

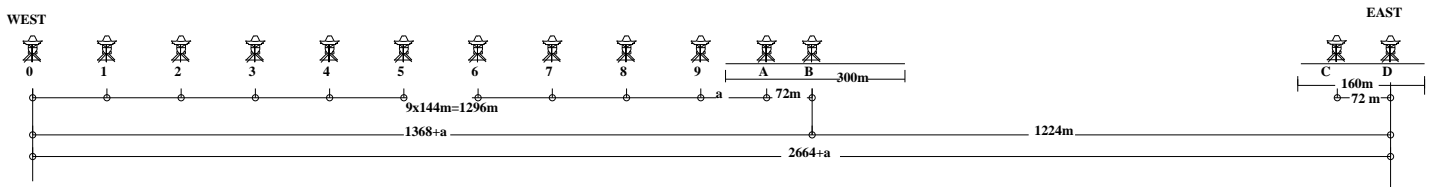
# DESIGN DOCUMENTATION

PART V

VARIOUS

July 16, 1993

Version: 1.0.0



# WSRT

USER DOCUMENTATION

## CONTENTS OF PART V

*This is part V of the WSRT User Documentation.*

*The WSRT User Documentation consists of 7 Parts; we may refer to other parts of the User Documentation. To get more information about how to obtain a copy and/or updates of parts of the User Documentation please send an e-mail request to [wsrt@nfra.nl](mailto:wsrt@nfra.nl)*

*The roman number in the pagenumber indicates the part.*

<b>1</b>	<b>Miscellaneous tables and graphs</b>	<b>V-1-1</b>
1.1	Useful Equations and graphs . . . . .	V-1-1
1.1.1	Plane Trigonometry . . . . .	V-1-1
1.1.2	Spherical Trigonometry . . . . .	V-1-3
1.2	Coordinate Transformations . . . . .	V-1-4
1.2.1	Altitude ,azimuth – $\alpha, \delta$ transformation . . . . .	V-1-4
1.2.2	$l, b - \alpha, \delta$ transformation . . . . .	V-1-6
1.2.3	Precession (approximate — From Kraus (86) . . . . .	V-1-6
1.3	Molecular and Recombination Line frequencies . . . . .	V-1-6
1.4	References . . . . .	V-1-6
<b>2</b>	<b>Some mathematical expressions of visibility functions</b>	<b>V-2-1</b>
2.1	Visibility function for a circular source . . . . .	V-2-1
2.2	Visibility function for a double point source . . . . .	V-2-2
<b>3</b>	<b>The Archive of WSRT Observations: a brief guide</b>	<b>V-3-1</b>
3.1	Contents and composition . . . . .	V-3-1
3.1.1	Contents . . . . .	V-3-1
3.1.2	Composition . . . . .	V-3-1
3.1.3	The software . . . . .	V-3-1
3.2	Starting an archive query . . . . .	V-3-1
3.3	Selecting and retrieving observations . . . . .	V-3-2
3.4	People to contact for information . . . . .	V-3-4
3.5	Summary of ARCQUERY commands . . . . .	V-3-5

# WSRT PART V

USER DOCUMENTATION CHAPTER 1

## MISCELLANEOUS TABLES AND GRAPHS

*A selection from chapter 9 from the old manual. Figures have all be (re)drawn by O.M. Kolkman.*

### 1.1 USEFUL EQUATIONS AND GRAPHS

#### 1.1.1 PLANE TRIGONOMETRY

$$\begin{aligned}\sin^2 x + \cos^2 x &= 1 \\ 1 + \tan^2 x &= \sec^2 x \\ 1 + \cot^2 x &= \operatorname{cosec}^2 x\end{aligned}$$

$$\begin{aligned}\sin(a \pm b) &= \sin a \cos b \pm \cos a \sin b \\ \cos(a \pm b) &= \cos a \cos b \mp \sin a \sin b\end{aligned}$$

$$\tan(a \pm b) = \frac{\tan a \pm \tan b}{1 \mp \tan a \tan b}$$

$$\begin{aligned}\sin(2a) &= 2 \sin a \cos a \\ \cos(2a) &= \cos^2 a - \sin^2 a \\ &= 2 \cos^2 a - 1 \\ &= 1 - 2 \sin^2 a\end{aligned}$$

$$\begin{aligned}\sin \frac{a}{2} &= \pm \sqrt{\frac{1 - \cos a}{2}} \\ \cos \frac{a}{2} &= \pm \sqrt{\frac{1 + \cos a}{2}} \\ \tan \frac{a}{2} &= \frac{\sin a}{1 + \cos a}\end{aligned}$$

$$\begin{aligned} 2 \sin a \sin b &= \cos(a - b) - \cos(a + b) \\ 2 \cos a \cos b &= \cos(a - b) + \cos(a + b) \\ 2 \sin a \cos b &= \sin(a + b) - \sin(a - b) \end{aligned}$$

$$\begin{aligned} \sin a \pm \sin b &= s \sin \left( \frac{a \pm b}{2} \right) \cos \left( \frac{a \mp b}{2} \right) \\ \cos a \pm \cos b &= s \cos \left( \frac{a \pm b}{2} \right) \cos \left( \frac{a \mp b}{2} \right) \\ \tan a \pm \tan b &= \frac{\sin(a \pm b)}{\cos a \cos b} \end{aligned}$$

$\cos(na)$  and  $\sin(na)$ ,  $n = 2, 3, 4, \dots$  can be computed with de Moivre's formula:

$$\begin{aligned} \cos(na) + j \sin(na) &= (\cos a + j \sin a)^n \\ e^{jna} &= (e^{ja})^n \end{aligned}$$

e.g:  $n = 3$

$$\begin{aligned} \cos(3a) + j \sin(3a) &= (\cos a + j \sin a)^3 \\ &= \cos^3 a + 3j \cos^2 a \sin a - 3 \cos a \sin^2 a - j \sin^3 a \\ &= (\cos^3 a - 3 \cos a \sin^2 a) + j (3 \cos^2 a \sin a - \sin^3 a) \end{aligned}$$

thus:

$$\begin{aligned} \cos(3a) &= \cos^3 a - 3 \cos a \sin^2 a (= 4 \cos^3 a - 3 \cos a) \\ \sin(3a) &= 3 \cos^2 a \sin a - \sin^3 a (= 3 \sin a - 4 \sin^3 a) \end{aligned}$$

In this Pascal's triangle is useful

						1						
						1	1					
					1	2	1					
				1	3	3	1					
			1	4	6	4	1					
		1	5	10	10	5	1					
	1	6	15	20	15	6	1					
	1	7	21	35	35	21	7	1				
1	8	28	56	70	56	28	8	1				

etcetera

So

$$(a + b)^5 = 1a^5 + 5a^4b + 10a^3b^2 + 10a^2b^3 + 5ab^4 + 1b^5$$

Generally

$$(a + b)^n = \binom{n}{0} a^n + \binom{n}{1} a^{n-1} b^1 + \binom{n}{2} a^{n-2} b^2 = \dots$$

with  $\binom{n}{m} = \frac{n!}{m!(n-m)!}$  for  $n \geq m \geq 0$

Some expansions into power series of common functions.

$$e^x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots \text{ (all real values of } x \text{)}$$

$$a^x = 1 + \frac{x \ln a}{1!} + \frac{(x \ln a)^2}{2!} + \frac{(x \ln a)^3}{3!} + \dots$$

$$\ln(1+x) = x - \frac{x^2}{2!} + \frac{x^3}{3!} - \frac{x^4}{4!} + \dots$$

$$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \dots$$

$$\cos x = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \dots$$

$$\arcsin x = x + \frac{1}{2} \frac{x^3}{3} + \frac{1 \cdot 3}{2 \cdot 4} \frac{x^5}{5} + \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6} \frac{x^7}{7} + \dots \quad (x^2 < 1, -\pi/2 < \arcsin x < \pi/2)$$

$$\arctan x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \dots \quad (x^2 < 1)$$

$$\sinh x = x + \frac{x^3}{3!} + \frac{x^5}{5!} + \dots \quad (|x| < \infty)$$

$$\cosh x = 1 + \frac{x^2}{2!} + \frac{x^4}{4!} + \dots \quad (|x| < \infty)$$

$$\operatorname{arc} \sinh x = x - \frac{1}{2} \frac{x^3}{3} + \frac{1 \cdot 3}{2 \cdot 4} \frac{x^5}{5} - \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6} \frac{x^7}{7} + \dots \quad (|x| < 1)$$

### 1.1.2 SPHERICAL TRIGONOMETRY

Let  $a, b, c$  be the sides of a spherical triangle with opposite angles  $A, B, C$  respectively, where each side is measured by the angle subtended at the center of the sphere.  $R$  is the radius of the sphere.

RIGHT SPHERICAL ANGLE,  $C = 90^\circ$

$$\begin{aligned} \sin a &= \tan b \cot B = \sin A \sin c \\ \sin b &= \tan a \cot A = \sin B \sin c \\ \cos A &= \tan b \cot c = \cos a \sin B \\ \cos B &= \tan a \cot c = \cos b \sin A \\ \cos c &= \cot A \cot B = \cos a \cos b \end{aligned}$$

OBLIQUE TRIANGLE

$$\text{Area} = (A + B + C - 180^\circ) \frac{\pi R^2}{180}$$

Law of sines:

$$\frac{\sin A}{\sin a} = \frac{\sin B}{\sin b} = \frac{\sin C}{\sin c}$$

Law of cosines for sides:

$$\begin{aligned} \cos a &= \cos b \cos c + \sin b \sin c \cos A \\ \cos b &= \cos a \cos c + \sin a \sin c \cos B \\ \cos c &= \cos a \cos b + \sin a \sin b \cos C \end{aligned}$$

Law of cosines for angles

$$\begin{aligned}\cos A &= -\cos B \cos C + \sin B \sin C \cos a \\ \cos B &= -\cos C \cos A + \sin C \sin A \cos b \\ \cos C &= -\cos A \cos B + \sin A \sin B \cos c\end{aligned}$$

Extended cosine formulae

$$\begin{aligned}\sin a \cos B &= \cos b \sin c - \sin b \cos c \cos A \\ \sin a \cos C &= \cos c \sin b - \sin c \cos b \cos A\end{aligned}$$

Haversine formulae

$$\begin{aligned}\cos \frac{A}{2} &= \sqrt{\frac{\sin s \sin(s-a)}{\sin b \sin c}} \\ \sin \frac{A}{2} &= \sqrt{\frac{\sin(s-b) \sin(s-c)}{\sin b \sin c}} \\ \tan \frac{A}{2} &= \sqrt{\frac{\sin(s-b) \sin(s-c)}{\sin s \sin(s-a)}} \\ \text{where } s &= (a+b+c)/2\end{aligned}$$

## 1.2 COORDINATE TRANSFORMATIONS

### 1.2.1 ALTITUDE ,AZIMUTH – $\alpha, \delta$ TRANSFORMATION

The formulae relating the azimuth,  $A$  (measured from south through west), and altitude (or elevation),  $a$ , to the hour angle,  $h$ , and declination,  $\delta$ , are:

$$\begin{aligned}\cos a \sin A &= \cos \delta \sin h \\ \cos a \cos A &= -\sin \delta \cos \phi + \cos \delta \cos h \sin \phi \\ \sin a &= \sin \delta \sin \phi + \cos \delta \cos h \cos \phi \\ \cos \delta \cos h &= \sin a \cos \phi + \cos a \cos A \sin \phi \\ \sin \delta &= \sin a \sin \phi - \cos a \cos A \cos \phi\end{aligned}$$

where  $\phi$  is the observer's latitude, and hour angle,  $h$ , is related to the right ascension,  $\alpha$ , by:

$$h = \text{local sidereal time} - \alpha$$

In figure 1.1 on page 1-3 there is a diagram of azimuth and elevation as a function of hour angle and declination.

PARALLACTIC ANGLE,  $q$

$$\sin q = \frac{\cos \phi \sin h}{\cos a}$$

Atmospheric refraction in terms of  $q$ :

$$\begin{aligned}\Delta\alpha &\approx \pm(n-1) \sec \delta \sin q \begin{cases} + & \text{if } 12^{\text{h}} < h < 24^{\text{h}} \\ - & \text{if } 0^{\text{h}} < h < 12^{\text{h}} \end{cases} \\ \Delta\delta &\approx \pm(n-1) \cos q \begin{cases} + & \text{if } \phi < 0 \\ - & \text{if } \phi > 0 \end{cases}\end{aligned}$$

where  $\Delta\delta$  and  $\Delta\alpha$  are (true - observed) values (in radians), and  $n$  is the refractive index.

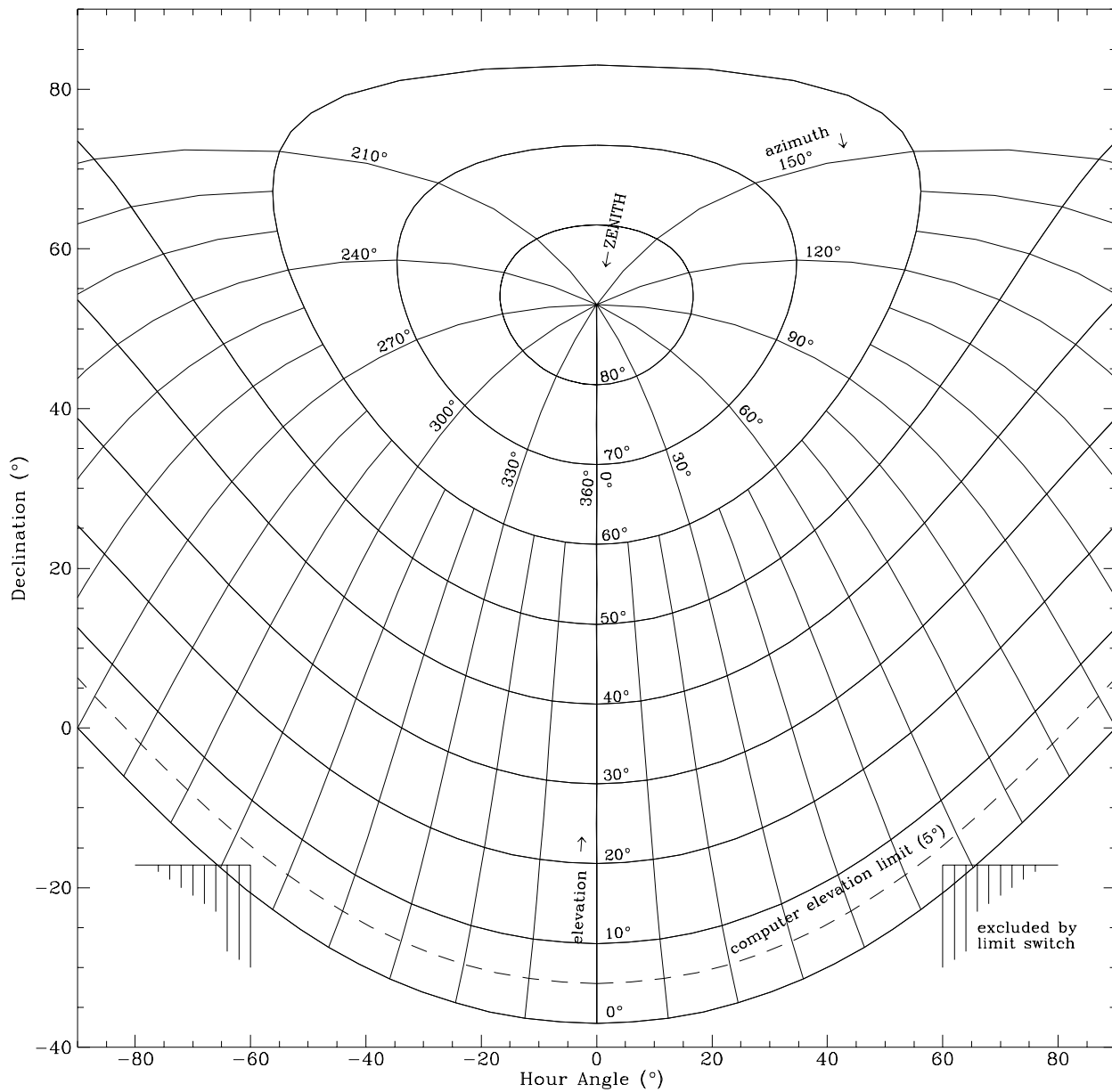


Figure 1.1: Azimuth-Elevation diagram for a latitude of 53°. (0° Azimuth is South)

### 1.2.2 $l, b - \alpha, \delta$ TRANSFORMATION

The formulae relating new galactic longitude,  $l$  and new galactic latitude,  $b$ , to right ascension,  $\alpha$ , and declination,  $\delta$ , (epoch 1950.0) are :

$$\begin{aligned}\cos b \cos(l - 33^\circ) &= \cos \delta \cos(\alpha - 282.25^\circ) \\ \cos b \sin(l - 33^\circ) &= \cos \delta \sin(\alpha - 282.25^\circ) \cos 62.6^\circ + \sin \delta \sin 62.6^\circ \\ \sin b &= \sin \delta \sin 62.6^\circ - \cos \delta \sin(\alpha - 282.25^\circ) \sin 62.6^\circ \\ \cos \delta \sin(\alpha - 282.25^\circ) &= \cos b \sin(l - 33^\circ) \cos 62.6^\circ - \sin b \sin 62.6^\circ \\ \sin \delta &= \cos b \sin(l - 33^\circ) \sin 62.6^\circ + \sin b \cos 62.6^\circ\end{aligned}$$

Conversion grids for  $\alpha, \delta - l, b$  transformation can be found in figure 1.2 on page 1-5

$l, m - \alpha, \delta$  TRANSFORMATION The formulae relating the uniform  $l, m$  coordinates in a Westerbork map to the right ascension,  $\alpha$ , and declination,  $\delta$ , are:

$$\begin{aligned}l &= -\cos \delta \sin(\alpha - \alpha_0) && \text{(radians)} \\ m &= \frac{1}{\tan \delta_0} - \frac{\cos \delta \cos(\alpha - \alpha_0)}{\sin \delta_0} && \text{(radians)}\end{aligned}$$

where  $\alpha_0, \delta_0$  are the coordinates of the observed field center, and  $l, m$  are relative to the field center.

### 1.2.3 PRECESSION (APPROXIMATE — FROM KRAUS (86))

$$\begin{aligned}\Delta\alpha &= m + n \sin \alpha \tan \alpha && \text{per year} \\ \Delta\delta &= n \cos \alpha && \text{per year}\end{aligned}$$

Coordinates on given date are  $\alpha + \Delta\alpha, \delta + \Delta\delta$ , counting years after 1950 as positive and before 1950 as negative.

The values of  $m$  and  $n$  are

Epoch	m		n	
	sec. time	sec.time	sec.arc	sec.arc
1900.0	3.07234	1.33646	20.0468	
1950.0	3.07327	1.33617	20.0426	
2000.0	3.07420	1.33589	20.0383	

Neglect of nutation causes a maximum error of about  $9''$ , with a 19 yr period. Neglect of annual aberration causes a maximum error of about  $20''$ .

## 1.3 MOLECULAR AND RECOMBINATION LINE FREQUENCIES

Table 1.1 contains the frequencies of molecular and recombination lines in the wavelength range of the WSRT. Recombination line frequencies from Lilley and Palmer (1967) Molecular line frequencies from Lovas *et al.* (1979)

## 1.4 REFERENCES

Kraus, J.D. (1986): “*Radio Astronomy*” (2nd edition) Cygnus-Quasar Books, Ohio. ISBN:- (see also review in part II Chapter 9.1, book 6).

Lilley and Palmer (1967): *Astrophys. J. Suppl.* **16**, p. 143.

Lovas, Snyder and Johnson (1979): *Astrophys. J. Suppl.* **41**, p. 451.



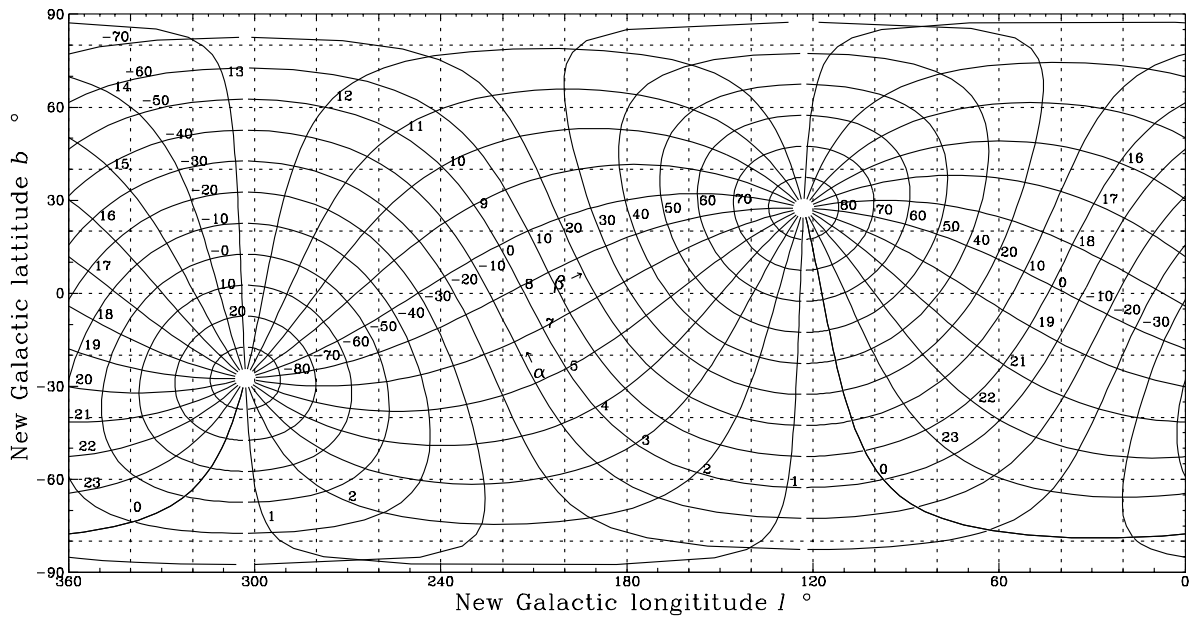
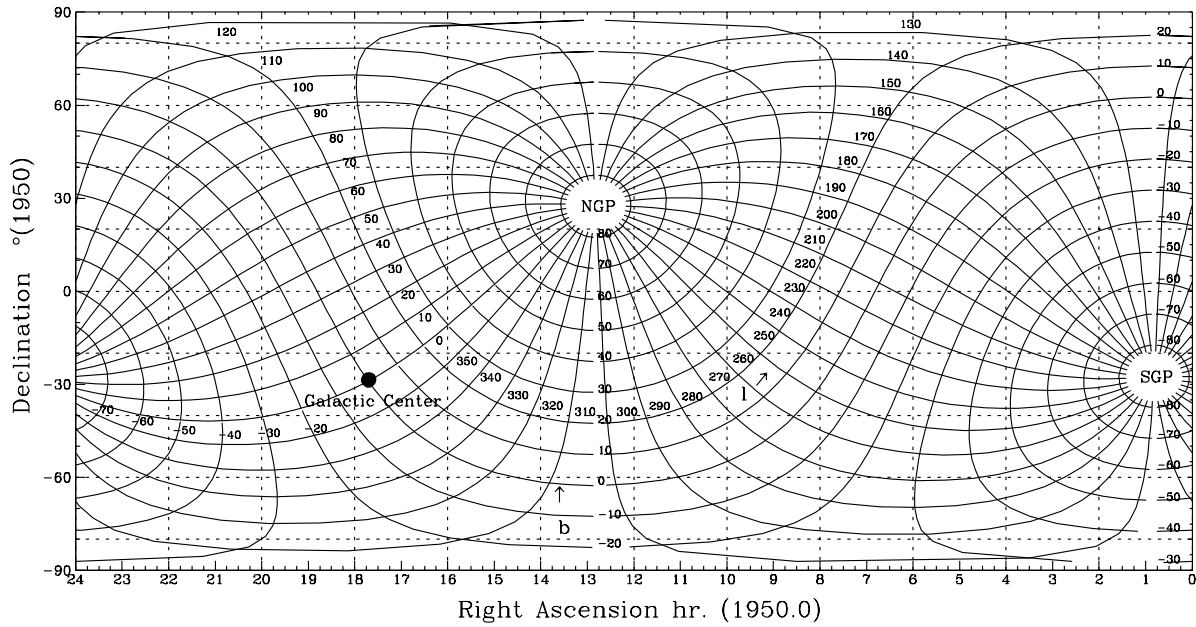


Figure 1.2: Conversion Charts from equatorial to new galactic coordinates and vice versa (after Kraus, 1986)

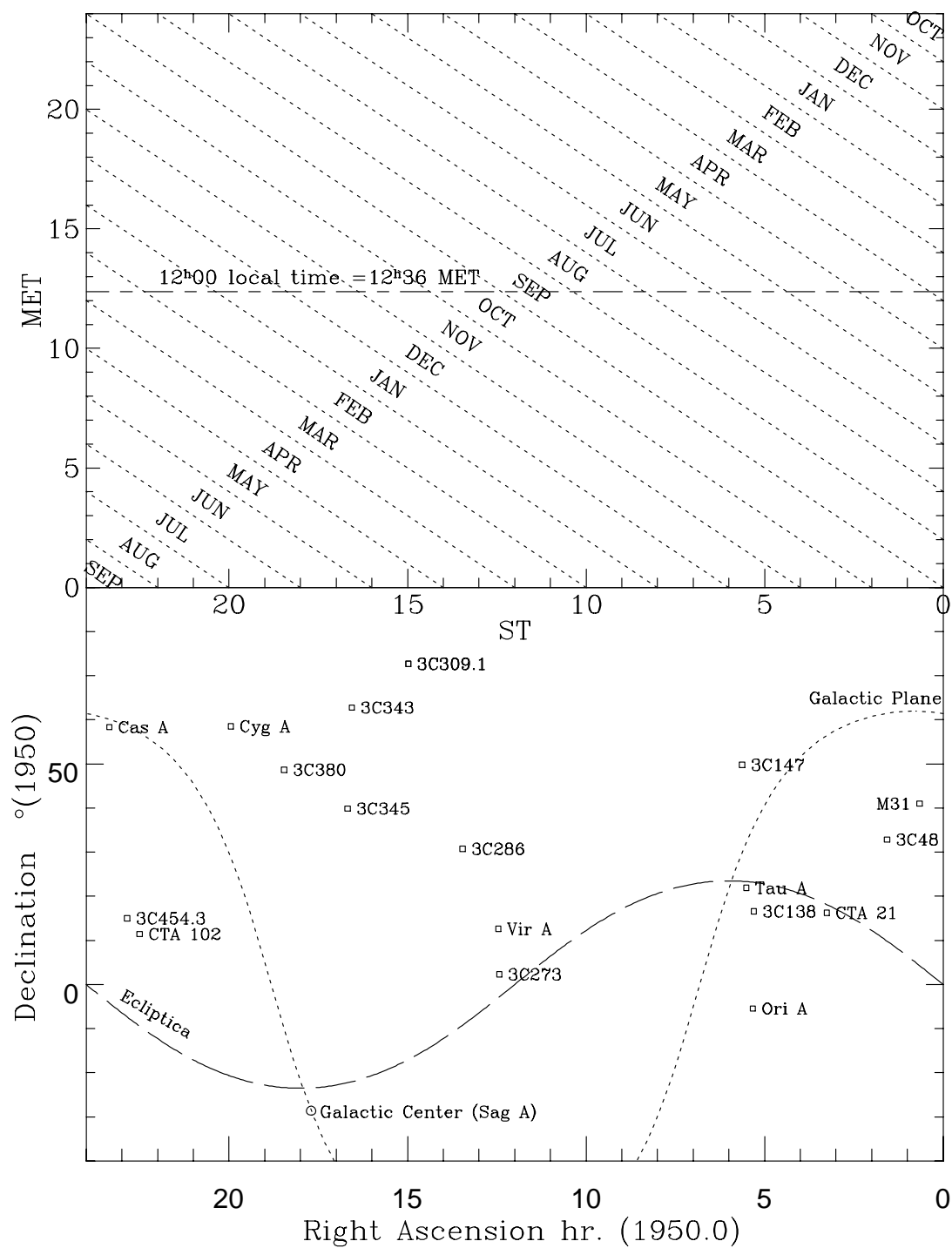


Figure 1.3: MET vs. LST and the position of the SUN and other important radio sources on the sky. The 12<sup>h</sup>LT=12<sup>h</sup>36MET line indicates the upper culmination of the sun. At 12<sup>h</sup>LT the ST on a given date equals the Right ascension of the sun

607-610 MHz			
H 349 $\delta$	608.3247		
1365-1425 MHz			
H 166 $\alpha$	1424.734	H 242 $\gamma$	1366.551
H 167 $\alpha$	1399.386	H 263 $\delta$	1413.645
H 168 $\alpha$	1374.601	H 264 $\delta$	1397.761
H 209 $\beta$	1420.236	H 265 $\delta$	1382.113
H 210 $\beta$	1400.138	H 266 $\delta$	1366.698
H 211 $\beta$	1380.417	H 283 $\epsilon$	1413.145
H 239 $\gamma$	1418.334	H 284 $\epsilon$	1398.398
H 240 $\gamma$	1400.787	H 285 $\epsilon$	1383.855
H 241 $\gamma$	1383.528	H 286 $\epsilon$	1396.514
He 166 $\alpha$	1425.314	He 209 $\beta$	1420.814
He 167 $\alpha$	1399.938	He 210 $\beta$	1400.708
He 168 $\alpha$	1375.161	He 211 $\beta$	1380.980
HI	1420.4058	Atomic Hydrogen	
CH <sub>2</sub> CHCN	1371.794	Vinyl Cyanide	
4770-5020 MHz			
H 109 $\alpha$	5008.923	H 159 $\gamma$	4772.441
H 110 $\alpha$	4874.157	H 172 $\delta$	4994.541
H 137 $\beta$	5005.033	H 173 $\delta$	4909.394
H 138 $\beta$	4897.779	H 174 $\delta$	4826.172
H 139 $\beta$	4793.567	H 185 $\epsilon$	4989.870
H 157 $\gamma$	4955.413	H 186 $\epsilon$	4910.858
H 158 $\gamma$	4862.780	H 187 $\epsilon$	4833.505
He 109 $\alpha$	5010.964	He 138 $\beta$	4899.774
He 110 $\alpha$	4876.144	He 139 $\beta$	4795.520
He 137 $\beta$	5007.073		
H <sub>2</sub> CO	4829.6596	Formaldehyde	
HCOOH	4916.312	Formic Acid	
CH <sub>3</sub> OH	500.3208	Methanol	

Table 1.1: Molecular and line frequencies

## SOME MATHEMATICAL EXPRESSIONS OF VISIBILITY FUNCTIONS

### 2.1 DERIVATION OF THE MATHEMATICAL EXPRESSION FOR THE VISIBILITY FUNCTION OF A CIRCULAR GAUSSIAN SOURCE WHOSE FULL WIDTH HALF MAXIMUM IS $d$ ARCSEC

The expression for the brightness distribution of a circular two-dimensional Gaussian centered at the origin (0,0) of some orthogonal  $x, y$  coordinate system on the sky is:

$$I(x, y) = \frac{1}{2\pi\sigma_x\sigma_y} e^{-\frac{1}{2}\frac{x^2}{\sigma_x^2}} e^{-\frac{1}{2}\frac{y^2}{\sigma_y^2}}$$

For the circularly symmetric Gaussian  $\sigma_x = \sigma_y$  where  $\sigma_x, \sigma_y$  are the standard deviations. The visibility function of the brightness distribution in the  $u, v$ -plane (where  $u, v$  are the coordinates of the projected baseline in wavelengths), is then given by a Fourier transform of the form.

$$\mathcal{V}(u, v) = \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} I(x, y) e^{2\pi j(ux+vy)} dx dy$$

Since the source is symmetric we can choose an arbitrary set of  $x, y$  and  $u, v$  coordinates such that the projected baseline of our interferometer lies entirely along the  $u$ -axis. Thus  $v = 0$

$$\begin{aligned} \mathcal{V}(u, 0) &= \frac{1}{2\pi\sigma_x\sigma_y} \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} e^{-\frac{1}{2}\frac{x^2}{\sigma_x^2}} e^{-\frac{1}{2}\frac{y^2}{\sigma_y^2}} e^{2\pi jux} dx dy \\ &= \frac{1}{2\pi\sigma_x} \int_{-\infty}^{+\infty} e^{-\frac{1}{2}\frac{x^2}{\sigma_x^2}} e^{j2\pi ux} dx \end{aligned}$$

The Gaussian is an even function centered at (0,0); thus

$$\mathcal{V}(u, v) = \frac{2}{\sqrt{2\pi}\sigma_x} \int_0^{+\infty} e^{-\frac{1}{2}\frac{x^2}{\sigma_x^2}} \cos(2\pi ux) dx$$

Solution of the integral gives

$$\int_0^{+\infty} e^{-\frac{1}{2}\frac{x^2}{\sigma_x^2}} = \frac{1}{2}\sqrt{2\pi}\sigma_x e^{-2\pi^2 u^2 \sigma_x^2}$$

Thus

$$\mathcal{V}(u, 0) = e^{-2\pi^2 u^2 \sigma_x^2}$$

The half power radius,  $x$ , of a Gaussian is related to the standard deviation by  $\frac{1}{2} = e^{-\frac{1}{2}\frac{x^2}{\sigma_x^2}}$ , which results in  $x = 1.1774\sigma_x$

Thus the diameter,  $d = 2x = 2.3548\sigma_x$

$$\begin{aligned} \mathcal{V}(u, 0) &= e^{-\frac{2\pi^2 u^2 d^2}{5.5452}} \\ &= e^{-3.6997u^2 d^2} && d \text{ in radians} \\ \text{or } \mathcal{V}(u, 0) &= e^{-8.367 \times 10^{-11} u^2 d^2} && d \text{ in arcsec} \end{aligned}$$

Use of this expression yields the graph given in figure 2.1

## 2.2 DERIVATION OF THE MATHEMATICAL EXPRESSION FOR THE VISIBILITY FUNCTION OF A DOUBLE POINT SOURCE

In general, we can relate the complex visibility function  $\mathcal{V}(u)$ , to a one-dimensional sky brightness distribution by

$$\mathcal{V}(u) = \int_{-\infty}^{+\infty} I(x) e^{j2\pi ux} dx$$

where  $I(ux)$  is the sky brightness distribution, and  $u$  is the projected baseline in wavelengths.

$\mathcal{V}(u) = |\mathcal{V}|e^{j\Phi_{\mathcal{V}}}$ , where  $|\mathcal{V}|$  is the visibility amplitude and  $\Phi_{\mathcal{V}}$  is the phase.

For the case of a double point source with components located at  $-\frac{\alpha}{2}$  and  $\frac{\alpha}{2}$  with respect to the fringe stopping center, each component having flux density  $S$ ,

$$\begin{aligned} \int_{-\infty}^{+\infty} I(x) e^{j2\pi ux} dx &= S e^{-j2\pi u \frac{\alpha}{2}} + S e^{j2\pi u \frac{\alpha}{2}} \\ &= 2S \frac{e^{-j2\pi u \frac{\alpha}{2}} + e^{j2\pi u \frac{\alpha}{2}}}{2} \\ &= 2S \cos(2\pi u \frac{\alpha}{2}) \end{aligned}$$

When  $u \rightarrow 0$ , we obtain the total flux,  $2S$ . By dividing through by  $2S$  we obtain the normalized visibility curve for a source whose total flux density is unity.

$$|\mathcal{V}|e^{j\Phi_{\mathcal{V}}} = \cos 2\pi u \frac{\alpha}{2} = \cos \pi u \alpha$$

This function goes to 0 for  $u\alpha = \frac{n}{2}$ ,  $n = 1, 3, 5, \dots$ . The first minimum occurs for  $u = \frac{1}{2\alpha}$  for  $\alpha$  in radians. If  $\alpha$ , the separation between the components, is expressed in arcsec, then  $u = \frac{103132.4}{\alpha}$  at the first minimum, where  $u$  is the projected baseline in wavelengths.

The amplitude of the visibility curve, plotted in figure 2.2, is given by

$$|\mathcal{V}| = |\cos(\pi u \alpha)|$$

Depending on whether  $\cos(\pi u \alpha)$  is positive or negative, the phase will be 0, or 180°.

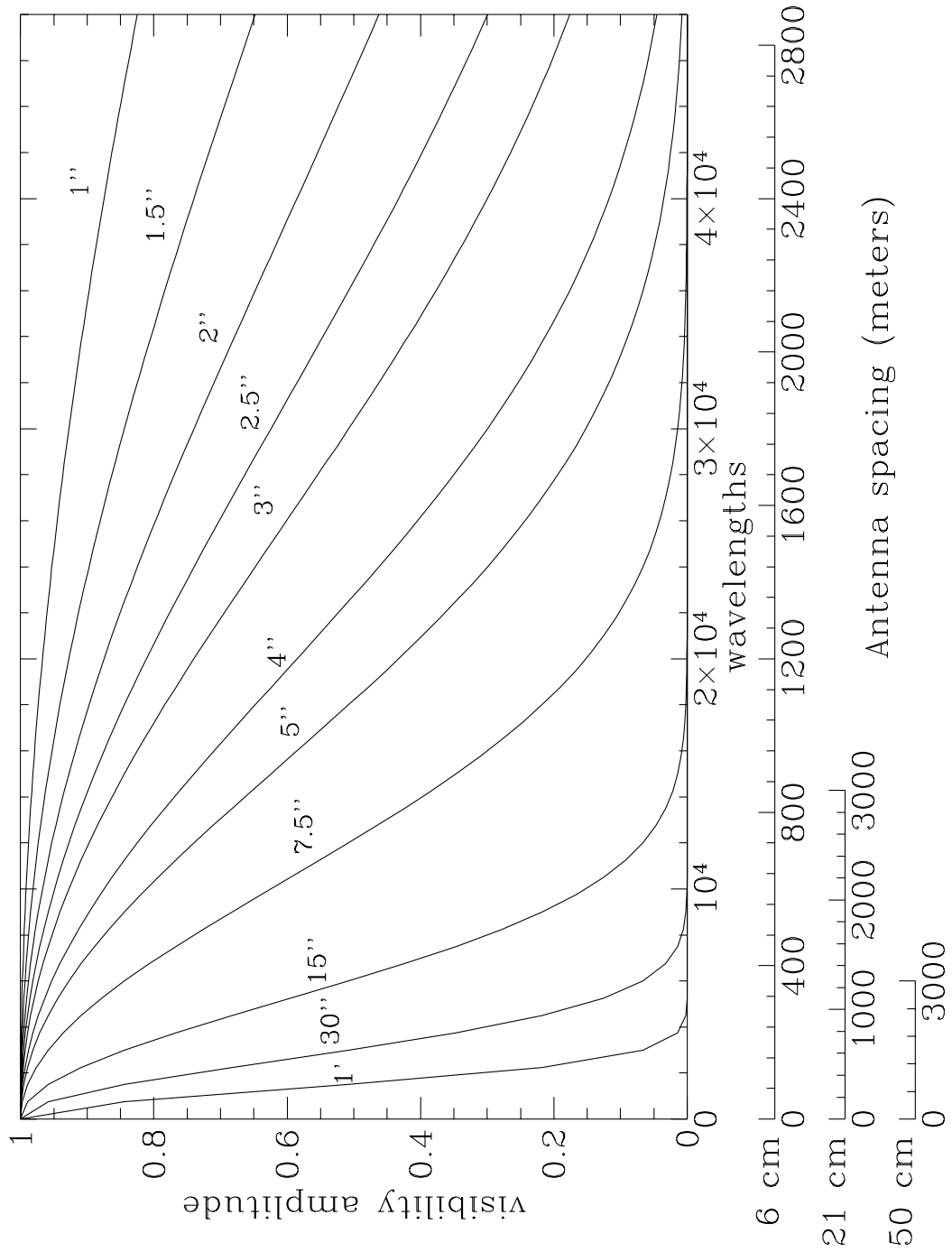


Figure 2.1: Visibility amplitude of circular Gaussian models of diameter 1'' to 1'

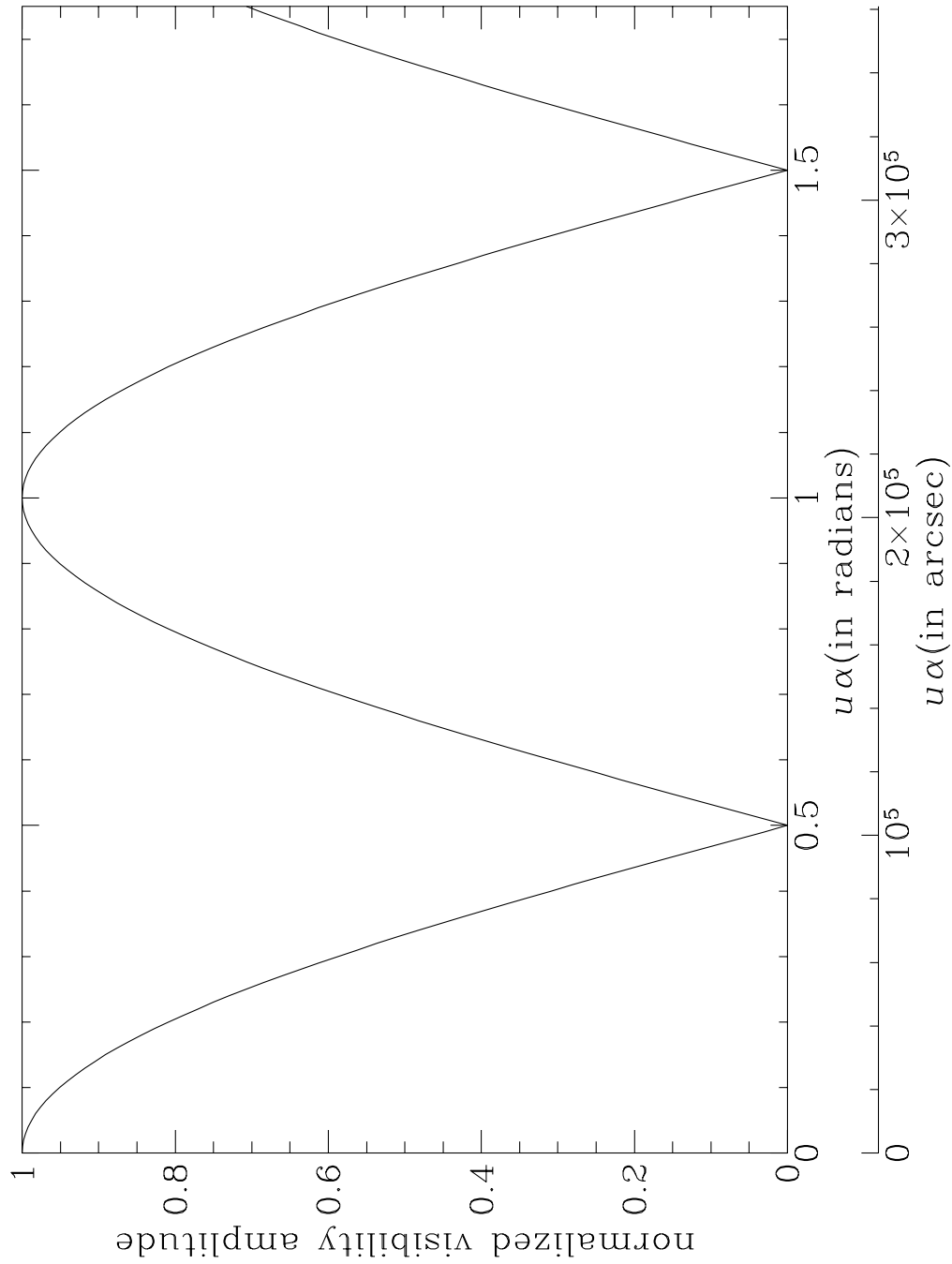


Figure 2.2: Visibility amplitude of a double point source whose components are separated by  $\alpha$ .  
 $(|\mathcal{V}| = |\cos(\pi u\alpha)|)$

# THE ARCHIVE OF WSRT OBSERVATIONS: A BRIEF GUIDE

*by Ernst Raimond*

## 3.1 CONTENTS AND COMPOSITION

### 3.1.1 CONTENTS

The archive contains all observations obtained with the WSRT since the beginning of its operations in 1970 (The Leiden archive is due to be given its own catalogue in 1993). VLBI observations are the only systematic exception. They have only been archived when WSRT "local" observations were done simultaneously with those in the VLBI network.

### 3.1.2 COMPOSITION

The archive consists of two components:

**Data:** Approximately 120 Gbytes (end 1992) of scientific and calibration observations in WSRT format, stored on optical disks (transfer from magnetic tapes complete in 1993). Observations of which the proprietary period of two years has expired can be made available upon request.

**Catalogue of observations:** The catalogue of approximately 75,000 observations (end 1992) done since 1979 can be queried via computer networks. The archive manager (Tony Foley) will assist users with catalogue queries for the earlier observations until they have been added.

### 3.1.3 THE SOFTWARE

The catalogue software is called ARCQUERY. This catalogue software is identical to the catalogue software used for the La Palma archive. There is a NFRA note (and a La Palma Users Guide) on this.

## 3.2 STARTING AN ARCHIVE QUERY

**environment:** ARCQUERY, the user-interface to the WSRT observations catalogue, runs on the NFRA Vax-cluster (alias RZMVX1) in Dwingeloo.



**logging on:** The NFRA VAX-cluster can be reached:

```
Telnet:  connect rzmvx1.nfra.nl (192.87.1.100)
Surfnet: set host rzmvx1
PSI:     set host/x29 (0204)15210040005
```

**userid:** ARCQUERY (captive account, no password required)

**initials:** Your initials are required to identify files created in the query-session.

**menu of functions:** The most important functions are:

- General HELP on ARCQUERY, and its commands;
- Information on available catalogues (HELPCAT);
- An EXAMPLE\_QUERY session (use "hold-screen" key to examine it page by page);
- EXIT to logout of the ARCQUERY account;
- ARCQ[QUERY] to actually start a query session.

**catalogue:** Specify the catalogue to query: WSRTOLD (complete name required), the WSRT observations catalogue (or OBSCAT\_LP, the La Palma observations catalogue, or AGK3, etc.)

**restore context:** If your defaults and query-context from a previous session were saved, you may restore them now.

**ARCQUERY prompt:** You're now in the program ARCQUERY. It is command-driven. The few essential commands are described in section 3.3; a full list in section 3.5

**HELP:** Context-sensitive help is available at any level of the program.

### 3.3 SELECTING AND RETRIEVING OBSERVATIONS

#### SE[LECT] <sup>1</sup>

#### Making and refining a selection

This is the most fundamental ARCQUERY command.

**examples:**

```
SEL[ECT] OBJE[CT_NAME] = ngc4* & RA = (6:0:0 to 6:10:0) & DEC >= 40
SEL [EQ]POS = (6:23,23:35)
SEL GAPOS = (90,30,1)
```

The 1st example selects all items from the catalogue with object names starting with the characters "NGC4" (also if the catalogue item contains embedded spaces, e.g. "NGC 4235" or "NGC 4115"), with right ascensions between 6h0 and 6h10, and with declinations exceeding 40°.

The 2nd example selects items within 1 arcmin (the default search radius) from the equatorial position RA=6<sup>h</sup>23<sup>m</sup>00<sup>s</sup>, DEC=23°35'00".

The 3rd example selects items within 1 degree from the galactic position  $l=90^{\circ}0$ ,  $b=30^{\circ}0$ .

**syntax:**

- *relational operators:* =, >, >=, <, <=, <>; or the FORTRAN-like equivalents: .EQ., .GT., .GE., .LT., .LE., .NE.
- *logical operators:* & (.AND.), | (.OR.), .EQV., .NEQV. (.XOR.), .NOT.

<sup>1</sup>In this guide the following conventions are used:

- COMMAND and KEYWORDS are printed in upper-case, although ARCQUERY is case-insensitive unless otherwise specified (by a DEFAULT command)
- Unnecessary parts of the command or keywords are usually given between square brackets []. The remaining part must be an unambiguous abbreviation.

- catalogue keywords: type `HELP SEL WSRT` (or type `SEL ?`) for a list with explanation, or type `SEL xxx` (a nonsense keyword) for just a list. Keywords, like commands can be abbreviated as long as the abbreviation remains unambiguous.
- *values*: single values, value-sets (value1,value2...), value-ranges (value1 TO value2) and, for strings values including wildcards (\* or %) are allowed. Blanks, embedded in specified strings, are significant; embedded in catalogue item strings they're not.

**/qualifiers:** They influence the way a command is executed. Type `HELP QUALIFIER` or `QUAL ?` to obtain general information, or `SEL / ?` to obtain a list of qualifiers for the `SELECT` command. The most commonly used ones are `/INPUT=`, `/OUTPUT=` (see below under "step-by-step approach"), `/EQUINOX` to indicate the equinox used in coordinate specifications, `/PRINT` to print the output.

**step-by-step approach:** This is a more practical alternative to specifying your selection in one, long and complicated, `SELECT`-command. Each `SELECT` command produces a local output table in the format of the original catalogue (table 0). By default, subsequent commands use the last output-table as input table. The qualifiers `/INPUT` and `/OUTPUT` may be used to override the defaults.

**example:** A step-by-step alternative to the 1st example `SELECT`-command given above (`SELECT OBJE=ngc4* & RA=(6:0:0 to 6:10:0) & DEC>=40`) would be:

```
step 1: SEL OBJE=ngc4*      380 items in table 1,
step 2: SEL RA=(6:0 to 6:10) 86 items in table 2,
step 3: SEL DEC>=40        43 items in table 3.
```

**speed and disk-space:** Operations on a large table (WSRT catalogue contains more than 75,000 entries) take more time than those on a small one. Narrowing down the selection considerably in the first step is therefore efficient in terms of time and disk-space. Selections from table 0 (the WSRT catalogue) are fastest if one of the indexed keywords (`OBJECT_NAME`, `SEQUENCE_NR`, `PROJECT_NR`, `DATE`, `VOLUME` and all items involving `POSITION` and `BOX`) is used.

The three steps in the example could have been taken in a different order: interchanging steps 1 and 2 would have made very little difference in the space used, since the first selection would again result in approximately 400 items in table 1. However, the interchange of steps 1 and 2 would cost more time since `OBJECT_NAME` is an indexed keyword, and `RA` is not. On the other hand, doing step 3 as the first one would be unwise since many thousands of items would be selected with `DECLINATION >= 40°`. However, it would have been efficient to combine steps 2 and 3 into the following first step: `SEL/MAXBOXSIZE(50,50) BOX=(12:05,65,2.5,50)` It would result in 345 items in table 1 and it would be fast because all searches in a cone (keyword `POSITION`) and in a `BOX` use the index on positions. The qualifier overrides the default maximum boxsize of  $2^\circ * 2^\circ$ .

**interruption of search:** A search process may be interrupted by typing `Ctrl-C`. Options are available to abort the process, to keep what you have so far or to continue with or without listing the selection on the screen. `Ctrl-E` does not stop the search but shows what percentage of the catalogue has been searched and how many items have been selected so far.

## REQ[UEST]

## Requesting selected observations

You can request that the selected observations be sent to you. However, before the request can be granted by the NFRA archive manager, two conditions must be fulfilled. You'll be warned if either one is not.

**conditions:** Your address must be known to the archive manager (see command `ADDRESS_INFO`, below). You must either have proprietary rights to the observations requested, or the two-year proprietary period must be expired.

**examples:**

```
REQ/OUT[PUT_TYPE] = WSRT  request the observations listed in the default input-table
                           to be copied in WSRT-format;
REQ/OUT=UVFITS/INP=3     request the observations in table 3 to be copied in
                           UVFITS-format.
```

**comments:** You'll be prompted to accompany your request with comments or special wishes. For instance, you need to specify whether or not you want the standard calibrations applied before the data are copied. Also it is wise to explain your request if your right to the requested data is not obvious.

## **AD[DRESS\_INFO]**

## Supplying address information

First-time users must identify themselves, at least when requesting data. This serves to protect observers' proprietary rights. The initials you've given at the start of the session will become permanently attached to the name/address-record.

The command `SHOW ADDRESS` tells you what information is already known. `SHOW INSTITUTES` provides a list of known institutes. Selecting one of these automatically completes most of the address information. If you're working at an unknown institute, you must supply the details.

### **examples:**

<code>AD[DRESS]</code>	to enter a menu-session, in which you're prompted for the information.
<code>AD *</code>	to restore all original information
<code>AD INSTITUTE=VLA</code>	to indicate that you moved to the VLA.

## **EX[IT]**

## Leave ARCQUERY

Upon leaving `ARCQUERY`, all print-output produced during the session will be spooled to the default printer-queue (use `SHOW DEFAULT` to see what it is). Alternatively, all print-output, and the session log-file if you wish, may be mailed to you. This is the sensible option when the archive is accessed remotely.

Saving everything you did so far (the query-context) in order to continue some other time is an option. [WARNING: files produced via the captive `ARCQUERY` account are saved for 7 days only]

### **examples:**

<code>EX[IT]/nos[ave]</code>	leave without saving context.
<code>EX/mail=all/s</code>	mail print-output and log to me and save the context.
<code>EX/mail=log</code>	mail log-file only; it can be re-executed in a subsequent session. You will be prompted for the save/nosave option.

Ctrl-Z is an alternative for `EXIT/save`.

## 3.4 PEOPLE TO CONTACT FOR INFORMATION

### **Archive manager:**

Tony Foley	
NFRA	phone: +(31)(0)5219 7244
Postbus 2	fax: +(31)(0)5219 7332
7990 AA Dwingeloo	telex: 42043 srzm nl
the Netherlands	
e-mail: internet:	folred@nfra.nl
SPAN:	ESTCS1::PSI%DWINGELOO::FOLRED
	NSSDCA::PSI%DWINGELOO::FOLRED
PSI:	PSI%(0)(204)1521004::FOLRED

### **author of this guide:**

Ernst Raimond	
NFRA	phone: +(31)(0)5219 7244
Postbus 2	fax: +(31)(0)5219 7332
7990 AA Dwingeloo	telex: 42043 srzm nl
the Netherlands	

e-mail: internet: exr@nfra.nl  
 SPAN: ESTCS1::PSI%DWINGELOO::EXR  
 NSSDCA::PSI%DWINGELOO::EXR  
 PSI: PSI%(0)(204)1521004::EXR

## 3.5 SUMMARY OF ARCQUERY COMMANDS

### General

CO[UNT] Obtain simple statistics with respect to one or two parameters  
 DEF[AULT] Set/modify defaults on formats, search areas, listings, etc.  
 EX[IT] Exit program (cf. section 3.3)  
 H[ELP] Obtain help (context sensitive)  
 MA[IL\_COMMENT] Send mail to archive manager  
 SH[OW] show information on or status of: (your) ADDRESS\_INFO,  
 CATALOGUE, CODE\_GROUPS, DEFAULTS, INSTITUTES,  
 ITEMS (in catalogue), REQUESTS,SYMBOLS, TABLES,  
 UNITS, (other) USERS

### Selecting and table-handling

CA[LSELECT] Select calibrations in time window around selected observations  
 DE[LETE] Delete input-table  
 DI[FFERENCE] Get observations from 1st (specified) table not occurring in 2nd  
 ED[IT] Edit listing by hand to produce new table  
 I[NTERSECTION] Get common observations from two specified tables  
 REN[AME] Rename a table  
 RET[URN\_TABLE] Retrieve table obtained from mailserver-session of  
 ARCQUERY  
 SE[LECT] Select observations (cf. section 3.3)  
 SO[RT] Sort one or more tables in order of a number of parameters  
 U[NION] Combine two tables with observations from either one

### Listing, etc.

L[IST] List specified parameters of observations already selected  
 T[YPE] Copy list files to the screen  
 P[RINT] Copy list files to print-queue  
 SP[OOL] Spool output to printer

### Requesting

AD[DRESS\_INFO] Enter/modify address information (request entering in users-file,  
 cf. section 3.3)  
 MO[DIFY\_REQ] Propose modification to entries in Catalogue  
 REQ[UEST] Request for observations (cf. section 3.3)