ATMOSFERA ZIEMSKA

Skład chemiczny

GAZ	MASA MOL.	% OBJĘT.
N_2	28.01	78.110
O_2	31.999	20.953
A_r	39.942	0.943
H_2O	18.005	0 - 7
CO_2	44.009	0.01 - 0.1
O_3	47.998	0 - 0.01

$dp = -\rho \cdot g \cdot dh$ $\quad$ $p = n \cdot k \cdot T$ $\quad$ $\rho = n \cdot m$

$\frac{dp}{p} = -\frac{mg}{kT} \cdot dh$ $\quad$ $p = p_0 \cdot e^{-h/[kT/mg]}$

$H = kT/mg$ -----skala wysokości

$p = p_0 \cdot e^{-h/[H}$

$H \approx 7 + 1$ km jeśli $h<120$ km

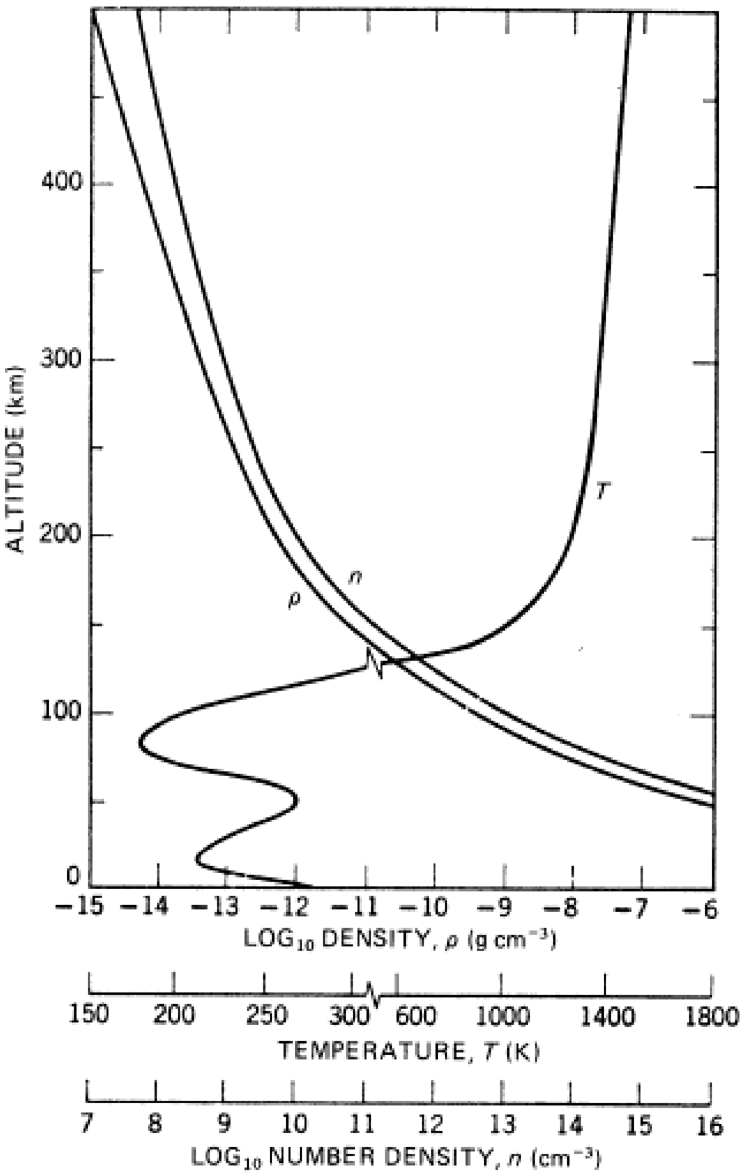
Grubość atmosfery

$n_T = \int_0^{n\infty} n_0 e^{-h/H} dn$ $\quad$ $p = n \cdot k \cdot T$

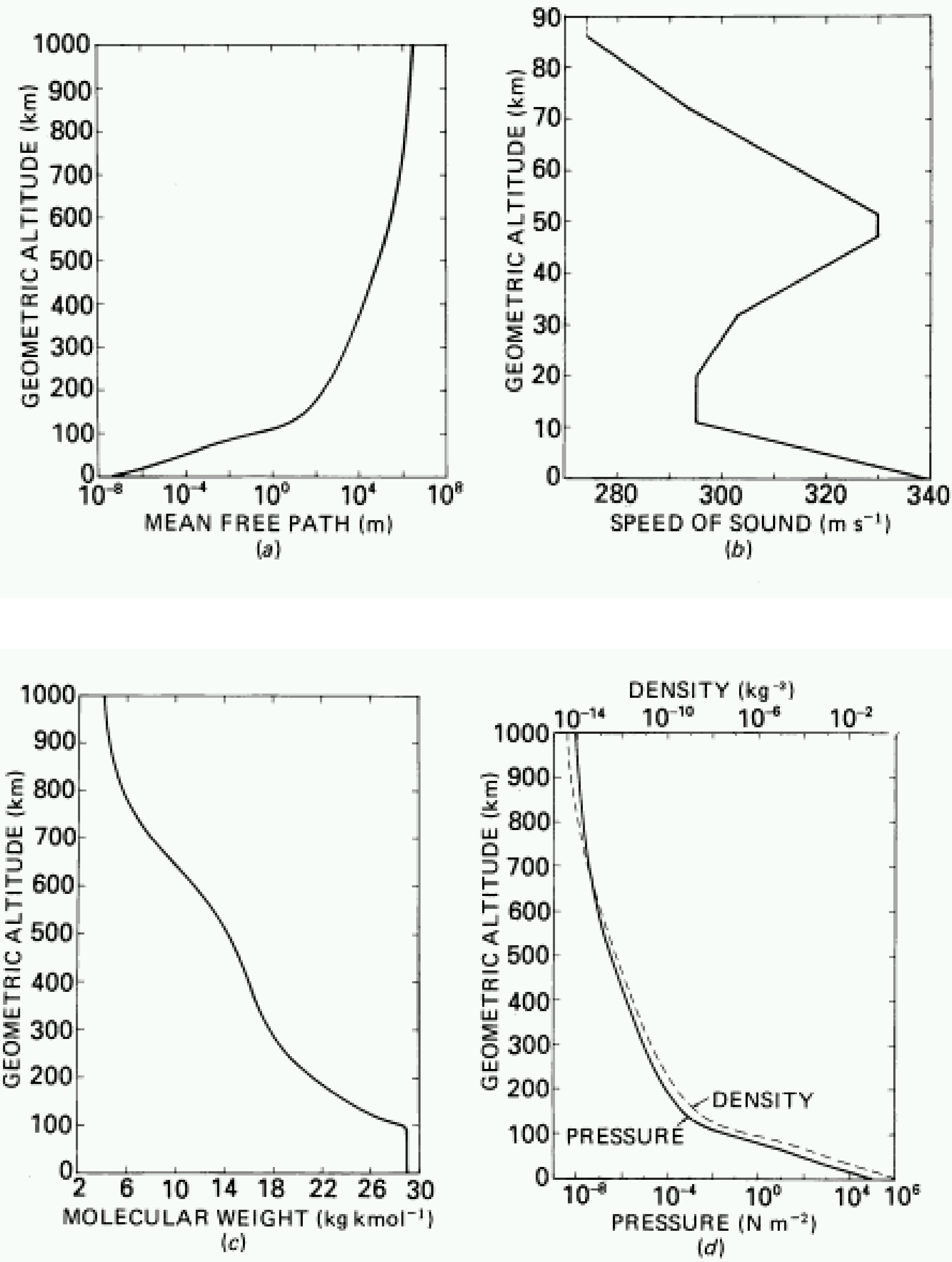
$n_0 = \frac{p_0}{kT}$

$n \cdot T = n_0 \cdot H = \frac{p_0}{kT} \cdot H$

(COSPAR International Reference Atmosphere, 1961.)

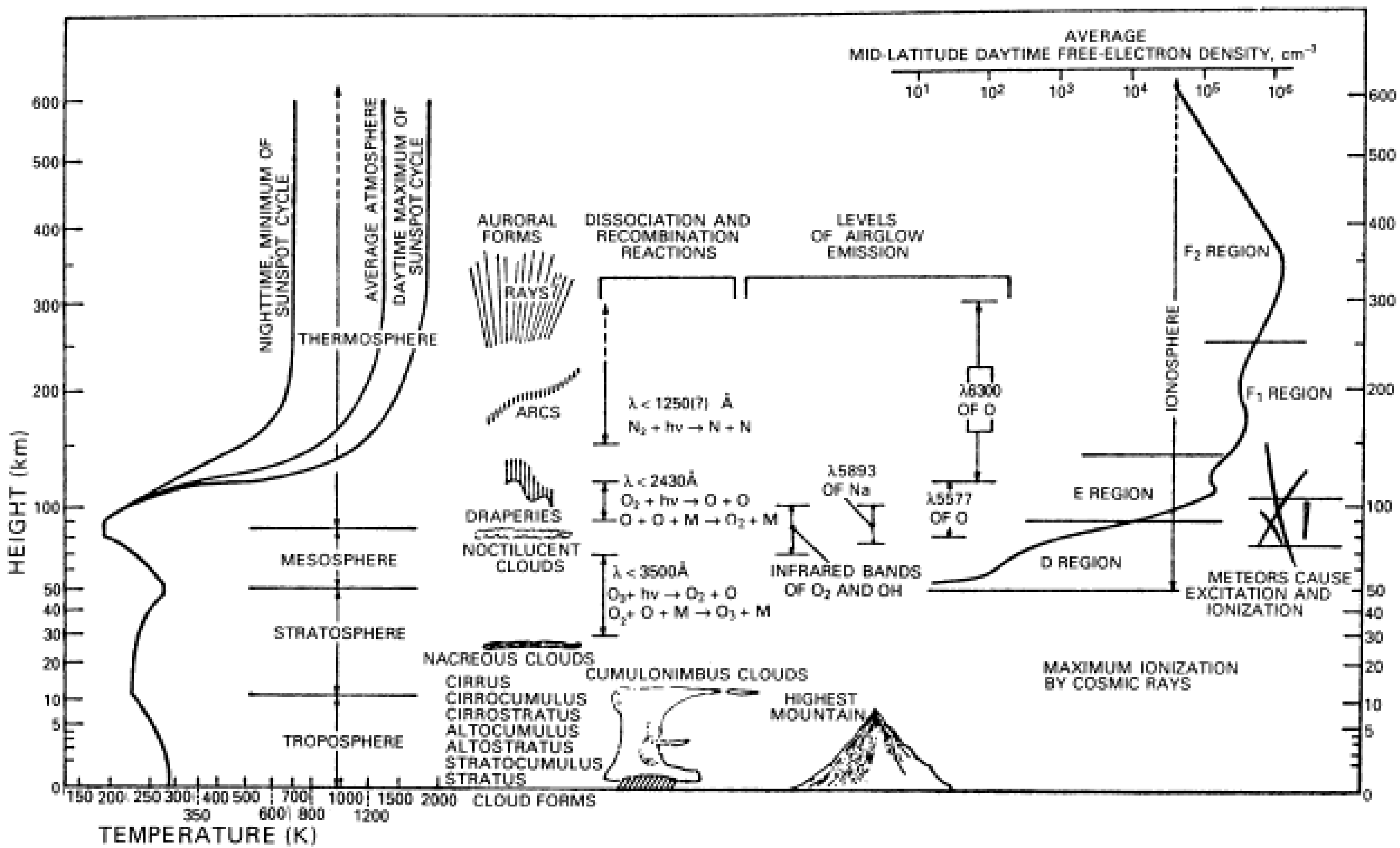


(*a*) Mean free path as a function of geometric altitude. (*b*) Speed of sound as a function of geometric altitude. (*c*) Mean molecular weight as a function of geometric altitude. (*d*) Total pressure and mass density as a function of geometric altitude.



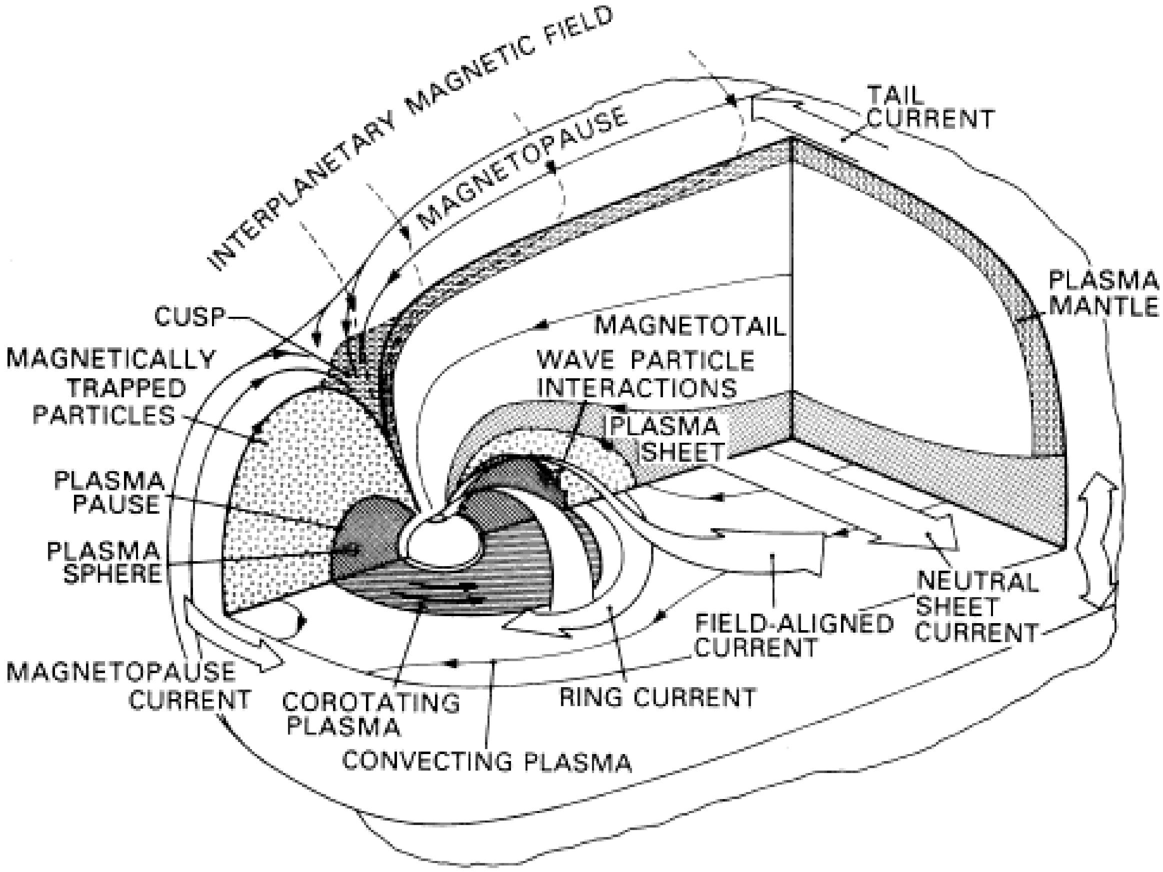
Structure of the upper atmosphere

(Adapted from Harris, M. F. in *American Institute of Physics Handbook*, D. E. Gray, ed., McGraw-Hill Book Company, 1972.)

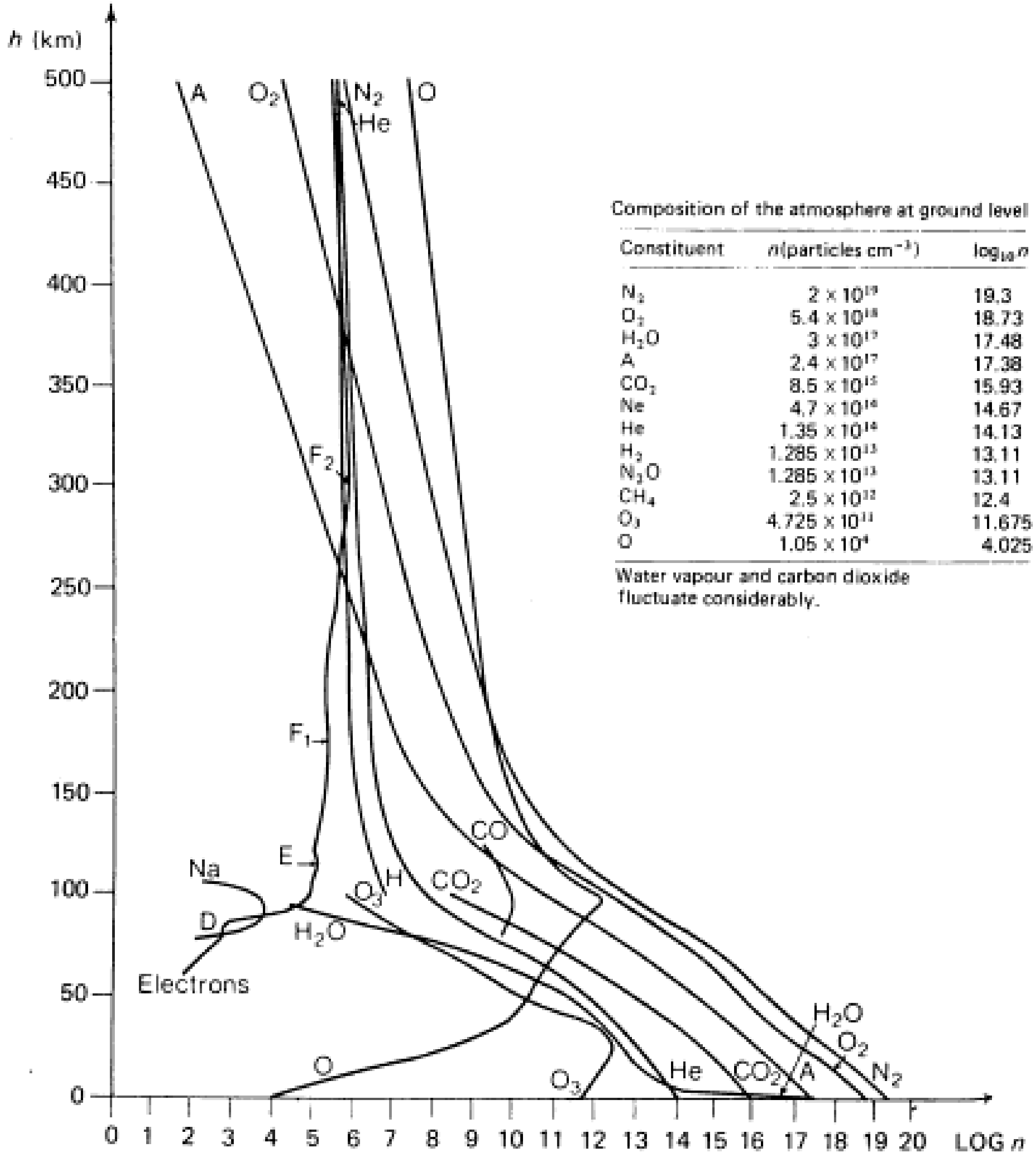


Earth's magnetosphere

Schematic view of the Earth's magnetosphere.



(From NASA)

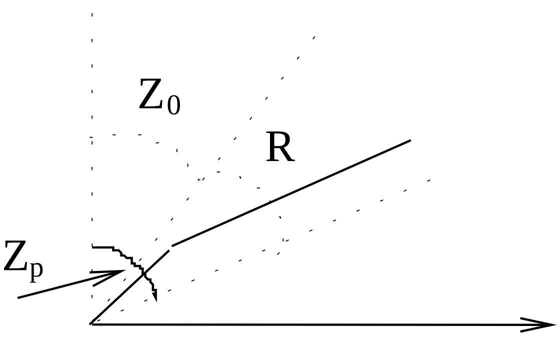


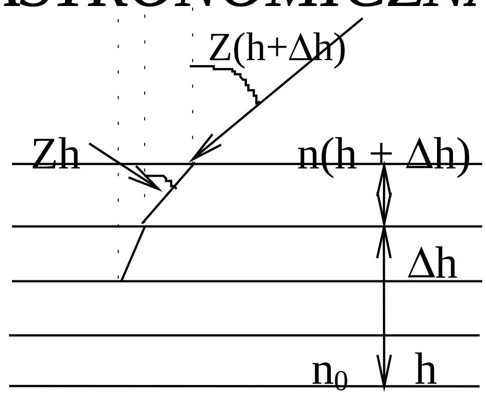
Composition of the atmosphere at ground level

Constituent	n(particles cm^{-3})	$\log_{10} n$
N_2	2×10^{19}	19.3
O_2	5.4×10^{18}	18.73
H_2O	3×10^{17}	17.48
A	2.4×10^{17}	17.38
CO_2	8.5×10^{15}	15.93
Ne	4.7×10^{14}	14.67
He	1.35×10^{14}	14.13
H_2	1.285×10^{13}	13.11
N_2O	1.285×10^{13}	13.11
CH_4	2.5×10^{12}	12.4
O_3	4.725×10^{11}	11.675
O	1.05×10^{4}	4.025

Water vapour and carbon dioxide fluctuate considerably.

REFRAKCJ A ASTRONOMICZNA





$$\frac{\sin Z\,(h+\Delta h)}{\sin Z\,(h)} = \frac{n(h)}{h(h+\Delta h)}$$ dla h

$$\frac{\sin Z\,(h)}{\sin Z\,(h-\Delta h)} = \frac{n\,(h-\Delta h)}{n(h)}$$ dla h - Δh

$$\frac{\sin Z\,(h+\Delta h)}{\sin Z\,(h-\Delta h)\,\frac{n\,(n-\Delta h)}{n(h)}} = \frac{n(h)}{n\,(h+\Delta h)}$$

$$\frac{\sin Z\,(h+\Delta h)}{\sin Z\,(h-\Delta h)} = \frac{n\left(h-\Delta h\right)}{n\,(h+\Delta h)}$$

$Z_0 = Z_p - R$

$Z_p = R + Z_0$

$$\boxed{\frac{\sin Z_p}{\sin Z_0} = n_0}$$

$R = Z_p - Z_0$

$$\frac{\cos R \sin Z_0 + \sin R \cos Z_0}{\sin Z_0} = n_0$$

$1 + R\ \mathrm{ctg} Z_0 = n_0$;

$$\boxed{R\ \mathrm{ctg} Z_0 = n_0 - 1}$$

$$R = (n_0 - 1)\ \mathrm{tg} Z_0$$

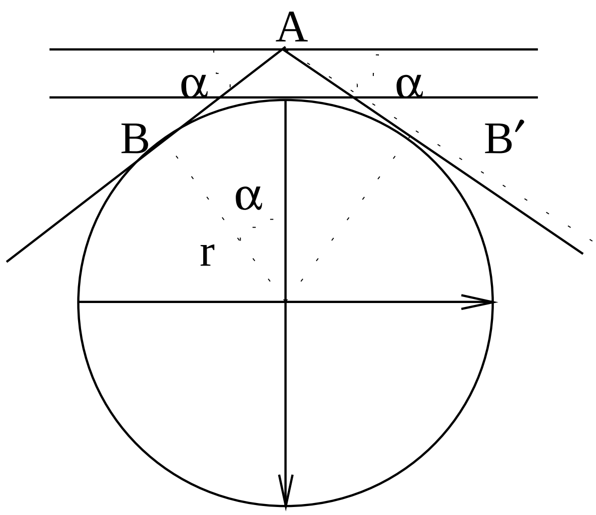
$$R = 206266''\ (n_0 - 1)\ \mathrm{tg} Z_0$$

$$R = 60.25''\frac{b}{760}\left(\frac{273}{273+t}\right) tgZ_0$$

$n = 1 + 2876 \cdot 10^{-4} + 1.624 \cdot 10^{-6}/\lambda^2 + 1.36 \cdot 10^{-8}/\lambda^4$ [λmkm]

ZASIĘG WIDOCZNOŚCI

bez refrakcji



$$a^2 = (r + h)^2 - r^2 =$$
$$r^2 + 2rh + h^2 - r^2$$
$$a^2 = 2rh + h^2 \approx 2rh$$

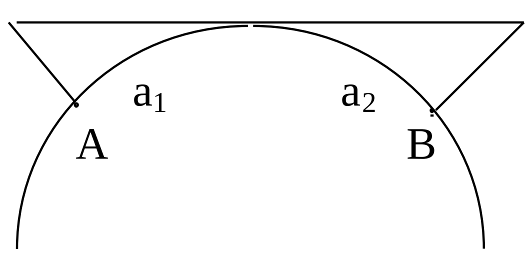
$$a = \sqrt{2r} \cdot \sqrt{h}$$

$$a = 3.6\sqrt{h[m]}\ [km]$$

$$\alpha = \gamma$$

Z UWZGLĘDNIENIEM REFRAKCJI

$$a = 3.9\sqrt{h[m]}\ [km]$$



$$AB = 3.9(\sqrt{h_2[m]} + \sqrt{h_1[m]})\ [km]$$

WSCHODY ZACHODY GWIAZD

$\cos z = \sin\varphi \cdot \sin\delta + \cos\varphi \cdot \cos\delta \cdot \cos t$

dla $z = 90°$ $\qquad \cos z = 0$

$$\cos t = -\frac{\sin\varphi \sin\delta}{\cos\varphi \cos\delta} = -\mathrm{tg}\delta \cdot \mathrm{tg}\varphi$$

$\sin\delta = \sin\varphi \cdot \cos z - \cos\varphi \cdot \sin z \cdot \cos A$

dla $z = 90°$ $\qquad \cos z = 0$ $\qquad \sin z = 1$

$$\cos A = -\frac{\sin\delta}{\cos\varphi}$$

$\delta_{\odot} = -23°27'8''$ $\qquad \approx 23$ XII

$\delta_{\odot} = +23°27'8''$ $\qquad \approx 23$ VI

$\delta_{\odot} = 0$ $\qquad$ 21 III, 22 IX

ŚWITY I ZMIERZCHY

$h_{¤} = -18°$ -świt astronomiczny

$h_{¤} = -12°$ -świt żeglarski

$h_{¤} = -6°$ -świt cywilny

$$\cos t = \frac{\sin h - \sin d \cdot \sin j}{\cos d \cdot \cos j}$$

$$h = h_{¤} - R$$

$$\cos a = \frac{\sin h \cdot \sin j - \sin d}{\cos h \cdot \cos j}$$

KOŁO PODBIEGUNOWE

BIAŁE NOCE

DNIE I NOCE POLARNE

$\varphi - 90° + \delta_{¤} > -0°51'$ $90° - \varphi + \delta_{¤} < 0°51'$

CZAS W ASTRONOMII

Czas gwiazdowy

$$S = t_r$$

$$S = \alpha + t$$

Czas rzeczywisty słoneczny

$$T_{\text{¤}} = 12^h + t_{\text{¤}}$$

Czas średni słoneczny

$$T_m = t_m + 12^h$$

Równanie czasu

$$\eta = T_m - T_{\text{¤}} \approx t_m - t_{\text{¤}} = \alpha_{\text{¤}} - \alpha_m$$

$$T_m = T_{\text{¤}} + \eta$$

365.2422 średnia doba słoneczna = 366.2422 średniej doby gwiazdowej

1 dob. gw. = K· śred.dob.słon.

K = 1.002734

1dob.słon. = K′·1 dob.gw.

K′ = 0.997270

$$\Delta S = K \cdot \Delta T_m$$

$$\Delta T_m = K' \cdot \Delta S$$

$$S = S_0 + T_m \cdot K$$

$$S = S_0 - \frac{l}{24^h} \cdot 3^m \cdot 56^s.55$$

Time

The *Julian date* (*JD*) corresponding to any instant is the interval in *mean solar days* since 4713 BC January 1 at Greenwich mean noon (1200 UT). (Midnight, January 1, 1961 = 0000 UT January 1, 1961 = JD 2,437,300.5.)

A procedure (from Fliegel, H. F. & van Flandern, T. C., *Comm. ACM*, **11**, 657, 1968) for finding the Julian date (*JD*) for a given year (*I*), month (*J*), and day of the month (*K*) is given by the following FORTRAN (integer) arithmetic statement:

$$\begin{aligned} JD = K - 32\,075 + 1461*(I + 4800 + (J - 14)/12)/4 \\ + 367*(J - 2 - (J - 14)/12*12)/12 \\ - 3*((I + 4900 + (J - 14)/12)/100)/4. \end{aligned}$$

For example, December 25, 1981 ($I = 1981$, $J = 12$, $K = 25$) = *JD* 2,444,964.

One *Besselian year* is the period of a complete circuit of the mean Sun in right ascension beginning at the instant when its right ascension is $18^{h}\,40^{m}$. The epochs to which stellar coordinates are referred are in Besselian year numbers. (The epoch 1950.0 started December 31, 1949 at 2209 UT.)

A *mean sidereal day* is the interval between two successive upper culminations or transits of the vernal equinox.

The *civil* or *mean solar day* is $\frac{1}{365.2422}$ of a *tropical year*, the interval between two successive passages of the Sun through the vernal equinox.

Sidereal time is the hour angle of the vernal equinox.

Apparent solar time is the local hour angle of the Sun, expressed in hours, plus 12 hours.

Mean solar time is the local hour angle, plus 12 hours, of a fictitious *mean sun* which moves along the equator at a constant rate equal to the average annual rate of the Sun.

Mean solar time at 0° longitude is called *universal time* (*UT*, formerly *Greenwich mean time* or GMT).

Ephemeris time (*ET*) is based on the time interval of a *tropical year*. 1 *ephemeris second is* $\frac{1}{31\,556\,925.9747}$ of the tropical year 1900.

$$ET = UT + \Delta T \quad (\Delta T = +52.5\text{ s, January 1, 1982}).$$

International atomic time = $ET - 32.18\ s$.

In 1981:

$$\begin{aligned} 1 \text{ mean solar day} &= 1.002\,737\,909\,31 \quad \text{mean sidereal days} \\ &= 24^{h}\,03^{m}\,56^{s}.555\,36 \text{ of mean sidereal time.} \end{aligned}$$

Pacific standard time = *UT* − 8^{h}.
Mountain standard time = *UT* − 7^{h}.
Central standard time = *UT* − 6^{h}.
Eastern standard time = *UT* − 5^{h}.
Colonial standard time = *UT* − 4^{h}.
Western European time = *UT*.
Central European time = *UT* + 1^{h}.
Eastern European time = *UT* + 2^{h}.

Notation for time-scales

A summary of the notation for time-scales and related quantities used in the *Astronomical Almanac* is given below. Additional information is given in the *Supplement* to the *Almanac*.

UT = UT1; universal time; counted from 0^{h} at midnight; unit is mean solar day.
UT0 local approximation to universal time; not corrected for polar motion.
GMST Greenwich mean sidereal time; GHA of mean equinox of date.
GAST Greenwich apparent sidereal time; GHA of true equinox of date.
TAI international atomic time; unit is the SI second.
UTC coordinated universal time; differs from TAI by an integral number of seconds, and is the basis of most radio time signals and legal time systems.
ΔUT = UT − UTC; increment to be applied to UTC to give UT.
DUT = predicted value of ΔUT, rounded to $0^{s}.1$, given in some radio time signals.
ET ephemeris time; was used in dynamical theories and in the Almanac from 1960–83; but is now replaced by TDT and TDB.
TDT terrestrial dynamical time; used as time-scale of ephemerides for observations from the Earth's surface. TDT = TAI + $32^{s}.184$.
TDB barycentric dynamical time; used as time-scale of ephemerides referred to the barycenter of the solar system.
ΔT = ET − UT (prior to 1984); increment to be applied to UT to give ET.
ΔT = TDT − UT (1984 onwards); increment to be applied to UT to give TDT.
ΔT = TAI + $32^{s}.184$ − UT.
ΔAT = TAI − UTC; increment to be applied to UTC to give TAI.
ΔET = ET − UTC; increment to be applied to UTC to give ET.
ΔTT = TDT − UTC; increment to be applied to UTC to give TDT.

For most purposes, ET up to 1983 December 31 and TDT from 1984 January 1 can be regarded as a continuous time-scale. Values of ΔT for the years 1620 onwards are given in the *Astronomical Almanac*.

The name Greenwich mean time (GMT) is not used in astronomy since it is ambiguous and is now used, in the sense of UTC in addition to the earlier sense of UT; prior to 1925 it was reckoned for astronomical purposes from Greenwich mean noon (12^h UT).

Relationships with local time and hour angle

The following general relationships are used:

Local mean solar time	= universal time + east longitude.
Local mean sidereal time	= Greenwich mean sidereal time + east longitude.
Local apparent sidereal time	= local mean sidereal time + equation of equinoxes
	= Greenwich apparent sidereal time + east longitude.
Local hour angle	= local apparent sidereal time − apparent right ascension
	= local mean sidereal time − (apparent right ascension − equation of equinoxes).

A further small correction for the effect of polar motion is required in the production of very precise observations.