How to predict the meridian passage time of a star.

This is not an exercise we need in routine cel nav, but it has come up in a discussion group, so we will outline the procedure. There are various levels of the solution, depending on the accuracy needed. We will use as an example, the problem of finding the meridian passage of Deneb on July 1, 2010 at Lon 0°.... this was the requested location, though the procedure does not differ for other longitudes, as we will show.

First, to get a quick estimate that might be used for example, just to guess when the star will be visible (without other aids such as the star finder), we can just look at what is called the "Planet Diagram" in the Nautical Almanac (NA). First we have to look up the SHA of Deneb, which we get from the daily pages for July1, 2010. This will not vary much over the year (s) but still should be checked and the best used. In this case it is SHA Deneb = 49° 32.6' This number tells you the longitude of the star on a star globe, measured west from Aries, 0 to 360 around the globe.

Then take a look at the Planet Diagram and find the date and SHA range you care about, as shown in fig 2. You can see by interpolation that the answer you want is just past 02h GMT, but this is a crude solution.

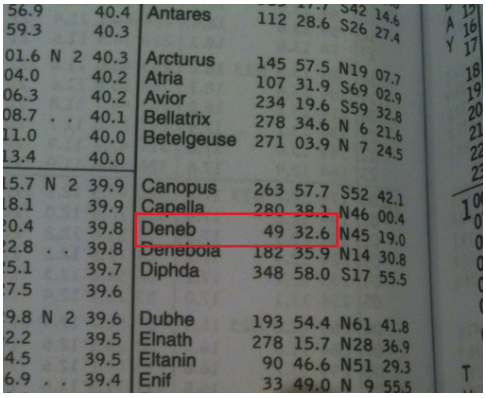

Fig 1. Daily page of NA for July 1, 2010

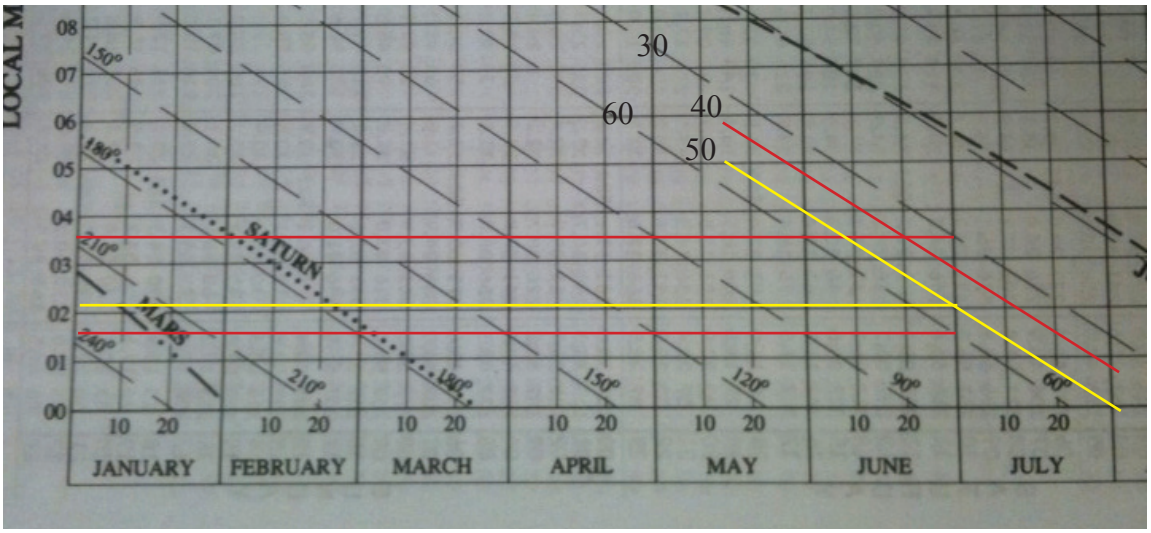

Fig 2. Section of the Planet Diagram from NA 2010, showing that SHA of about 50 crosses the meridian at just past 02 hr GMT

To improve on this solution, look to the bottom left of the daily pages and you will find the mer pass time of Aries. This too is not used often if at all in routing cel nav, but can be used to set up some star finders and related tasks. This is shown for date in question in Fig 3. Keep in mind then that Deneb is west of Aries by 49° 32.6', which we can convert from arc to time (using the standard arc to time table from the almanac based on 15°/hr rotation) to learn that Deneb will cross the greenwich meridian 3h 18m 10s before Aries will, and so we get our second improved estimate of the mer pass time of Deneb to be 5h 23m 18s - 3h 18m 10s = 02h 05m 8s as an improved estimate of the time. Note this is consistent with our first crude estimate.

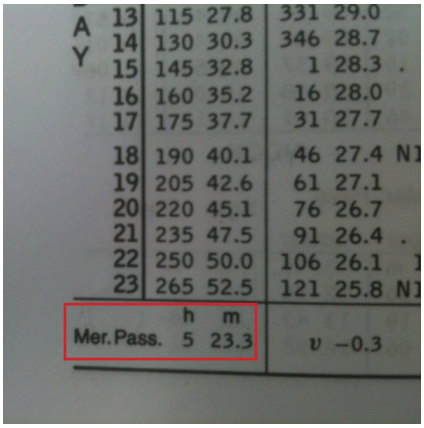

Fig 3. Bottom left corner of Daily page of NA for July 1, 2010, showing the mer pass time of Aries = 05h 23.3m GMT = 05h 23m 18s GMT.

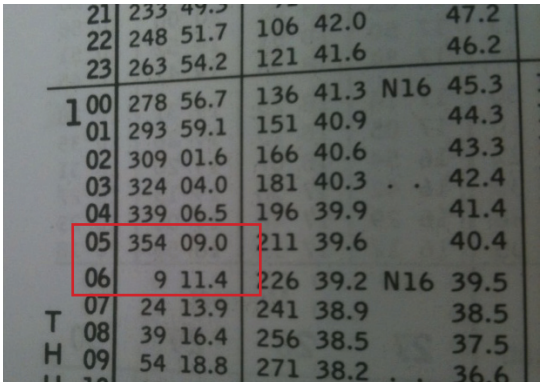

Fig 4. Daily page of NA for July 1, 2010, showing Aries crossing the Greenwich meridian between 05h and o6h.

But there are still ways to improve this. First the estimate they give as 23.3 m can be improved by doing the interpolation yourself. See Fig4 for the data that spans GHA Aries crossing the Greenwich Meridian. If you interpolate this numerically you find that the answer is not 23.3m but 23.338m, which means the mer pass time should be 5h 23m 20.2 s, which shifts the result by 2 seconds, to get 02 05 10.

But this is still not right. If you look up the GHA of Deneb at 02h 05m 10s you will find the answer is 359° 51.9', which means Deneb has not quite reached the meridian yet. When it crosses 0° 0' then that is what the GHA will be.

To get the right answer we have to make another correction that we do not have to make when computing the same mer pass time of the sun because we keep time by the sun and not by the stars.

The earth circles the sun 360° in about 365 days, which means it moves relative to the stars at the rate of 360/365 = 0.0411° per hr, which is about 2.5' per hour (the value adopted by the almanac). If we could see the stars behind the sun, we would see that every hour the sun moves eastward through the stars by 2.5'. Another way to think of that is every hour the GP of the sun moves west across the globe at a rate of 15° per hour, but every star moves a bit faster at 15.0417° per hour.

Since the stars are moving faster, our estimate using the sun rate will be too slow. The time we just predicted 02h 05m 10s assumes the assumed the GP of Deneb was moving at 15°/hr, so we converted the SHA to time and got 02 05 10 for the mer pass time, but if we do it right and use 15.0417° per hour we will get

Mer pass time of Deneb on Lon 0° 0' on July 1, 2010 = 02h 05m 43s UTC.

There is a 33s correction, which is just (2.5' /hr) x (3h 18m 10s) x (60s/15')

Celestial Navigation Data for 2010 Jul 1 at 2:05:43 UT

For Assumed Position: Latitude 0 00.0
Longitude 0 00.0

Object	Almanac Data GHA	Dec	Hc	Zn	Altitude Corrections Refr	SD	PA	Sum
	° '	° '	° '	°	'	'	'	'
MOON	339 20.4	S 7 35.7	+68 02.7	110.7	-0.4	15.0	20.5	35.1
JUPITER	307 34.0	S 0 08.7	+37 34.0	90.2	-1.3	0.3	0.0	-0.9
ACHERNAR	285 56.0	S57 10.6	+ 8 33.4	148.2	-6.2	0.0	0.0	-6.2
AL NA'IR	338 13.6	S46 54.3	+39 22.8	160.9	-1.2	0.0	0.0	-1.2
ALPHECCA	76 40.1	N26 40.8	+11 53.4	297.3	-4.5	0.0	0.0	-4.5
ALPHERAT	308 13.3	N29 08.9	+32 42.5	54.6	-1.5	0.0	0.0	-1.5
ALTAIR	12 37.6	N 8 53.8	+74 35.7	305.6	-0.3	0.0	0.0	-0.3
ANKAA	303 45.3	S42 14.6	+24 17.3	137.5	-2.2	0.0	0.0	-2.2
ANTARES	62 56.1	S26 27.4	+24 02.3	240.8	-2.2	0.0	0.0	-2.2
ATRIA	57 59.4	S69 02.9	+10 55.5	198.0	-4.9	0.0	0.0	-4.9
DENEB	0 00.2	N45 19.0	+44 41.0	360.0	-1.0	0.0	0.0	-1.0
DIPHDA	299 25.6	S17 55.5	+27 52.2	110.4	-1.9	0.0	0.0	-1.9
ELTANIN	41 14.2	N51 29.3	+27 55.2	332.3	-1.9	0.0	0.0	-1.9
ENIF	344 16.6	N 9 55.5	+71 28.4	57.2	-0.3	0.0	0.0	-0.3
FOMALHAU	325 53.7	S29 33.7	+46 04.4	135.3	-1.0	0.0	0.0	-1.0

To check your answer in exercises like this, use the USNO AA page (www.usno.navy.mil/USNO/astronomical-applications/data-services/cel-nav-data), which will give data like that shown above.

Again, we must stress that even though we can make such predictions, there is no virtue in doing so. They are not needed in any aspect of modern cel nav, which accounts for why we need to make special corrections rather than standard ones using given tables.

Instead, if you do happen to measure the mer pas time of a star and want to get your longitude from it, just look up the GHA of the star at that time and that is your longitude. It will take just a minute or two of work.