

Wynne drew attention to the potential problem of ghost images generted in the relay optics and from reflections at the IDT window and mesh, and from the back surface of the modulating grid.

k) Great Circle Interruptions

At present the ITT accepts interruptions due only to earth and moon occultations and to antenna switching. MESH foresee periods devoted to IDT calibration lasting 15 min every 30 days or so.

The Project Team would ask for a full breakdown of great circle interruptions. Kovalevsky asked what approach was being considered by MESH for the z-axis scanning after periods of significant downtime. This has not been documented, but Schuyer stated that normal work by MESH should address this point.

l) Input Catalogue

The requirement appearing in the SDR System Specification for an upper limit of 100000 stars in the Input Catalogue was not accepted. The figure of 100000 stars was given to MESH only as a model of star observations for the purposes of accuracy evaluation.

Perryman would clarify this point with MESH and the Project Team. The final format of the Input Catalogue (number of stars as a function of magnitude) would not be defined until after the receipt of observing proposals. Flexibility in total number of stars (which could be much more than 100000) and the associated observing programme, should be retained at this time.

6. Conventions

It was agreed that it would be useful to develop a set of conventions and definitions common to the scientific consortia, ESA and MESH. An attempt to do this would be made by Perryman and the System Analysis section assuming that cooperation by all parties would be forthcoming.

7. Software Coordination

Responses to the questionnaire distributed by Schuyer/Vaghi had not been received. HST Members agreed on the principles of compiling such a common information bank, but considered it premature to submit detailed information on planned software. HST Members agreed to forward details of relevant and sufficiently self-contained software routines as they develop.

8. HIPPARCOS Committee for Observing Proposal Selection

Following the deadline for the receipt of observing proposals, the Selection Committee should review the proposals, identify astrophysical and astrometric shortcomings in the totality of the proposals, and forward the accepted proposals to the ICC by 1982 December 31.

Høg proposed that Prof. Blaauw is invited to chair the Selection Committee. Grenon proposed Prof. P.O. Lindblad. Kovalevsky, Murray and Turon supported the choice of Prof. Blaauw and it was agreed that Prof. Blaauw was the HST's nomination as the Selection Committee chairman. It was proposed that the following names would be forwarded to the Chairman of the Selection Committee for his consideration when constructing the Committee: Baglin, Blackwell, Feitzinger, Gliese, Hack, Hansen, van den Heuvel, Jaschek, Lequeux, Lindblad, Martinet, Murray, Pacquet, Pagel, Renzini, Tammann, de Vegt, Wielen.

Kovalevsky proposed that a representative of the ICC is present at the meeting(s) of the Selection Committee; Perryman would attend in the capacity of Committee Secretary.

Perryman would forward the above recommendations to the AWG for their consideration.

M.A.C. Perryman

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14/7/82

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M.A.C. PERRYMAN

14/2/82

Fourth Meeting

of the

HIPPARCOS SCIENCE TEAM

29-30 June 1982

AGENDA

Status Report (L. Emiliani/M. Perryman)

Agenda for Future Meetings

Documentation

TYCHO Status

SDR: Documentation received from MESH
Review of System Technical Report
Review of Payload Technical Report

Distribution and Review of System + Payload Specifications

Review of ESTEC RIDs

Scientific Consortia Schedules

Software Coordination

Programme Selection Committee

Any other business

ANNEX II

esa estec

HIPPARCOS

Doc.No. : ESA-HIP-00326
Issue No.: 01
Date : 14.6.82
Page : (i)

TITLE: ASTROMETRIC ERROR DUE TO VEILING GLARE

PREPARED BY: R.D. WILLS

CHECKED BY:

APPROVED BY:

1. Veiling glare as a function of distance

Measurements by the University of Wisconsin have been reported in ref.1. Since these were made on an IDT having an IFOV of 180 μm diameter the values have been scaled by a factor of 0.44 for the 120 μm IFOV which will be used for Hipparcos. The validity of this scaling is subject to confirmation and is assumed to be dependent on the (presently unknown) mechanism responsible for the effect. Numerical values were taken from the graphs on pages 3,4,6,7 and 8 of ref. 1 and averaged. To simplify the calculations an empirical fit was made in the range of distance $r \leqslant 9$ mm having the form

$$g(r) = 10^{-5} + \exp(-7.5r^{0.235}).$$

The fit of this curve to the experimental data is shown in fig. 1. The lack of information on the magnitude of the effect for $r < 0.5$ mm is a potential source of error in the following evaluations.

2. Phase error resulting from disturbance by a single star

During observation of a star giving a periodic signal of amplitude I_o veiling glare from another star within the total field of view may give a disturbing signal I_1 having the same periodicity as I_o but a different phase. If the phase difference is ϕ the resultant of the signals will have a phase ε relative to I_o given by

$$\tan\varepsilon = \frac{\sin\phi}{a+\cos\phi} \quad \text{where } a = \frac{I_o}{I_1}$$

The extreme values of ε are given by $\cos\phi = -\frac{1}{a}$ provided $a \geqslant 1$. Then $|\varepsilon|_{max} = \arctan\frac{1}{a} \approx \frac{1}{a}$.

In general all values of ϕ are equally probable so the mean square error is given by

$$\sigma_\phi^2 = \frac{1}{\pi}\int_0^\pi \varepsilon^2 \, d\phi$$

For large a $\quad \varepsilon \approx \sin\phi/a \quad$ so that $\sigma_\phi^2 = 1/2a^2$

For small a $\quad \varepsilon \longrightarrow \phi \quad$ so that $\sigma_\phi^2 = \pi^2/3$

The results of numerical integrations for intermediate values of a are shown in fig. 2. An empirical fit over the whole range is given by

$$\frac{1}{\sigma_\phi^2} = \frac{3}{\pi^2} + 2a^2\left[1 - \frac{a^{1/2}}{1+a^4}\right]$$

3. Variation of error with magnitude and position of interfering star

The rms astrometric error due to an rms phase error σ_ϕ is given by $\sigma_v = \frac{s}{2\pi}\sigma_\phi$ where s is the slit period of the main grid. In the case of disturbance of a star of magnitude B_o by a star of magnitude

B_1 at a distance r, σ_ϕ can be determined as a function of a where

$$\frac{1}{a} = g(r) \times 10^{0.4(B_0 - B_1)}$$

The values of σ_ϕ and σ_v as functions of r for different values of $B_0 - B_1$ are shown in fig. 3, taking s = 1.2".

For a given value of B_0 the rms value of σ_v for stars of B_1 in any position in the field of view can be obtained as

$$\overline{\sigma_v^2} = f^2 \int_{FOV} \sigma_v^2(r, B_0 - B_1) . \rho(B_1) \, 2\pi r \, dr$$

where $\rho(B_1)$ is the mean surface density of stars of magnitude B_1 per deg^2 and f is the scale factor of the IDT, taken to be 0.0926 deg mm^{-1}. The curves of this function in figure 4 give some idea of which stars will give the greatest contribution to the veiling error of stars of a given magnitude B_0. Attention is drawn to the extended plateaux of the curves for $B_0 \gtrsim 7$.

In principle a final rms veiling error for a given B_0 can be obtained by summing over B_1. This parameter is shown by the line in fig. 5 but is not very meaningful because there can be several interfering stars in the field of the view at the same time and their disturbances should be summed vectorially in the phase error before these are converted to astrometric error. In addition, the distribution of actual errors is such that the rms error is not a good parameter to describe it, as will be discussed below.

4. Monte-Carlo simulations

In order to obtain a clearer insight into the effect, simulations were made in which disturbing stars were randomly distributed about a reference star and given random relative phases. The numbers of these stars were selected by a Poisson generator taking account of their distribution in magnitude. Because the effect is not significant beyond a few mm from the reference star (except for the rare very bright disturbing stars) the position of the reference star was fixed at the centre of the field of view. In addition, to save computing time stars were only considered when they fell within a magnitude-dependent distance beyond which their effects could be considered negligible.

For each disturbing star the phase error was calculated and these were summed to give a resultant for the reference star, which was converted to an astrometric error. For each magnitude B_0, 1000 reference stars were simulated: their errors were histogrammed and rms values were determined. The latter are shown as crosses in fig 5. The wide scatter for the brighter stars is due to the low probability of a disturbing star of sufficient brightness.

The integral probability distributions are shown in fig. 6. From these the probability that a star of $8 \leq B \leq 14$ has a veiling error greater than (e.g.) 3 mas can be read directly. For that particular value the probability is about 2% for a B = 9 star but increases to 35% for a B = 12 star. Note that fig. 3 shows that 3 mas is the error expected in the situations considered by Röser in ref. 2 ($B_0 - B_1 = 4.5$ mag, $r = 0.09$ deg ; $B_0 - B_1 = 7$ mag, $r = 0.37$ deg)

References

1. J.P. Camus : "Measurement results on veiling glare by University of Wisconsin", MAT-HIP-00617 (27.04.1982)

2. S. Röser : "Influence of veiling glare upon star observations by Hipparcos" (May 10, 1982)

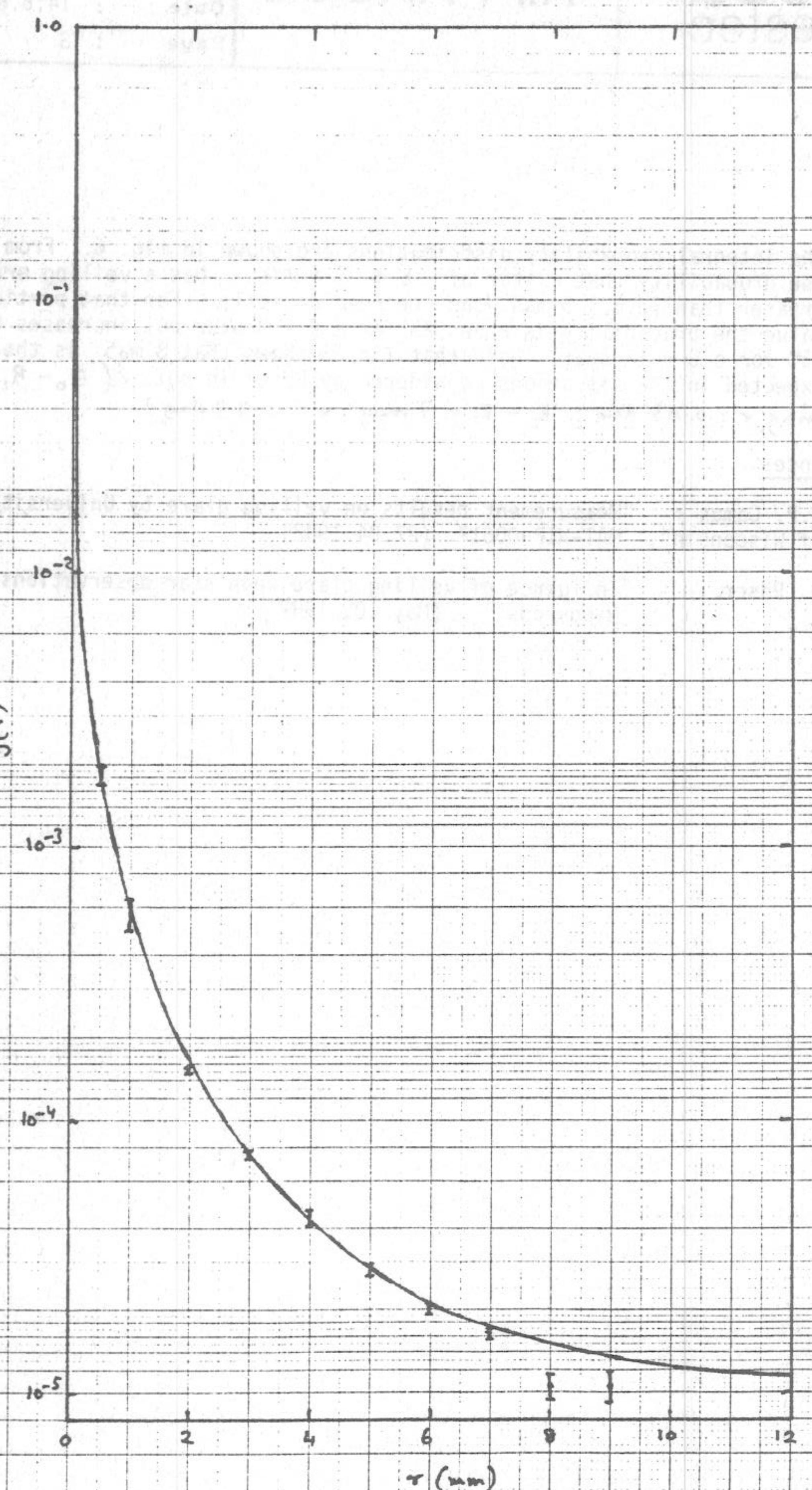


fig 1

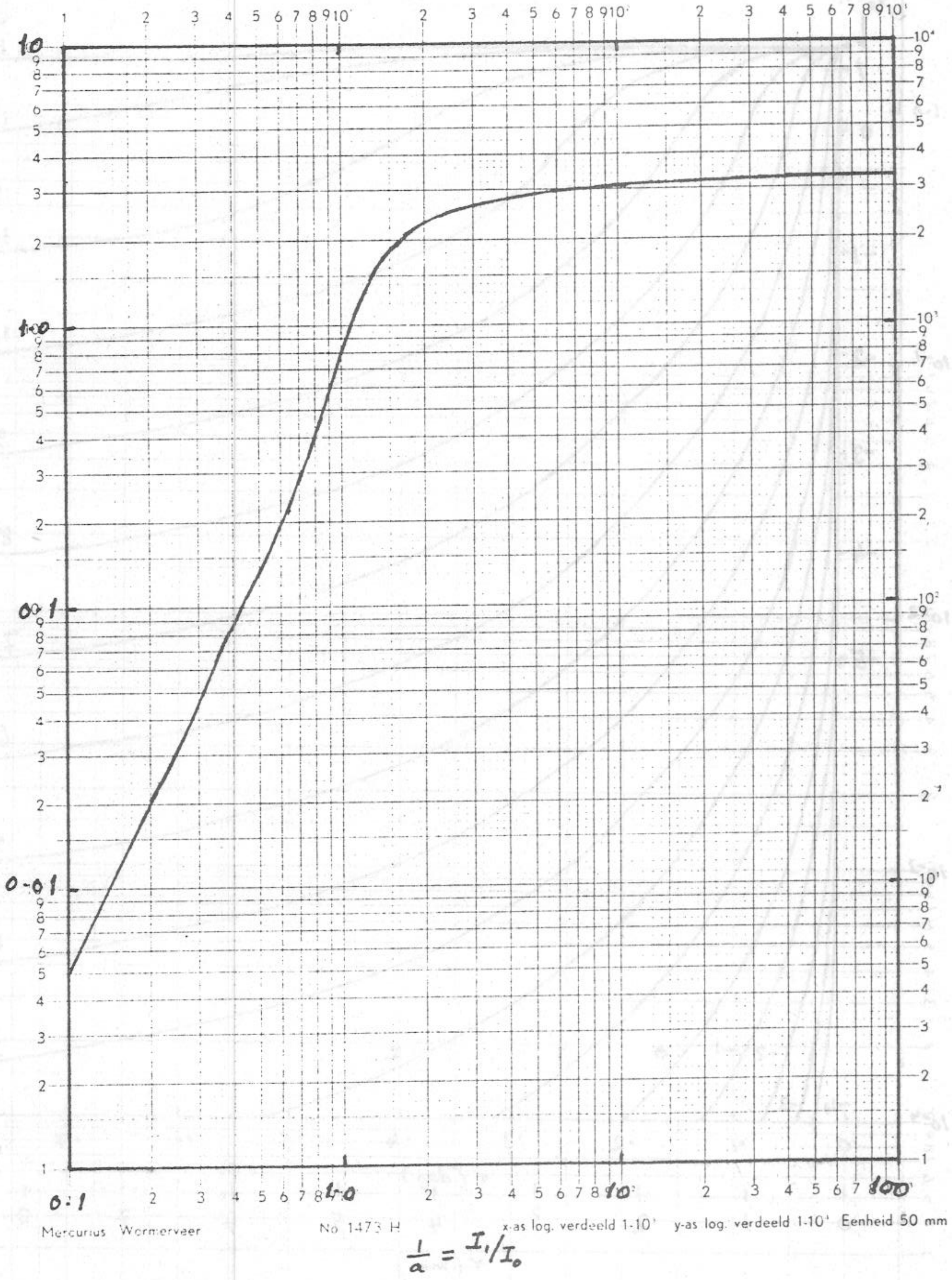
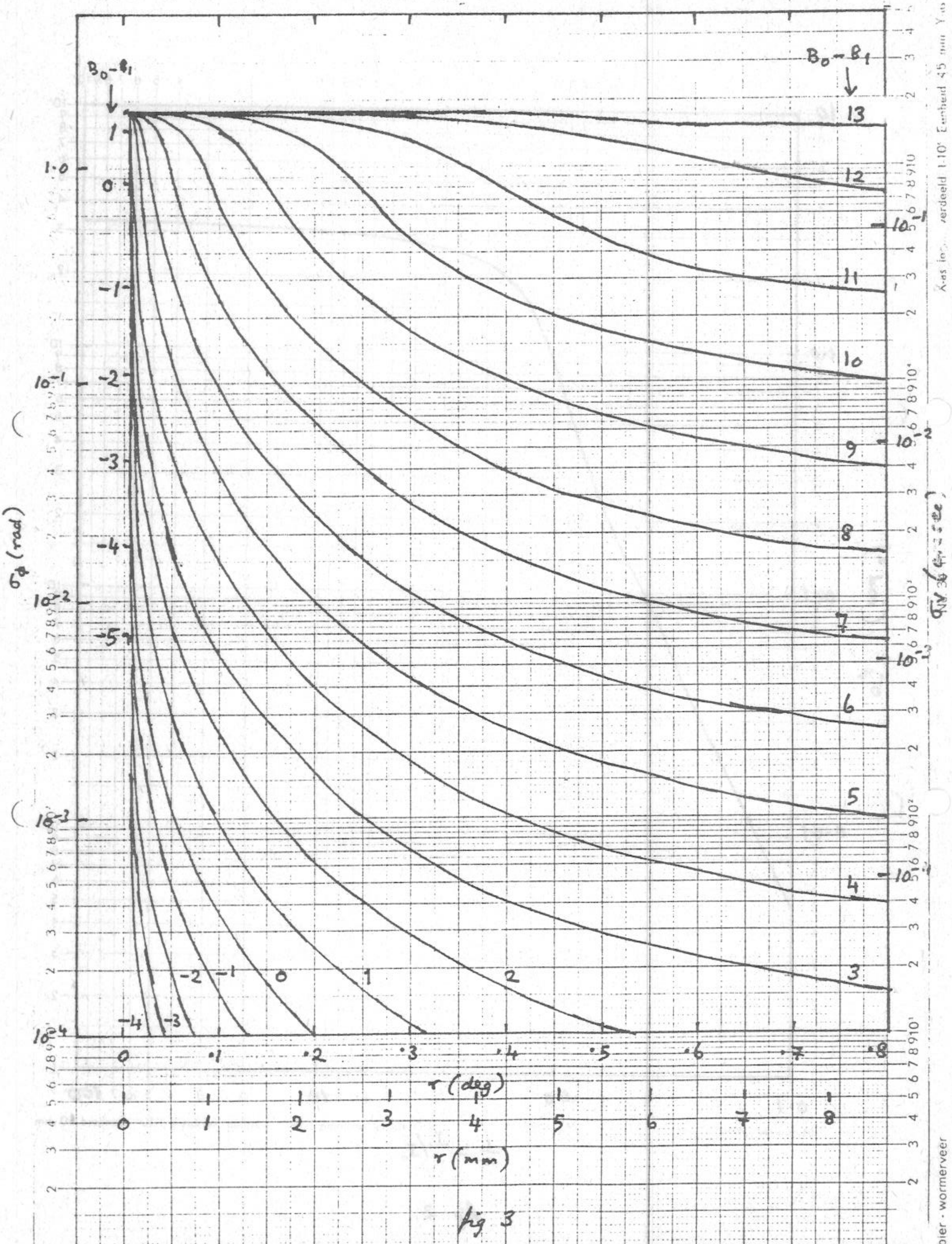
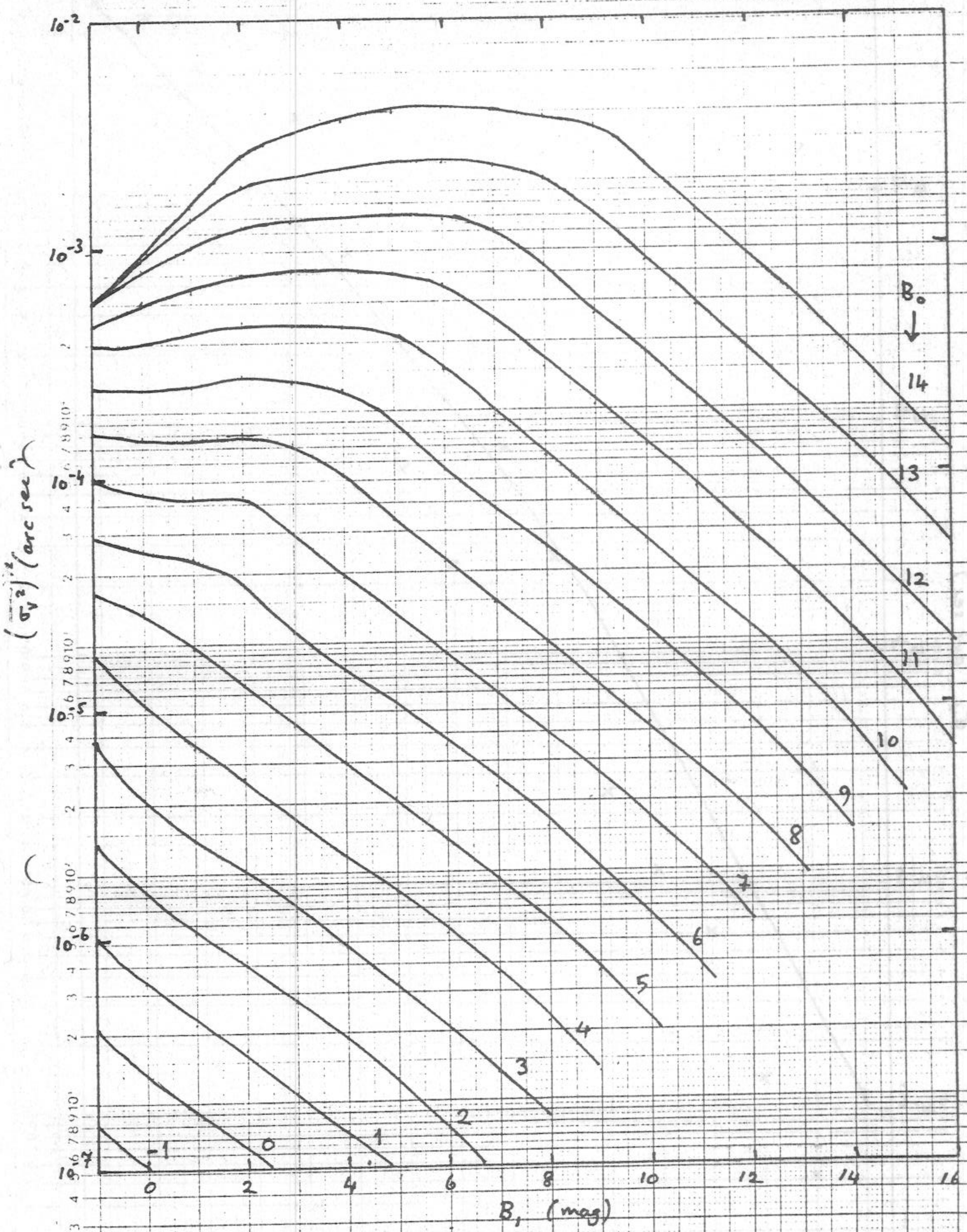

10
1·0
0·1
0·01
σ_φ² (rad²)
0·1
1·0
10
100
1/a = I₁/I₀
Mercurius Wormerveer
No. 1473 H
x-as log. verdeeld 1-10³
y-as log. verdeeld 1-10⁴
Eenheid 50 mm

fig 2



$B_0 - B_1$
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
σ_ϕ (rad)
σ_V
r (deg)
r (mm)
meetpapier · wormerveer

fig 3



10-2
10-3
10-4
10-5
10-6
10-7
(σv²)½ (arc sec²)
B0 ↓
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
0
2
4
6
8
10
12
14
16
B1 (mag)

fig 4

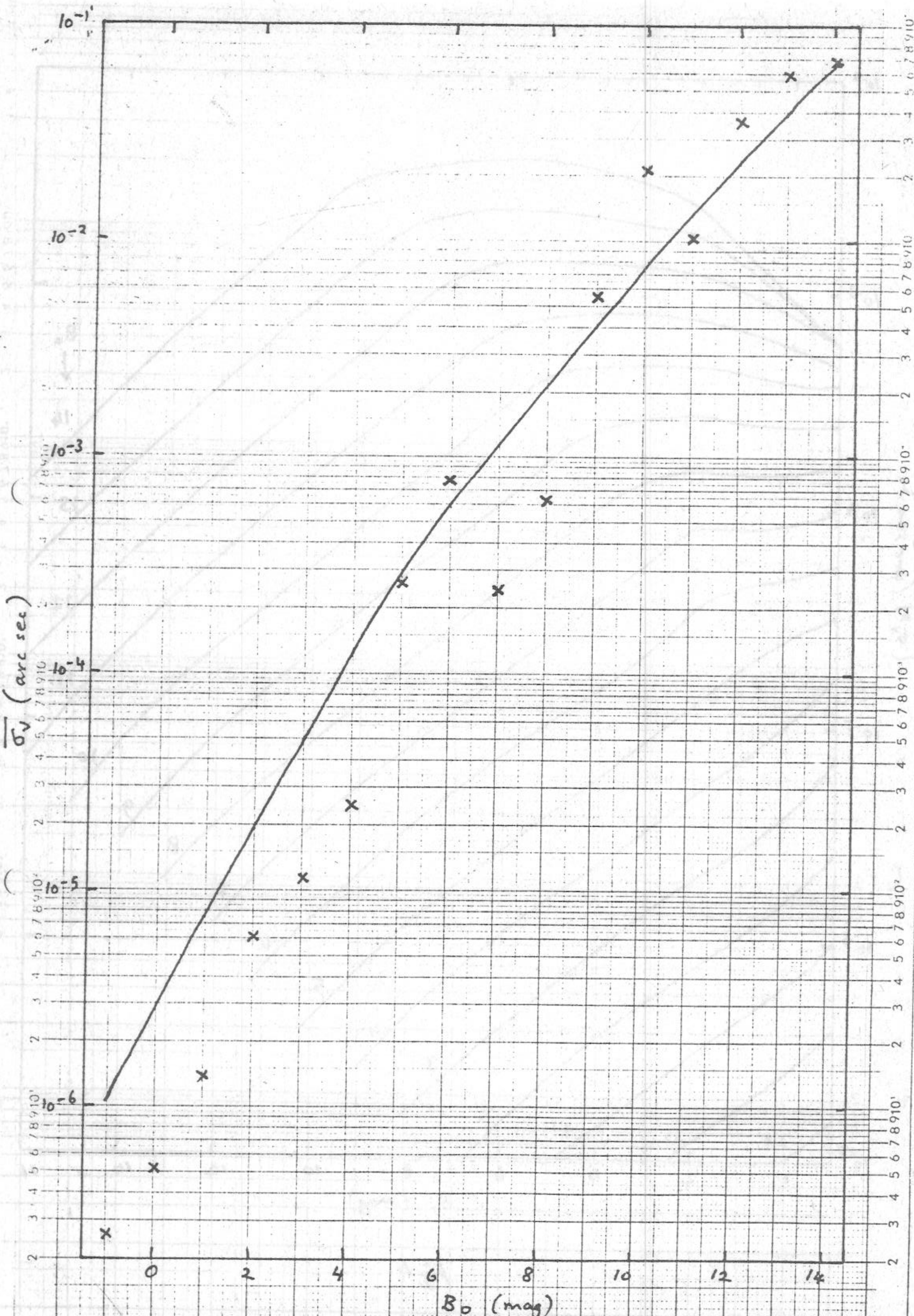
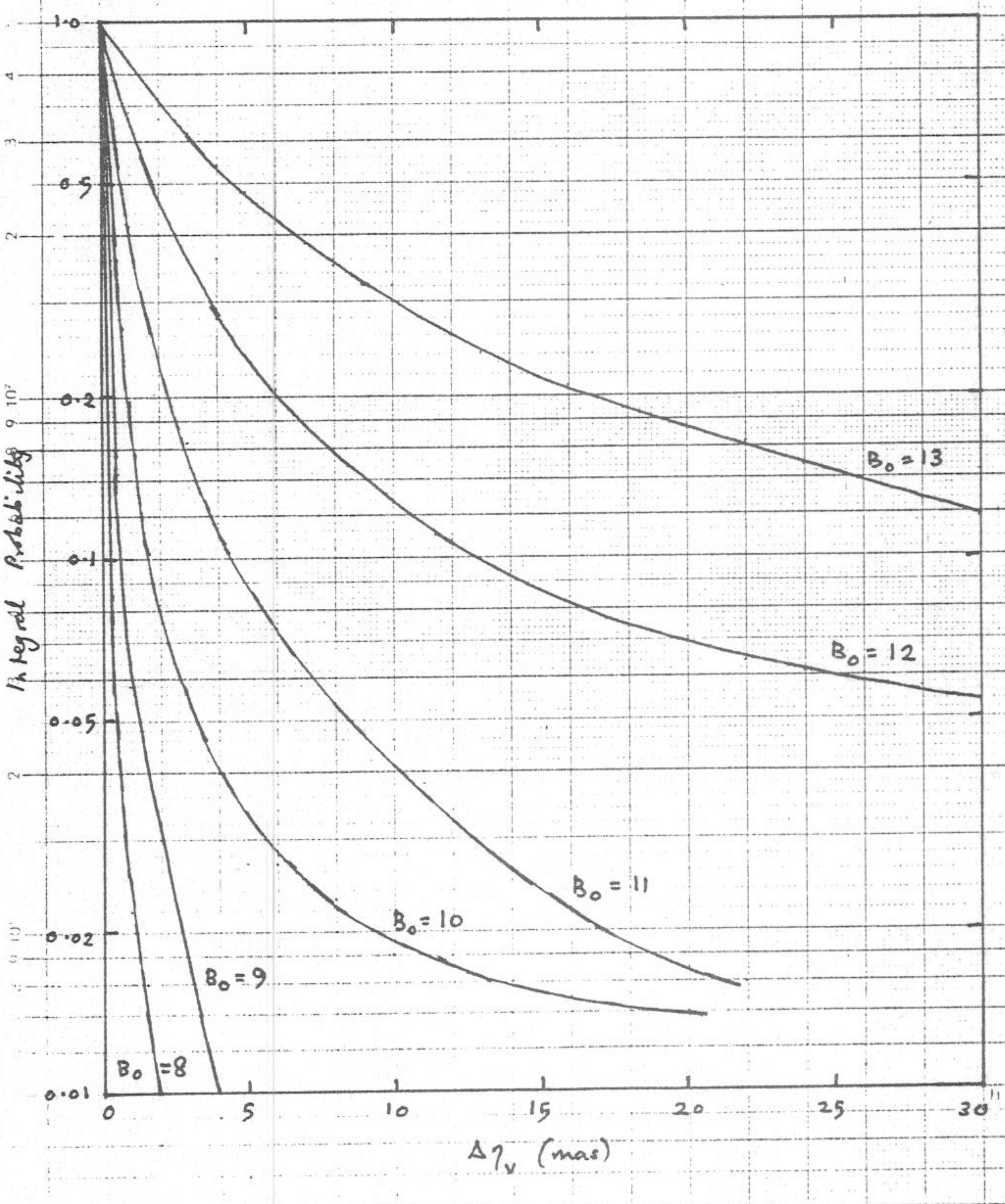


fig 5



1.0
0.5
0.2
0.1
0.05
0.02
0.01
Integral Probability
$B_o = 13$
$B_o = 12$
$B_o = 11$
$B_o = 10$
$B_o = 9$
$B_o = 8$
0
5
10
15
20
25
30
$\Delta \eta_v$ (mas)

Fig. 6