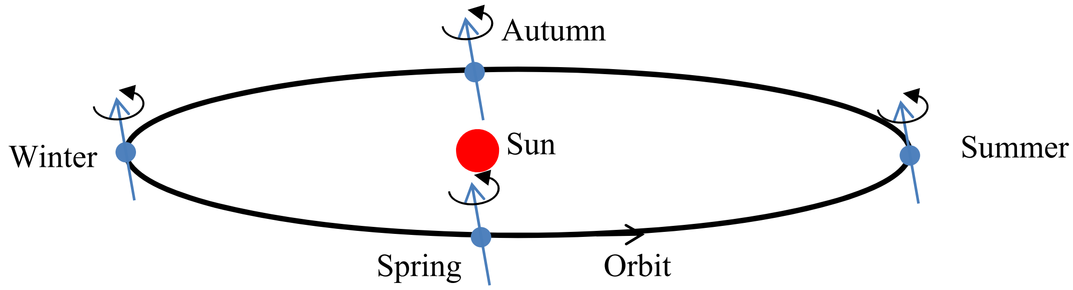
The visibility of constellations

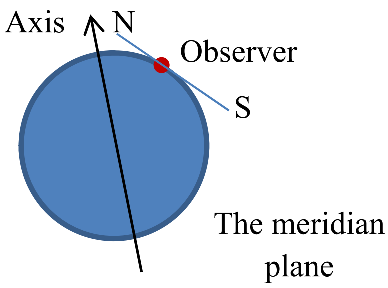
Introduction

To see what's going on think of the huge celestial sphere, the universe of the stars, within which our tiny Earth is spinning around on its axis and orbiting the Sun. As it orbits over a year its axis remains nearly fixed in space. Looking down on the northern hemisphere from the stars, the Earth is spinning anticlockwise on its axis and moving anticlockwise around the Sun.



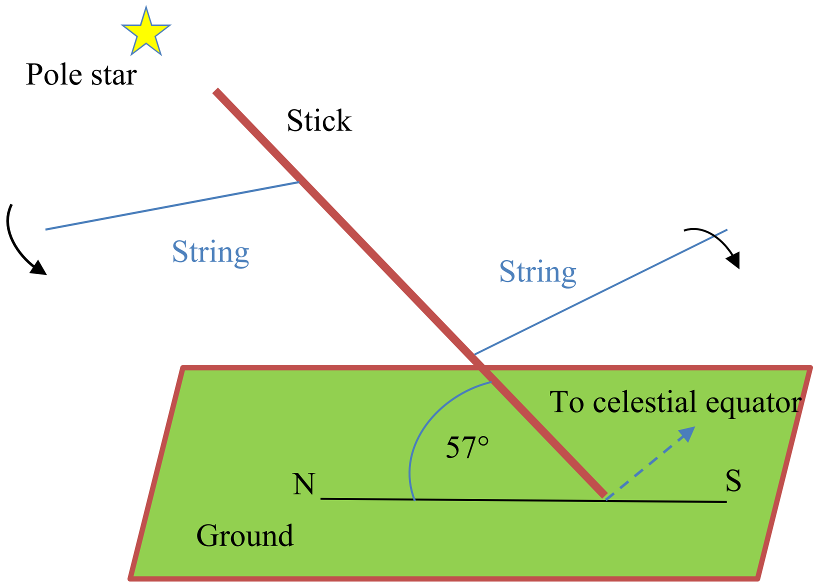
Now imagine yourself standing somewhere in the northern hemisphere. The Earth's rotation on its axis has the effect of making the stars go around in a circle in the sky. Your location and the Earth's axis define a plane (called the meridian plane) that locates South and North directions.

Looking southwards, the stars go around clockwise once a sidereal day, though the centre of the circle of rotation is below the horizon. Looking northwards the stars circle anticlockwise with centre of rotation near the Pole star. OK so far? The point to remember is that the meridian plane contains the axis of rotation of the stars as seen from your location. Now for some questions.



How high will a given constellation rise in the sky?

Put a longish straight stick in the ground and point it towards the Pole star. Tie round it a piece of string and stretch this out. Swing the string round the stick keeping it at the same distance. The end of the string is doing in a few seconds what the stars do in a sidereal day. It should be obvious that the end of the string is furthest from the ground when it passes through the meridian plane between North and South.



Likewise any constellation is highest above the horizon when it is in the meridian plane. The same happens every sidereal day, so the constellations rise to the same height every day. Of course a constellation occupies a stretch of sky so there's not one moment when, for example, *Orion* is due south, or *Leo* is due south. The table that will follow just quotes constellation locations to the nearest hour. As an example take our latitude (λ) as 57° N. I've used this in the previous sketch. If the string is stretched out near the top of the stick then it can go around a complete circle without hitting the ground. This represents the orbits of circumpolar stars that are above the horizon all the time. If the string is stretched out much lower down then it can't be turned all around the stick without hitting the ground. This represents constellations that rise somewhere in the East quadrant, get to their greatest height due south and set in the West.

The coordinates of stars and constellations are given by two numbers, the right ascension (RA) and the declination (Dec). The declination is the one of interest just now. It measures how many degrees above the celestial equator the constellation (or a representative point in it) can be found. The celestial equator is the extension of the Earth's equatorial plane. Therefore a line due south but raised up in the air by an angle of (90° - λ) = 33° in our example will point to the celestial equator. **Hopefully it's now obvious that the highest a constellation will rise is above the southern horizon to an angle of (Dec + 90° - λ)**. Declinations south of the equator are denoted by negative numbers so anything with a declination of less than -33° will be invisible to us at any time of the year. Indeed, given that the horizon is always hazy for at least the lowest 5° then in practice one can't see objects in the sky with declinations as far south as (90° - λ). This rules out being able to see at least 39 of the 88 constellations from our location. (51 constellations are flagged in the table to be given later as being in the southern celestial hemisphere, 4 on the equator and the remaining 33 in the northern hemisphere). I've included in the table the heights above the horizon of the constellations for our latitude of 57°.

At what time of the year will a constellation be at its highest at midnight?

We measure time relative to the direction of the Sun. This has two consequences. First, since the direction of the Sun relative to the spin axis of the Earth changes through the year (because of the Earth's orbit around the Sun), the time at which a constellation is highest will change over a year. Secondly, for high latitudes like ours, during the summer it doesn't get astronomically dark (the Sun at least 18° below the horizon) for about 3 months. Constellations that reach their highest point at midnight (local time) near the summer solstice may not be visible in the all-night twilight. This renders a few more constellations invisible from our latitude.

Let's concentrate on the first point. The right ascension is the equivalent coordinate to terrestrial longitude. The zero of right ascension is the celestial longitude line that goes through the 'first point of Aries', marked symbolically ♈. This symbol represents the ram's horns – Aries was a ram – but for good astronomical reasons the first point of Aries is now in the constellation of Pisces. Right ascensions are measured Eastward from this zero and conveniently for us are measured in hours and minutes. The Sun is on this zero line at the spring equinox (about 21st March). Hence at midday on 21st March the Sun is due south. Therefore constellations with RA of 12 hours will be due south at midnight. The table that's to come flags *Corvus* but it has a declination of 20° S and so will be pretty near the horizon haze for us. *Leo* and *Ursa Major* have RA 11 hours and *Canes Venaciti* and *Coma Berenices* RA 13 h. It takes 1 year for the Sun to go around the Earth's axis once (we're looking from the point of view of the Earth) and hence 12 months to cover 24 hours of RA. This is very convenient! 1 hour of right ascension is therefore covered in half a month. *Leo* and *Ursa Major* will have peaked at midnight some 2 weeks earlier (early March) and *Canes Venaciti* and *Coma Berenices* will peak about 2 week's later (early April). From the RAs listed we can now draw up a table of when the constellations will be in the general direction of due south at local midnight. Sagittarius, the constellation containing the galactic centre, has RA of 19 h and decl. 25° S. This not only puts it in the horizon haze at the best of times but means it peaks at midnight at end June/early July, right in the middle of the all-night twilight period. One needs to head south on holiday to get a good view of Sagittarius in the summer. The dates of peak height at midnight don't depend on latitude.

There's one more point worth saying. 'Local midnight' is not clock midnight. I have another note on the relation between astronomical and clock time (see the web page blue panel piece "Midwinter days and other stories"). 'Local midnight' is basically 12 hours after a sundial with its gnomon pointing due south says it's midday. Clock time can differ from this by 'day light saving' in the summer, by an offset of geographical longitude of the observer from the zero of the local time zone and by the 'equation of time'. If this doesn't mean much then don't worry for the constellation right ascensions have only been given to the nearest hour.

The following table shows for all 88 constellations their maximum altitude at latitude 57° N and the month when they are highest at local midnight. From the declinations (Dec) given for each constellation, maximum heights for other locations can be calculated simply, as mentioned in the text. Along with the declination, the right ascension (RA) shows their general location in the sky. See the web for details of the meanings of the names, the shape of the constellation figures, the boundaries of the constellations and interesting stellar features within them. The areas in square degrees shown in the table enable the relative sizes of the constellations to be compared. Greyed out constellations are ones that though technically visible are probably not due to horizon haze or background light.

Constellation	IAU Abbreviation	Area in sq. deg.	RA (h)	Dec (°)	Max height (°) above horizon for latitude 57° N	Month when max height at midnight
Andromeda	And	722.3	1	40	73	Early Oct
Antlia	Ant	238.9	10	-35	Not vis	Mid Feb
Apus	Aps	206.3	16	-75	Not vis	Mid May
Aquarius	Aqr	979.9	23	-15	18	Early Sep
Aquila	Aql	652.5	20	5	38	Mid Jul
Ara	Ara	237.1	17	-55	Not vis	Early Jun
Aries	Ari	441.4	3	20	53	Early Nov
Auriga	Aur	657.4	6	40	73	Mid Dec
Bootes	Boo	906.8	15	30	63	Early May

Caelum	Cae	124.9	5	-40	Not vis	Early Dec
Camelopardus	Cam	756.8	6	-70	Not vis	Mid Dec
Cancer	Cnc	505.9	9	20	53	Early Feb
Canes Venatici	CVn	465.2	13	40	73	Early Apr
Canis Major	CMa	380.1	7	-20	13	Early Jan
Canis Minor	Cmi	183.4	8	5	38	Mid Jan
Capricornus	Cap	413.9	21	-20	13	Early Aug
Carina	Car	494.2	9	-60	Not vis	Early Feb
Cassiopeia	Cas	598.4	1	60	93	Early Oct
Centaurus	Cen	1060.4	13	-50	Not vis	Early Apr
Cepheus	Cep	587.8	22	70	103	Mid Aug
Cetus	Cet	1231.4	2	-10	23	Mid Oct
Chamaeleon	Cha	131.6	11	-80	Not vis	Early Mar
Circinus	Cir	93.4	15	-60	Not vis	Early May
Columba	Col	270.2	6	-35	Not vis	Mid Dec
Coma Berenices	Com	386.5	13	20	53	Early Apr
Corona Austrina	CrA	127.7	19	-40	Not vis	Early Jul
Corona Borealis	CrB	178.7	16	30	63	Mid May
Corvus	Crv	183.8	12	-20	13	Mid Mar
Crater	Crt	282.4	11	-15	18	Early Mar
Crux	Cru	68.4	12	-60	Not vis	Mid Mar
Cygnus	Cyg	804	21	40	73	Early Aug
Delphinus	Del	188.5	21	10	43	Early Aug
Dorado	Dor	179.2	5	-65	Not vis	Early Dec
Draco	Dra	1083	17	65	98	Early Jun
Equuleus	Equ	71.6	21	10	43	Early Aug
Eridanus	Eri	1137.9	3	-20	13	Early Nov
Fornax	For	397.5	3	-30	3	Early Nov
Gemini	Gem	513.8	7	20	53	Early Jan
Grus	Gru	365.5	22	-45	Not vis	Mid Aug
Hercules	Her	1225.1	17	30	63	Early Jun
Horologium	Hor	248.9	3	-60	Not vis	Early Nov
Hydra	Hya	1302.8	10	-20	13	Mid Feb
Hydrus	Hyi	243	2	-75	Not vis	Mid Oct
Indus	Ind	294	21	-55	Not vis	Early Aug
Lacerta	Lac	200.7	22	45	78	Mid Aug
Leo	Leo	947	11	15	48	Early Mar
Leo Minor	LMi	232	10	35	68	Mid Feb
Lepus	Lep	290.3	6	-20	13	Mid Dec
Libra	Lib	538.1	15	-15	18	Early May
Lupus	Lup	333.7	15	-45	Not vis	Early May
Lynx	Lyn	545.4	8	45	78	Mid Jan
Lyra	Lyr	286.5	19	40	73	Early Jul
Mensa	Men	153.5	5	-80	Not vis	Early Dec
Microscopium	Mic	209.5	21	-35	Not vis	Early Aug
Monoceros	Mon	481.6	7	-5	28	Early Jan

Musca	Mus	138.4	12	-70	Not vis	Mid Mar
Norma	Nor	165.3	16	-50	Not vis	Mid May
Octans	Oct	291	22	-85	Not vis	Mid Aug
Ophiuchus	Oph	948.3	17	0	33	Early Jun
Orion	Ori	594.1	5	5	38	Early Dec
Pavo	Pav	377.7	20	-65	Not vis	Mid Jul
Pegasus	Peg	1120.8	22	20	53	Mid Aug
Perseus	Per	615	3	45	78	Early Nov
Phoenix	Phe	469.3	1	-50	Not vis	Early Oct
Pictor	Pic	246.7	6	-55	Not vis	Mid Dec
Pices	Psc	889.4	1	15	48	Early Oct
Piscis Austrinus	PsA	245.4	22	-30	3	Mid Aug
Puppis	Pup	673.4	8	-40	Not vis	Mid Jan
Pyxis (=Malus)	Pyx	220.8	9	-30	3	Early Feb
Reticulum	Ret	113.9	4	-60	Not vis	Mid Nov
Sagitta	Sge	79.9	20	10	43	Mid Jul
Sagittarius	Sgr	867.4	19	-25	8	Early Jul
Scorpius	Sco	496.8	17	-40	Not vis	Early Jun
Sculptor	Scl	474.8	0	-30	3	Mid Sep
Scutum	Sct	109.1	19	-10	23	Early Jul
Serpens (Cap. and Caud.)	Ser	636.9	17	0	33	Early Jun
Sextans	Sex	313.5	10	0	33	Mid Feb
Taurus	Tau	797.2	4	15	48	Mid Nov
Telescopium	Tel	251.5	19	-50	Not vis	Early Jul
Triangulum	Tri	131.8	2	30	63	Mid Oct
Triangulum Australe	TrA	110	16	-65	Not vis	Mid May
Tucana	Tuc	294.6	0	-65	Not vis	Mid Sep
Ursa Major	UMa	1279.7	11	50	83	Early Mar
Ursa Minor	UMi	255.9	15	70	103	Early May
Vela	Vel	499.6	9	-50	Not vis	Early Feb
Virgo	Vir	1294.4	13	0	33	Early Apr
Volans	Vol	141.4	8	-70	Not vis	Mid Jan
Vulpecula	Vul	268.2	20	25	58	Mid Jul

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