**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 = $0^\text{h}$ to $\pm 12^\text{h}$.

*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 = $24^\text{h}$.

*Apparent Solar Time* (AST) is the Hour Angle of the Sun + $12^\text{h}$.

$$\text{AST} = \text{HA}_{\text{sun}} + 12^\text{h} \quad \text{AST range} = 0^\text{h} \text{ to } 24^\text{h}.$$  

*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 = $23^\text{h} 56^\text{m} 04^\text{s}$.

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

$$\text{ST} = \text{HA}_{\text{VE}} \quad \text{ST range} = 0^\text{h} \text{ to } 24^\text{h}.$$  

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.

$$\text{ST} = \text{RA}^* + \text{HA}^*$$  

Add or subtract $24^\text{h}$ as needed to keep ST in the $0^\text{h} - 24^\text{h}$ range.

Hour Angle is $0^\text{h}$ for objects on the meridian. Therefore, the Sidereal Time is the Right Ascension of objects on the meridian.

$$\text{ST} = \text{RA}_{\text{meridian}}$$  

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 $H_{AVE} = H_{ASun} + 12^h$
-- 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).

$-4^h 14^m + 24^h = 20^h - 14^m = 19^h 46^m$.

#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)

$-13^h 43^m + 24^h = -14^h + 17^m + 24^h = 10^h 17^m$.

#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.

<table>
<thead>
<tr>
<th>A(ST)</th>
<th>ST</th>
</tr>
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<tbody>
<tr>
<td>-</td>
<td>12^h</td>
</tr>
<tr>
<td>+ 18^h</td>
<td>12^h + 18^h = 30^h</td>
</tr>
<tr>
<td>- 56^m</td>
<td>30^h - 56^m = 29^h 4^m</td>
</tr>
<tr>
<td>+ 10^h</td>
<td>29^h 4^m + 10^h = 39^h 4^m (out of range)</td>
</tr>
<tr>
<td>- 24^h</td>
<td>39^h 4^m - 24^h = 15^h 4^m</td>
</tr>
</tbody>
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Normally this method is accurate to about ± 10 minutes.)