**PHYS 4270 / 5390 – Astronomical Techniques**

**Basic Practice with Right Ascension (RA), Hour Angle (HA) and Local Sidereal Time (LST)**

[The following is taken from my PHYS 1070 class notes and is intended for students who have not already worked with RA and Dec.]

Introduction:

Astronomers use the Equatorial Coordinate system. The Equatorial Coordinate system uses two coordinates – Right Ascension (RA or α) and Declination (Dec or δ) – to identify the position of celestial objects (see Fig. 1). RA and Dec are very similar to the coordinate system used to identify positions on Earth’s surface. Dec is an *exact* analogue to latitude, while RA is similar to longitude. The zero of declination is the Celestial Equator, while the North Celestial Pole has a declination of +90° and the South Celestial Pole is at –90°. The zero of right ascension is the Vernal Equinox (also called the First Point in Aries, and is the intersection of the equatorial plane with the ecliptic plane). RA is also an angle, but is normally given in units of time; from 0h to 24h. One hour corresponds to 360/24 = 15°.

Imagine Earth as a transparent sphere with a light at the centre and lines of latitude and longitude drawn on its surface. The lines of latitude project onto the Celestial Sphere as lines of declination. An arbitrary star has a fixed declination and so follows a circle of constant declination on the Celestial Sphere throughout one sidereal day. But where on this circle will we find this star at this moment? The star does have a fixed right ascension, but because Earth turns on its axis, we need one more piece of information to unambiguously locate the star at any given moment. That’s where the Local Sidereal Time (LST) comes in.

The LST is just the RA of an object that is on the observer’s Celestial Meridian at this moment. Thus, if we know the LST and we know the RA of the given star, then it is a simple matter to move our telescope from the Celestial Meridian along the star’s declination circle to our object. We refer to the angle from the Celestial Meridian as the Hour Angle (HA) (see Figure 2 and below).

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| http://www.jtwastronomy.com/tutorials/images/celestial_coordinates_equatorial.png  Figure 1 | http://www.physics.uc.edu/~sitko/Fall2002/1-Sky/HA-DEC.GIF  Figure 2 |

Hour Angle and Right Ascension

Exercise with angles/time:

RA can be given in degrees, i.e., from 0˚ through 360˚ but is normally given in units of time for convenience, from 0hto 24h, i.e., in hours, minutes, seconds (h,m,s) format. Clearly, 1h corresponds to 15˚ in this convention.

*1. Convert the angle 134.568˚ to h,m,s format*.

Dividing an angle in decimal degrees format by 15 gives the angle in decimal hours format: 134.568/15 = 8.972h.

Recall how to convert decimal format to h,m,s format. We already know the numerical value for the “hours”: 8. Thus, we must convert 0.972h to minutes and seconds. (Recall, 1h corresponds to 60m and 1m corresponds to 60s.)

Multiplying 0.972 by 60 gives the result in minutes: 58.272m. So the value for the “minutes” is 58. Finally, we must convert 0.272m to seconds by multiplying by 60: 16.3s.

The answer: 134.568˚ corresponds to 8h 58m 16.3s.

*2. It currently is 9:40 am. I have an appointment at 11:15am. How much time do I have to wait before my appointment begins?*

This is an operation we can all do in our heads. But we need to be aware how to get the answer formally.

Strictly, the problem is (11h 15m) – (9h 40m), which we can re-write (10h 75m) – (9h 40m) which reduces simply to 1h 35m. Because “15” is less than “40”, we had to borrow 1h or 60m and add this to the 15m yielding 75m. Then the subtraction becomes simple.

*Suppose now my appointment begins at 1:45pm? How much time do I have to wait?*

In this case, one has to realize that 1pm can actually be written as 13h. The answer then follows straightforwardly: (13h 45m) – (9h 40m) = 4h 5m.

*3. One star, whose RA or α1 = 12h 30m, is currently on the observer’s celestial meridian. How long would the observer have to wait before a second star, with α2 = 14h 0m, transits the meridian?*

The first thing to note is that the second star has a larger RA and so is E of the meridian. It will then transit the observer’s meridian in (14h 0m) – (12h 30m) = 1h 30m.

If the second star’s RA were smaller than the first star, the second star would have already recently transited that sidereal day.

The Hour Angle (HA) of a star is the angle between the observer’s Celestial Meridian and the RA of the star along the Celestial Equator. Hour Angle is positive to the W and negative to the E. The units of HA are also (h,m,s), even though HA represents an angle.

Local Sidereal Time:

The reason RA is not an exact analogue to longitude is because Earth rotates on its axis. In order to find a celestial object, one needs to know its Hour Angle as well as its Right Ascension. The HA unambiguously identifies where on the declination circle the object is at this moment.

The Local Sidereal Time (LST) is defined as the RA of an object on the observer’s meridian (or whose HA = 0h). The relationship between the RA of an object, α, its HA and the LST is:

HA = LST – α

For convenience, all three quantities, though angles, are measured in units of time; h,m,s.

*4. The LST is 17h 31m 18s and the RA of a star is 14h 42m 9s. What is the star’s HA?*

Using the equation above, HA = (17h 31m 18s) – (14h 42m 9s). In order to take this difference, one has to rewrite the equation as:

HA = (16h 91m 18s) – (14h 42m 9s) = (2h 49m 9s). That is, one has to borrow 1h or 60m from the “hours” column for the “minutes” column of the LST.

*Suppose the LST and RA were reversed? What is the star’s HA?*

In this case, the HA = (14h 42m 9s) – (17h 31m 18s). There are at least two ways to perform this operation.

The first is to realize that the HA in this case is –[(17h 31m 18s) – (14h 42m 9s)] = –(2h 49m 9s) = –2h 49m 9s. The second is to realize that the “14h”can be rewritten as (14h + 24h) = 38h. And so HA = (38h 42m 9s) – (17h 31m 18s) = (38h 41m 69s) – (17h 31m 18s) = 21h 10m 51s.

But are these the same answers? Yes, they refer to the same HA. Hour Angles between +12h to 24h refer to the E half of the sky. Which is best? The smaller (in absolute value) is preferred.