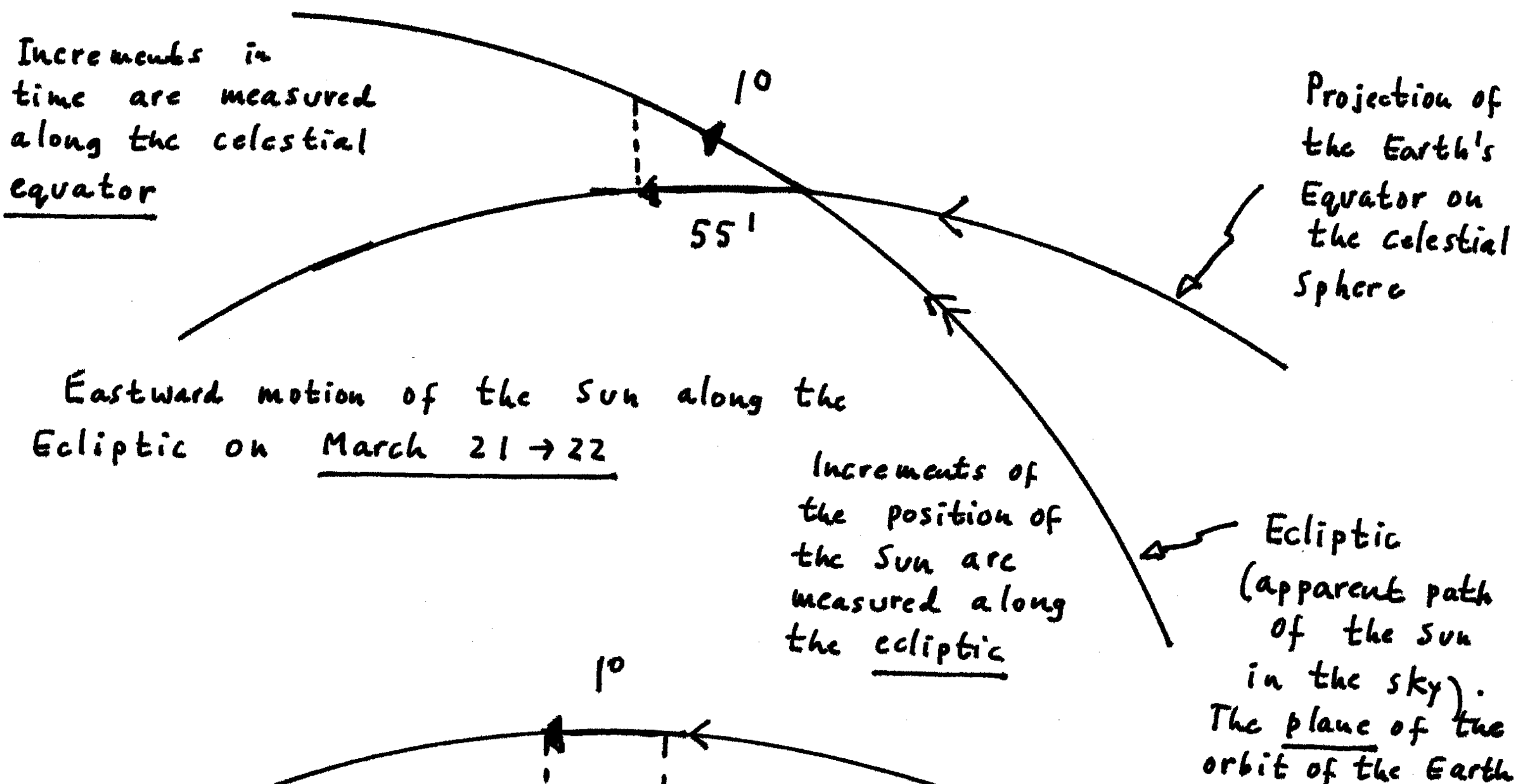
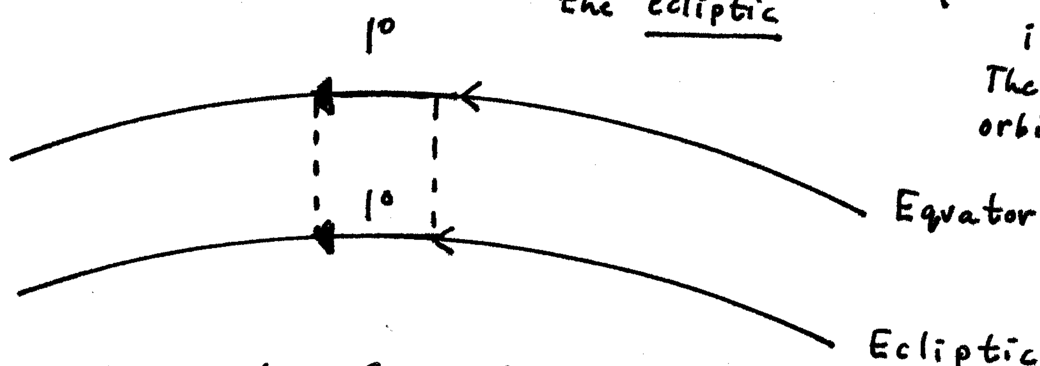
The Equation of Time

Cause one



Eastward motion of the Sun along the Ecliptic on March 21 → 22



Eastward motion of the Sun along the Ecliptic on June 21 → 22.

On both dates, the Sun is assumed to shift its position 1° along the Ecliptic. On March 21 → 22, the projected shift along the Ecliptic is about 55', while on June 21 → 22 it is 1°. This causes a non-uniformity of the intervals between successive transits of the Sun across the observer's meridian, that is, the time intervals between the Sun reaching its highest point due South.

Cause two

When the Earth is near perihelion, the Sun appears to move Eastward by about 1° 7' per day,

⟶

whereas at aphelion its apparent Eastward motion is about $1^{\circ}\ 3'$ per day. The difference, $4'$, corresponds to about sixteen seconds and causes the apparent solar day to differ by this amount between January and July. It follows that the speed of the Sun against the background stars is variable. So, astronomers use a completely fictitious mean Sun, which is assumed to travel along the celestial equator at a constant rate, completing one circuit in the same time that the real Sun takes to go right round the Ecliptic

The difference between (in position) between the mean Sun and the real Sun causes a difference between apparent Solar time and mean Solar time, the Equation of Time

E.O.T. = apparent Solar time − mean Solar time.

This E.O.T. can rise to as much as sixteen minutes. It is the same for every year; on four dates it becomes zero: April 16, June 15, Sept. 2 and Dec. 26

Minus indicates that the clock is ahead of the Sun eg. − 12 minutes on Jan. 24; plus that it is behind the sun eg. +16 minutes on October 27.

So, the E.O.T. has two components:

(i) the effect of the eccentricity of the orbit of the Earth, cause two (E_1) and

(ii) the effect of the obliquity of the Ecliptic, cause one, (E_2)

$\therefore$ E.O.T. = $E_1 + E_2$ →

J F^2

(a) Between 0 and eighty days after perihelion, E_1 and E_2 reinforce each other. That is, the true Sun is behind the mean Sun.

(b) Between eighty and one hundred and sixty-five days after perihelion, E_1 and E_2 exert opposing effects. That is, the true sun is mainly in advance of the mean Sun.

(c) Between one hundred and seventy days and two hundred and seventy days, E_1 and E_2 still oppose each other.

(d) For the rest of the year, they reinforce each other

The eccentricity of our orbit around the Sun is 0·0167

D.F.

2010, February 8

Calculating the mean density of "our" Galaxy

The total mass of the stars $= 2 \cdot 2 \times 10^{41}$ kg

The volume of the <u>disc</u> = area × thickness

$= \pi r^2 \times$ thickness

$= \pi \times (15\,kpc)^2 \times 1\,kpc$

$= 710\,(kpc)^3$

The volume of the <u>bulge</u>

$= \frac{4}{3}\pi \times (3\,kpc)^3$

$\approx 4 \times 27\,(kpc)^3$

$\approx 108\,(kpc)^3$

⇒ Total volume of the disc + bulge

$= 710\,(kpc)^3 + 108\,(kpc)^3$

$= 818\,(kpc)^3$

Mean density <u>(i)</u>

$$= \frac{2 \cdot 2 \times 10^{41}\,kg}{818\,(kpc)^3}$$

$= 2 \cdot 7 \times 10^{38}\,kg\,(kpc)^{-3}$

Mean density <u>(ii)</u>

$$= \frac{2 \cdot 2 \times 10^{41}\,kg}{818 \times 1000 \times 1000 \times 1000\,(pc)^3}$$

$$= \frac{2 \cdot 2 \times 10^{41}\,kg}{8 \cdot 18 \times 10^{11}\,(pc)^3}$$

$= 0 \cdot 2(7) \times 10^{30}\,kg\,(pc)^{-3}$

$= 2 \cdot 7 \times 10^{29}\,kg\,(pc)^{-3}$ **

JFRF!

Mean density <u>(iii)</u>:

$1\,pc = 31 \times 10^{15}\,m$

$\therefore (1\,pc)^3 = (31 \times 10^{15}\,m)^3$

$\approx 3 \times 10^{49}\,m^3$

∴ mean density <u>(iii)</u>

$$= \frac{2 \cdot 2 \times 10^{41}\,kg}{3 \times 10^{49}\,m^3}$$

$= 7 \cdot 3 \times 10^{-9}\,kg\,m^{-3}$

** $\approx 0 \cdot 14$ Solar masses (pc)

"Our" Galaxy

Mass ~ $1.1 \times 10^{11} M_{\odot}$ = 2.2×10^{41} kg, Thickness = 1000 pc (1 pc = 206000 A.U.)

Diameter ~ 25000 pc, Distance of the Sun from the centre ~ 8200 pc,

Period of revolution of the Sun about the centre = 2.2×10^{8} yr,

Distance of the Sun above the galactic plane = 8 pc, Diameter of the bulge ~ 6 kpc

Problems

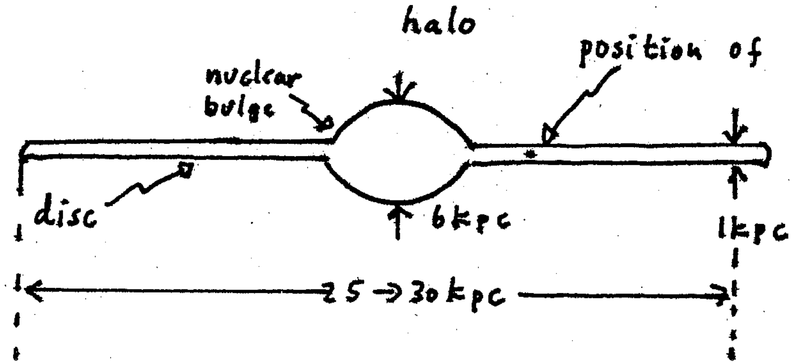
(a) The outer parts of the Milky Way are relatively dim and hard to define.

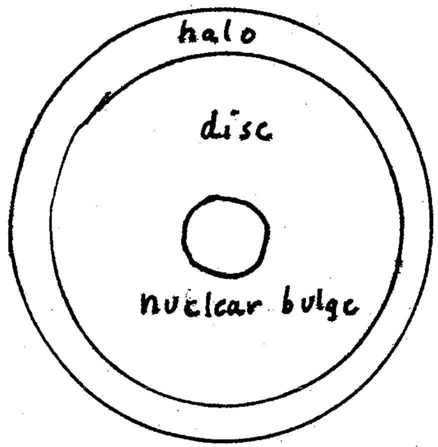
(b) We are located within the disc of the Milky Way.

(c) A good deal is thougut to be made up of so-called dark matter that does not emit light or any other kind of radiation that has yet been detected.

(c) continued. Dark matter is not merely invisible. Thus, whereas "ordinary" matter concists largely of baryons (protons, neutrons and related particles) dark matter is thought to consist, at least in part, of other, more exotic, types of particle.

Gravitational influences suggest that the dark matter associated with the Milky Way is substantial; perhaps ten times greater than the total mass of detectable matter.





The halo and bulge are roughly spherical; sometimes regarded as a single component — the Galactic spheroid.

Is the bulge really a distinct structural component or simply a central

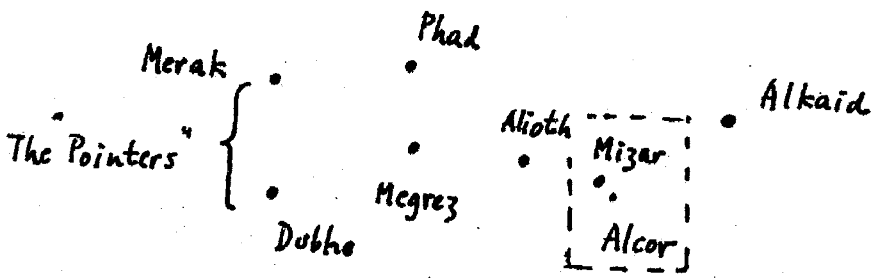
The principal spring constellations

As the days lengthen, the winter constellations make way those of spring.

Looking North

Part of Ursa Majoris

Learn all the names of the stars in the Plough — if you are keen to impress.



• Polaris, m = 2 Forty-ninth brightest star in the sky.

Very luminous ~ 600 $L_\odot$
distance ~ 250 l.y.
} One star in Ursa Minoris (α Ursa Minoris)

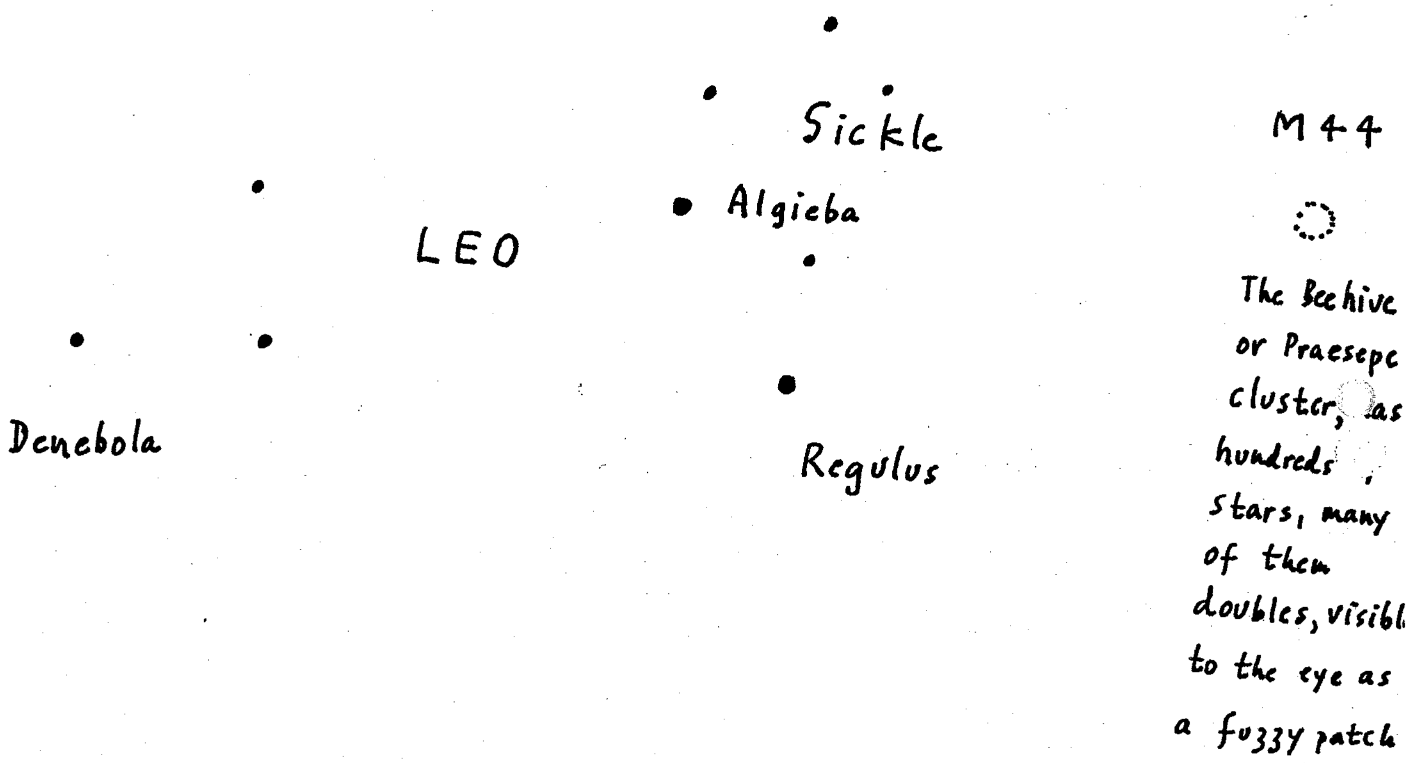
Mizar and Alcor form a famous optical double star in the bend of the handle of the Plough.

Optical aid reveals that Mizar is itself a double star, this time a true binary, with a companion 14" away.

JF²

Originally the beautiful maiden, Callisto, who was changed into a bear by Jupiter in order to escape the evil clutches of her boss, Juno. In Roman times, Juno was head of space, the Universe and everything, but she had a bit of a temper. So, being erudite does not necessarily make you an attractive person.

Looking South



Regulus, at the base of the head, is very close to the ecliptic and, as a result, is one of only four bright stars that can be covered by the Moon and the planets. This is termed an occultation.

The "Sickle" is a group of stars arranged rather in the fashion of a question-mark reflected in a mirror.

Incidentally, it is rare for a planet to occult a star; the Moon occulting a star is a less rare phenomenon.

DF

2009, January 19