EXAMPLE: August 6, 1879, Lat. 59° S., Long. 175° 27′ E., during evening twilight, observed an altitude of Achernar, near lower transit, 26° 52′; watch time, $4^h\ 31^m\ 12^s$; C − W, $0^h\ 18^m\ 07^s$; chro. fast of G. M. T., $12^m\ 42^s$; I. C., + 1′ 20″; height of eye, 24 ft. Find hour angle by both methods; thence the latitude.

R. A. ✱ + 12^h / L. S. T. lower trans.		$13^h\ 33^m\ 15^s.4$
Long.,	−	11 41 48
G. S. T.,		1 51 27 .4
R. A. M. S. Gr. $5^d 0^h$,	−	8 54 39 .8
Sid. int.,		16 56 47 .6
Red. (Tab. 8),	−	2 46 .6
G. M. T.,		16 54 01 .0
C. C. (sign reversed),	+	12 42
Chro. time,		5 06 43
C−W,	−	0 18 07
Watch time transit,		4 48 36
Watch time obs.,		4 31 12
t Mean time,		17 24
t Sid. time,		17 27

Watch time,		$4^h\ 31^m\ 12^s$
C−W,	+	0 18 07
Chro. t.,		4 49 19
C. C.,	−	12 42
G. M. T. 5^d,		16 36 37
R. A. M. S. Gr. $5^d 0^h$,	+	8 54 39 .8
Red. (Tab. 9),	+	2 43 .7
G. S. T.,		1 34 00 .5
Long.,	+	11 41 48
L. S. T.,		13 15 48 .5
R. A. ✱ + 12^h,		13 33 15 .4
t,		17 27

Obs. alt. ✱,		26° 52′ 00″
I. C.,	+	1′ 20″
dip,	−	4′ 48″
ref.,	−	1 55
	−	6 43
Corr.,	−	5′ 23″
h,		26° 46′ 37″
at^2,	−	3 03
H,		26 43 34
p,		32 09 32
L,		58 53 06 S.

R. A. ✱,	$1^h\ 33^m\ 15^s.4$
Dec.,	57° 50′ 28″ S.
p,	32° 09′ 32″
a (Tab. 26),	0″.6
at^2 (Tab. 27),	3′ 03″

BY A SINGLE ALTITUDE AT A GIVEN TIME.

339. This observation should be limited to conditions where the body is within three hours of meridian passage and where it is not more than 45° from the meridian in azimuth; also where the declination is at least 3°. On the prime vertical the solution by this method is inexact, and when the hour angle is 6^h, or the declination 0°, it is impracticable.

The problem is: Given the hour angle, declination, and altitude, to find the latitude. The solution is accomplished by letting fall, in the usual astronomical triangle, a perpendicular from the body to the meridian, and considering separately the distances on the meridian, from the pole and zenith, respectively, to the point of intersection of the perpendicular; the sum or difference of these distances is the co-latitude.

Following the usual designation of terms and introducing the auxiliaries φ' and φ'', the formulæ are as follows:

$$\tan \varphi'' = \tan d \sec t;$$
$$\cos \varphi' = \sin h \sin \varphi'' \operatorname{cosec} d;$$
$$L = \varphi' + \varphi''.$$

The terms φ' and φ'' will have different directions of application according to the position of the body relatively to the observer. From a knowledge of the approximate latitude, the method of combining them will usually be apparent; it is better, however, to have a definite plan for so doing, and this may be based upon the following rule:

Mark φ'' north or south, according to the name of the declination; mark φ' north or south, according to the name of the zenith distance, it being *north* if the body bears south and east or south and west, and *south* if the body bears north and east or north and west. Then combine φ'' and φ' according to their names; the result will be the latitude, except in the case of bodies near lower transit, when $180° - \varphi''$ must be substituted for φ'' to obtain the latitude.

It may readily be noted that if we substitute φ'' for declination and φ' for zenith distance, the problem takes the form of a meridian altitude; indeed, the method resolves itself into the finding of the zenith distance and declination of that point on the meridian at which the latter is intersected by a perpendicular let fall from the observed body.

The time should be noted at the instant of observation, from which is found the local time, and thence the hour angle of the celestial object.

If the sun is observed, the hour angle is the L. A. T. in the case of a p. m. sight, or 12^h − L. A. T. for an a. m. sight. If any other body, the hour angle may be found as hitherto explained.

EXAMPLE: June 7, 1879, in Lat. 30° 25′ N., Long. 81° 25′ 30″ W., by account; chro. time, $6^h\ 22^m\ 52^s$; obs. ☉ 75° 13′, bearing south and east; I. C. − 3′ 00″; height of the eye, 25 feet; chro. corr. − $2^m\ 36^s$. Find the latitude.

Chro. t.,	$6^h\ 22^m\ 52^s$	Obs. alt. ☉,	75° 13′ 00″	Dec.,	22° 45′ 09″.9 N.	Eq. t.,	$1^m\ 28^s.85$
C. C.,	− 2 36	Corr.,	+ 7 40	H. D.,	+ 14″.6	H. D.,	− $0^s.46$
G. M. T.,	6 20 16	*h*,	75 20 40	G. M. T.,	+ $6^h.3$	G. M. T.,	+ $6^h.3$
Eq. t.,	+ 1 26	S. D.,	+ 15′ 48″	Corr.,	{+ 91″.98 / + 1′ 32″}	Corr.,	− $2^s.85$
G. A. T.,	6 21 42	dip,	− 4′ 54″	Dec.,	22° 46′ 42″ N.	Eq. t.,	$1^m\ 26^s.0$
Long.,	− 5 25 42	*p. & r.*,	− 14			(*Add* to *mean* time.)	
L. A. T. = *t*,	{$0^h\ 56^m\ 00^s$ E. / 14° 00′ 00″}	I. C.,	− 3 00				
			− 8 08				
		Corr.,	+ 7′ 40″				

t	14° 00′ 00″	sec	.01310		
d	22 46 42	tan	9.62317	cosec	.41210
h	75 20 40			sin	9.98563
φ″	23 24 07 N.	tan	9.63627	sin	9.59898
φ′	7 02 30 N.			cos	9.99671
Lat.	30 26 37 N.				

EXAMPLE: May 28, 1879, p. m., in Lat. 6° 20′ S. by account, Long. 30° 21′ 30″ W.; chro. time, $7^h\ 35^m\ 10^s$; observed altitude of moon's upper limb, 75° 33′ 00″, bearing north and east; I. C., − 3′ 00″; height of eye, 26 feet; chro. fast of G. M. T., $1^m\ 37^s.5$. Required the latitude.

Chro. t.,	$7^h\ 35^m\ 10^s$	Obs. alt. ☾,	75° 33′ 00″	R. A. ☾,	$10^h\ 21^m\ 07^s.78$	Dec.,	6° 49′ 52″.4 N.
C. C.,	− 1 37.5	S. D.,	− 15′ 51″	M. D.,	+ $2^s.06$	M. D.,	− 14″.46
G. M. T.,	7 33 32.5	Aug.,	− 0 16	No. min.,	$33^m.54$	No. min.,	$33^m.54$
R. A. M. S.,	+ 4 22 37.3	dip,	− 5 00	Corr.,	+{$69^s.09$ / $1^m\ 09^s$}	Corr.,	−{485″ / 8′ 05″}
Red. (Tab. 9),	+ 1 14.5	I. C.,	− 3 00	R. A.,	$10^h\ 22^m\ 17^s$	Dec.,	6° 41′ 47″ N.
G. S. T.,	11 57 24.3	1st Corr.,	− 24 07				
R. A. ☾,	− 10 22 17	Approx. alt.,	75° 08′ 53″				
H. A. from Gr.,	1 35 07 W.	*p. & r.* (Tab. 24),	+ 14 37			Hor. Par.,	58′ 03″
Long.,	2 01 26 W.	*h*,	75 23 30				
t,	{$0^h\ 26^m\ 19^s$ E. / 6° 34′ 45″}						

t	6° 34′ 45″	sec	.00286		
d	6 41 47	tan	9.06973	cosec	.93324
h	75 23 30			sin	9.98573
φ″	6 44 26 N.	tan	9.07259	sin	9.06959
φ′	13 05 40 S.			cos	9.98856
Lat.	6 21 14 S.				

EXAMPLE: August 6, 1879, p. m., in Lat. 52° 47′ S. by D. R., Long. 146° 32′ E., observed altitude of Achernar, near lower transit, 24° 01′ 20″ bearing south and west; watch time, $6^h\ 48^m\ 22^s$; C−W, $9^h\ 46^m\ 27^s$; chro. corr. on G. M. T., + $1^m\ 57^s$; height of eye, 18 feet; I. C. + 1′ 00″. Find the latitude.

Watch time,	$6^h\ 48^m\ 22^s$	Obs. alt. ✱,	24° 01′ 20″	R. A. ✱,	$1^h\ 33^m\ 15^s.3$
C−W,	+ 9 46 27	Corr.,	− 5 19	Dec.,	57° 50′ 28″ S.
Chro. t.,	4 34 49	*h*,	23 56 01		
C. C.,	+ 1 57	I. C.,	+ 1′ 00″		
G. M. T., 5^d,	16 36 46	dip,	− 4′ 09″		
R. A. M. S.,	+ 8 54 39.8	ref.,	− 2 10		
Red. (Tab. 9),	+ 2 43.7		− 6 19		
G. S. T.,	1 34 09.5	Corr.,	− 5′ 19″		
R. A. ✱,	1 33 15.3				
H. A. from Gr.,	0 00 54 W.				
Long.,	9 46 08 E.				
H. A.,	9 47 02 W.				
	{$2^h\ 12^m\ 58^s$ / 33° 14′ 30″}				

t	33° 14′ 30″	sec .07760	
d	57 50 28	tan .20153	cosec .07233
h	23 56 01		sin 9.60818
$180°-\varphi''$	117 44 18 S.	tan .27913	sin 9.94699
φ'	64 54 15 N.		cos 9.62750
Lat.	52 50 03 S.		

BY THE POLE STAR.

340. This method, confined to northern latitudes, is available when the star Polaris and the horizon are distinctly visible, the time of the observation being noted at the moment the altitude is measured.

Two methods will be given. The first is sufficiently precise for nautical purposes, involving the computation of the formula:

$$L = h - p \cos t,$$

in which,

h = true altitude, deduced from the observed altitude;
p = polar distance = $90° - d$, the apparent declination being taken from the Nautical Almanac for the date;
t = star's hour angle.

Find the right ascension and declination of Polaris from the Nautical Almanac; then find the hour angle in the usual way.

To the log cosine of the hour angle add the logarithm of the polar distance in minutes; the number corresponding to the resulting logarithm will be a correction in minutes to be subtracted from the star's true altitude to find the latitude.

Attention must be paid to the sign of the correction $p \cos t$. If t is more than 6^h and less than 18^h, the sign of $\cos t$ is $-$; hence the formula becomes arithmetically:

$$L = h + p \cos t.$$

EXAMPLE: June 11, 1879, from an observed altitude of Polaris the true altitude was found to be 29° 5′ 55″. The time noted by a Greenwich chronometer was $13^h\ 41^m\ 26^s$; chro. corr. $-2^m\ 22^s$; Long. $5^h\ 25^m\ 42^s$ W.

Chro. time,	$13^h\ 41^m\ 26^s$
C. C.,	$-$ 2 22
G. M. T., 11^d,	13 39 04
R. A. M. S.,	+ 5 17 49
Red. (Tab. 9),	+ 2 15
G. S. T.,	18 59 08
R. A. ✱,	$-$ 1 14 04
H. A. from Gr.,	17 45 04 W.
Long.,	5 25 42 W.
H. A.,	12 19 22 W.
t,	$\{11^h\ 40^m\ 38^s$ E. / 175° 09′ 30″

h,	29° 05′ 55″
$p \cos t$,	+ 1 19 54
Lat.,	30 25 49 N.

R. A. ✱,	$1^h\ 14^m\ 04^s$	
Dec.,	88° 39′ 47″ N.	
p,	$\{$1° 20′ 13″ / 80′.2	
p, 80′.2	log	1.90417
t, 175° 09′ 30″	cos	($-$) 9.99845
$p \cos t$, $-\{$79′.9 / 1° 19′ 54″	log	($-$) 1.90262

341. The second method is more rigorous, and should be employed when greater accuracy is sought. It is embodied in Table 28.

Reduce the observed altitude of the star to the true altitude. Find from the Nautical Almanac the apparent right ascension and declination of the star at the time of observation. Find the hour angle in the usual manner.

With the hour angle take out the *first correction*, A, from Table 28, giving to it the sign $-$ when the hour angle is numerically less than 6^h; the sign + when the hour angle is greater than 6^h.

With the hour angle and altitude take out the *second correction*, B, from Table 28. The sign of this correction is always +. (If the altitude is greater than 60°, this correction may be found by taking that for 45° and multiplying it by the tangent of the altitude; adding, if desirable, the second term in the expression for B, viz: $+ 0''.0076 \sin^4 t \tan^3 h$.)

With B and the declination take out the *third correction*, C, from Table 28, giving it the sign + when the declination is less than 88° 48′; $-$ when the declination is greater than 88° 48′.

With A and the declination take out the *fourth correction*, D, from Table 28, giving it the same sign as that of A when the declination is less than 88° 48′; the opposite sign when the declination is greater than 88° 48′.

Combine these corrections with the true altitude according to their signs; the result is the latitude of the place of observation.

If, when several sights are taken, great precision is required, or the intervals are great, it will be necessary to take out the *first* and *second* corrections for each observation separately; in other cases the