Sidereal/Solar Time

We measure time by the position of celestial objects in our sky. The reference is the *celestial meridian* (the north-south line through the zenith). The angle between the celestial meridian and the object's meridian is called the *Hour Angle* (HA). Hour Angle is measured in time units ($^{h\ m\ s}$). Positive Hour Angles are West of the meridian; negative Hour Angles are East of the Meridian. HA range = 0^h to ± 12^h .

Solar Time is measured by the position of the Sun with respect to the celestial meridian.

One Solar Day is the interval between successive transits of the meridian by the Sun.

One Solar Day = 24^h.

Apparent Solar Time (AST) is the Hour Angle of the Sun + 12^h.

AST = HA_{sun} + 12^h AST range = 0^h to 24^h .

Sidereal Time is measured by the position of the Vernal Equinox with respect to the celestial meridian.

One Sidereal Day is the interval between successive transits of the meridian by the Vernal Equinox.

One Sidereal Day = $23^h\ 56^m\ 04^s$.

Sidereal Time (ST) is the Hour Angle of the Vernal Equinox (HA_{VE}).

ST = HA_{VE} ST range = 0^h to 24^h .

The angle from the Vernal Equinox to a star is equal to the Right Ascension of the star (RA_*); the angle from the star to the celestial meridian is the Hour Angle of the star (HA_*). The sum of these two angles is the Hour Angle of the Vernal Equinox, which is the Sidereal Time.

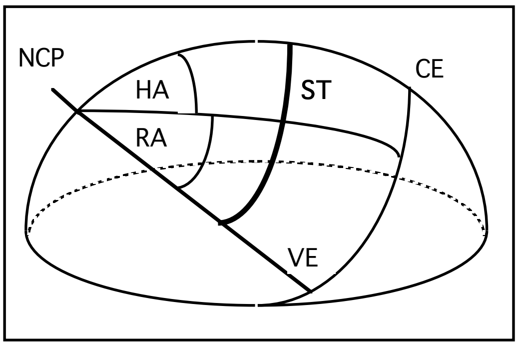
ST = RA_* + HA_*

Add or subtract 24^h as needed to keep ST in the 0^h - 24^h range.

Hour Angle is 0^h for objects on the meridian. Therefore, the Sidereal Time is the Right Ascension of objects on the meridian.

ST = $RA_{meridian}$

Thus, Sidereal Time tells what part of the sky is accessible for viewing (at a given Solar Time).



Sidereal Time runs more rapidly than Solar Time.
A Sidereal clock gains about 4 minutes per day on a Solar clock.
Sidereal Time gains ≈ 4^m per day, ≈ 2^h per month, ≈ 1 day per year over Solar Time.
When are Sidereal Time and Solar Time equal? ST = AST when $\mathbf{HA_{VE} = HA_{sun} + 12^h}$

-- that is, when the Sun is 12^h away from the vernal equinox, which occurs when the Sun is at the autumnal equinox. So ST = AST on the day of the autumnal equinox.

Sample calculations:

#1 If a star with RA = $4^h\ 27^m$ has HA = $-8^h\ 41^m$, what is the ST?

Use ST = RA* + HA*

ST = $4^h\ 27^m + -8^h\ 41^m = (4^h - 8^h) + (27^m - 41^m)$

= $-4^h - 14^m = -4^h\ 14^m$ (out of range).

$-4^h\ 14^m + 24^h = 20^h - 14^m =$ $\mathbf{19^h\ 46^m}$.

#2 What will be the HA of a star with RA = $17^h\ 36^m$ when the ST is $3^h\ 53^m$?

Use ST = RA* + HA*, and rearrange it to give HA* = ST - RA* .

Then HA* = $3^h\ 53^m - 17^h\ 36^m = (3^h - 17^h) + (53^m - 36^m)$

= $-14^h + 17^m = -13^h\ 43^m$ (out of range)

$-13^h\ 43^m + 24^h = -14^h + 17^m + 24^h =$ $\mathbf{10^h\ 17^m}$.

#3 Estimate the Sidereal Time at 11 pm CDT on June 8.

First convert this target to Standard Time: 10 pm CST on June 8.

(a) Begin when ST = AST, at noon on the autumnal equinox (≈ Sept 22), when ST = 12^h.

(b) For each month past September, add 2^h.

(c) For each day past the 22nd, add 4^m.

(d) Add the difference between the target time and noon.

(e) Add or subtract 24^h to get ST into the proper range.

		Δ(ST)	ST
(a)	Sept 22, noon	--	12^h
(b)	June 22, noon (add 9 mo x 2^h/mo)	+ 18^h	$12^h + 18^h = 30^h$
(c)	June 8, noon (subtract 14^d x 4^m/d)	- 56^m	$30^h - 56^m = 29^h\ 4^m$
(d)	June 8, 10 pm (add 10^h)	+ 10^h	$29^h\ 4^m + 10^h = 39^h\ 4^m$ (out of range)
(e)	Put ST into 0^h - 24^h range:	- 24^h	$39^h\ 4^m - 24^h$ = $\mathbf{15^h\ 4^m}$

(Normally this method is accurate to about ± 10 minutes.)