Galactic disk

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Louis. Howard

1. Intro. Ch 1
course overview.
student preparation.
stars constellations coordin.

2. telescopes optics light. ch 2 Prob. 2.3, 2.5
appert. synth signal vs ~~noise~~ res

1 wk. 3. Physics Ch 3 class.
~~gravitation~~ newtons laws def of force (3.1)
gravity 3.4
gausses law. (3.5)!
conserv. of energy 3.6
centripetal accel. 3.7.
EM
uncertainty princ.
hydrogen atom line spectra
Pauli excl. Princ.

~~1 wk. 4. Stat mech.~~
special rel.
time dilatation. 3.10
length contraction.
doppler shift. 3.13 *
315 class. mass energy equivalence 3.16

1 wk. end of 3rd full wk. 4. Stat mech.
thermo → entropy.
2^{nd} law increasing entr.
4.1 ! connect. of QM to SM $S = k\ln(\Omega)$ Ω came from QM
4.2 Ideal Gas. waves 4.4 in class.
4.5
4.8 problem handed out in class. evaluate C eq 4.4, 4.5

1½ → 2 wks. 5. **Stars.** Sun. Luminosity. Blackbody. Stellar types

metals vs temp.

5.8, 5.9 in class.

~~hydrostatic equil.~~

5.1

derive wein's law from BB spec.

5.4

5.5

5.11 — mostly from other texts! — hydrostatic equi'l

5.13 — L(r) 5.12 in class.

5.14 — eq. of stellar structure.

2 lect. 6. nuclear energy, nucleosynthesis forces.

6.1 calculation of ε(r).

6.5 PP chain CNO cycle

6.7 Helium burning.

6.10

calculate req. density for triple α.

6.12

fun { 6.13

6.14

white dwarfs neutron stars black holes

1½ wks. 7.

W.D. { 7.1 derive ch. eq. properly.

7.3 Rel. Q.M. S.M.

7.4.

7.6 neutron stars / pulsars.

7.7

Black holes / General Rel ①

7.8

7.9

mid term.

P, T, ρ in electron deg. cases

Theory of stellar properties/evolution HR diagram.

In class Grav energy of Supernova

1 wk (8). Population I/II Stars.

radiation press in $M > 60 M_\odot$ stars

HR diagram show exp. evid.

in class?? $\ast \rightarrow$ $\boxed{8.1}$

8.2 In class.

8.3 red giants

8.4 red super giants

planetary nebula

8.6 Super novae.

8.7.

Helium burning in detail.

need χ sec tables.

$DT \rightarrow {}^4He + n$

$D + p \rightarrow {}^3He$

$D + {}^3He \rightarrow {}^4He + X$

$pp \rightarrow D + e^+ + \nu$

$He + He \rightarrow {}^8Be$

$He + {}^8Be \rightarrow {}^{12}C$

---

1 wk. (9). Observational HR diagram.

stellar types.

distances, magnitudes

9.2

9.3.

star clusters

HR diagrams

moving cluster distance.

9.8 cepheids I/II

← Schw. ? other sources

? 9.9

9.10 Virial thm clusters.

9.12

mainly qualitative.

1 wk. 10. Binary Stars

10.1 in class. $\boxed{\text{orbit prop. masses.}}$ expand

10.1 roche surfaces??

lagrange points,

mass transfer ← yes. wrt xray sources.

10.3 contact binaries

semi detached : mass transfer

10.4 novae

10.5 x ray sources

Algol type.

mass transfer from lighter → heavier

how can lighter be larger more evolved?

ans. was more massive

never see tranf. from more massive to less because too rapid.

accretion disks.

10.6 nova

Entropy.

The second and third laws discuss the concept of entropy or the disorder of a system

$$\Sigma_\alpha \equiv \ln(\Omega_\alpha)$$ where $\Sigma \cdot k = S$

S = entropy
K = boltzmans constant

where Ω_α is the number of ways the state α can be constructed. (The state α being defined as all states in the infintesmal energy range E to E+DE for example.)

One can then show that this quantity has some remarkable properties

$$\frac{1}{\mathcal{T}} \to \frac{1}{kT} = \frac{\partial \Sigma}{\partial U}$$

k = boltzmans Constant.
T = temperature
U = Internal energy of the system.
(a total kinetic energy of the molecules),

this defining a temperature.

~~If~~ assume our ensemble of systems is in thermal contact with an infinite resevoir at temperature T. A way of doing this is to take the macroscopic system divide it up into a large number of subsystems each one still macroscopic. (ex divide the room into 1 cm^3 cubes) Then for any of the subsystems the rest of the system acts as a resevoir. In such a case the probability that a given subsystem will have an energy ε_L will be proportional to the Boltzman factor

$$P(\varepsilon_l) \propto \exp(-\varepsilon_l/KT)$$

Since the sum of all probabilities must be 1,

$$\sum_l P(\varepsilon_l) = 1$$

define

$$Z = \sum_l e^{-\varepsilon_l/KT} \quad \text{the partition function.}$$

$$P(\varepsilon_l) = \frac{e^{-\varepsilon_l/KT}}{Z} = \frac{e^{-\varepsilon_l/\tau}}{Z} \qquad \tau \equiv KT$$

and, the internal energy

$$U = \langle \varepsilon \rangle = \frac{\sum \varepsilon_l e^{-\varepsilon_l/KT}}{Z} = \frac{(\tau)^2}{Z} \frac{\partial Z}{\partial \tau}$$

$$= (\tau)^2 \frac{\partial}{\partial \tau} \ln Z$$

if one considers a piston and conservation of energy if the piston moves an infintesmal amount changing the volume by dV. then the internal ~~engy~~ energy will become

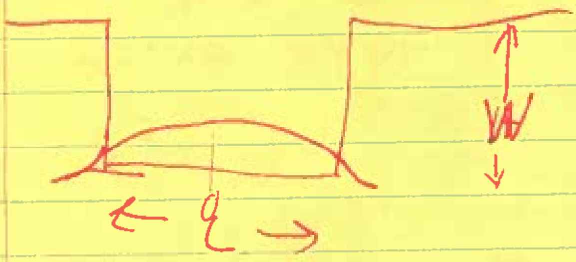
$$U(V_0 + dV) = U_0(V_0) + \left(\frac{\partial U}{\partial V}\right)_{S N} \Delta V$$

where the derivative is taken holding everything else fixed.
(S = entropy, N = number of particles)
The pressure is

$$P = -\left(\frac{\partial U}{\partial V}\right)_S$$

now the

Lowest energy state.



$$\sqrt{E_0 2m}\,\frac{\hbar L}{2} = \cancel{\pi/2} \quad \frac{\pi}{2}(2n+1)$$

$$E_0 = \frac{\pi^2}{\hbar^2 L^2 2m}(2n+1)^2$$

$$E_n = \frac{p_n^2}{2m} + \Theta(x^2 - L^2/4)\,W$$

$$\frac{1}{2m}\left(\frac{-1}{\hbar^2}\right)\frac{\partial^2 \psi}{\partial x^2} + V\psi = E_n\psi \qquad A_1 = ? \quad B_1 = 0$$

X in well ψ_1 $\quad \psi_n = A_n \cos\left(\sqrt{E_n 2m}\, x\hbar\right) + B_n \sin\left(\sqrt{E_n 2m}\,\hbar x\right)$

X out of well.

$\psi_2 \quad \frac{1}{2m}\left(\frac{-1}{\hbar^2}\right)\frac{\partial^2 \psi}{\partial x^2} = (E_n - W)\psi \qquad \psi = A'\exp\left(\overset{>0}{\sqrt{W-E_n}}\, 2m\hbar\right.$

$$\psi_1(L/2) = \psi_2(L/2)$$

$$\psi_1'(L/2) = \psi_2'(L/2)$$

$$A_1 \cos\left(\sqrt{E_n 2m}\,\hbar L/2\right) = A' \exp\left(\sqrt{W-E\,2m}\,\hbar L/2\right)$$

$$\sqrt{2mE_n}\,\hbar A_1 \sin(\quad) = -\sqrt{W-E\,2m}\,\hbar A' \exp(\quad)$$

$$\Rightarrow \sqrt{2mE_n}\,\hbar A_1 \sin = -\sqrt{W-E}\,2m\hbar A_1 \cos(\quad)$$

$$\sqrt{\frac{W-E_n}{E_n}} = \tan\left(\sqrt{2mE_n}\,\hbar L/2\right)$$

$W \to \infty \qquad \tan \to \infty.$

$\cos \to 0$

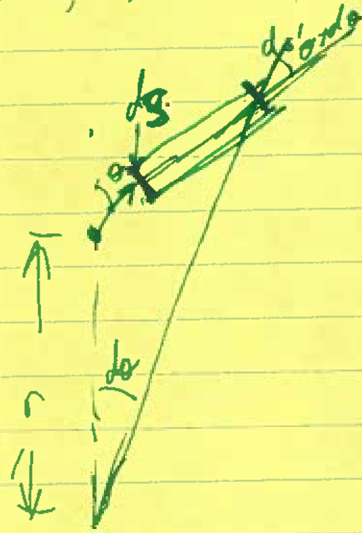
$$2\pi \int_{-1}^{1} 1-x^2 \, dx$$

$$2 - \frac{2}{3} = \frac{4}{3} \, 2\pi \cdot I_1$$

energy transfer

$\underline{I}(r, \theta)$ $\quad$ $I \, d\omega$ = energy flux/cm^2

($d\theta < 0$)



$\frac{\partial I}{\partial \theta} \sin^2\theta\cos\theta \, d\theta \, d\phi$

$\frac{1}{r}\int I \frac{\partial}{\partial \theta} \sin^2\theta\cos\theta \, d\theta$

$\cos^2 - \sin^2$

$\frac{1}{r}\int I \; 2\cos^2 - 1 \; d\theta \, d\phi$

why are sides ignored!
because gains/losses into $d\omega$
centered at ray direction θ!

$$\frac{\partial I}{\partial r}\cos\theta - \frac{\partial I}{\partial \theta}\frac{\sin\theta}{r} + \chi\rho I - \frac{1}{4\pi} j\rho = 0$$

dens. $\quad E = \frac{1}{c}\int I \, d\omega$

flux $\quad H = \int I \cos\theta \, d\omega$

press. $\quad P = \frac{1}{c}\int I \cos^2 d\omega$

$$\frac{\partial}{\partial r}\int I\cos\theta \, d\omega - \frac{\partial}{\partial \theta}\int I \frac{\sin\theta}{r} d\omega + \chi\rho\int I - \frac{1}{4\pi} j\rho \int d\omega = 0$$

$$\frac{\partial H}{\partial r} - \frac{1}{r}\int \frac{\partial I}{\partial \theta} \sin\theta \, d\omega$$

integ by parts

$\downarrow$

$$+ \frac{1}{r}\int I \cos\theta \, d\omega$$

$\cos^2 - \sin^2$

$-(1-\cos^2)$

$$\frac{\partial H}{\partial r} + \frac{H}{r} + c\chi\rho E - j\rho = 0$$

$$\frac{\partial}{\partial r}\int I\cos^2\theta \, d\omega - \frac{1}{r}\int \frac{\partial I}{\partial \theta}\sin\theta\cos\theta \, d\omega + \chi\rho\int I\cos\theta \, d\omega - \frac{1}{4\pi} j\rho \underbrace{\int \cos\theta \, d\omega}_{=0} = 0$$

$$c\frac{\partial}{\partial r}P + \frac{1}{r}\int I \frac{\partial (s\,c)}{\partial \theta} d\omega + \chi\rho H = 0$$

$$\frac{dP}{dr} + \frac{1}{r}(2P - E) + \frac{\chi\rho}{c} H = 0$$

$$\frac{dH}{dr} + \frac{1}{r} H + c\chi\rho E - c\chi\rho a T^4 - \varepsilon\rho = 0$$

$$\frac{1}{4\pi r^2} \frac{dL}{dr} = \varepsilon\rho$$

$$H = \frac{1}{4\pi r^2} L.$$

$$\Rightarrow \frac{dH}{dr} = \frac{1}{4\pi r^2}\frac{dL}{dr} - \frac{1}{2\pi r^3} L \ldots$$

$$= \frac{2H}{r}$$

$$\int \left(-\frac{\partial I}{\partial \theta}\right) \frac{\sin\theta}{r} \, d\omega.$$

$$-\frac{1}{r}\int \frac{\partial I}{\partial \theta} \sin\theta \, d\omega = \frac{-1}{r}\int -\sin\theta \frac{\partial I}{\partial x} \sin\theta \, dx\, d\phi$$

$$= -\frac{1}{r}\int (1-x^2) \frac{\partial I}{\partial x} \, dx\, d\phi$$

$$= \frac{1}{r}\int \frac{\partial}{\partial x}(-1+x^2)\, I \, dx\, d\phi$$

$$\boxed{= \frac{1}{r}\int 2x I \, dx\, d\phi.}$$

$$-\frac{1}{r}\int \frac{\partial I}{\partial \theta} \cos\theta \sin\theta \, d\omega = \frac{1}{r}\int \sin\theta \cos\theta \sin\theta \frac{dI}{dx} \, dx\, d\phi$$

$$= +\frac{1}{r}\int x(1-x^2) \frac{dI}{dx} \, dx\, d\phi$$

$$= -\frac{1}{r}\int \frac{d}{dx}(x-x^3)\, I \, dx\, d\phi \;!$$

AST 3033
D. Levinthal
508 keen
x6760
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text The Physical Universe
F. Shu

recomended: structure and evolution of Stars
M. Schwarschild

Prob.

Ch 1 ~~Constellations~~
overview, consoellations, solarsystem, greek astronomy

Ch 2 light optics telescopes 2.3, 2.5

Ch 3 General Physics 3.4, 3.5, 3.6, 3.7
newtons laws 3.10, 3.13, 3.16
gravity, gauss' law
conservation of energy
centripital acceleration.
Electro Magnetism.
~~theor~~ Quantum Mechanics.
Uncertainty principle
hydrogen atom.
Pauli exclusion principle
Special relativity
time dilatation
length contraction
doppler shift.
mass-energy equivalence

Ch 4. Statistical mechanics. 4.1 4.2 4.5 4.8
thermodynamics, entropy and problem to
Second law. be handed out.
connection of QM to SM
Ideal gas law
Quantum Statistical Mechanics.

Ch 5 Stars 5.1, 5.4, 5.5, 5.11, 5.13 5.14
Sun, Luminosity, Blackbody radiation and problem to be handed
stellar types out.

Stellar structure (schwarzschild)
Hydrostatic equilibrium
radiative transport
convection.

Ch 6 nuclear energy 6.1, 6.5 6.7 6.10 6.12 6.13 6.14
nucleosynthesis
~~protoro~~ proton chain
CNO cycle
Helium burning.
~~Calculation of~~ energy production density of stars

Ch 7 White dwarfs neutron stars black holes
7.1, 7.3 7.4, 7.5 7.7, 7.8, 7.9

Structure of white dwarfs
Chandrasekhar mass limit
neutron stars / pulsars
Black holes / General relativity

Ch 8 Theoretical Hertzsprung-Russell diagram
stellar properties / evolution 8.1 8.3 8.4 8.6 8.
Population I / II stars
HR diagram
radiation pressure in high mass stars
red giants
red super giants
planetary nebula
Super novae

Ch 9 Observational Hertzsprung-Russell diagram

9.2 9.3 9.8 9.9 9.10 9.12

Stellar types
distances - magnitudes.
star clusters
H R diagrams
moving cluster distance
Cepheid variables.
Virial theorem of clusters.

Ch 10 Binary stars. 10.1 10.3 10.4 10.5 10.6

orbit paramaters
stellar masses
roche surfaces
mass transfer
contact binaries
Semi detached binaries
Algol type binaries
accretion disks
nova

recomended: Eddington Internal structure of Stars
Mathematical theory of relativity.
weinberg General relativity.

lecture 1.

1. Background to course Astro 3033
prof. D. Leviuthal
508 keen
x6760 / 1492
text: Physical Universe F Shu, $35.00
University Science Books.
highly recomended: Structure and Evolution of Stars.
M. Schwarschild.
Dover press $6.00

2. Student background.
How many have taken calculus
" 2048
" 2049
" Physics majors.

Pass out syllabus.

Grades. 10% homework.
1 or 2 midterms discuss 25% 25% / ~~35~~%
1 final cumulative 40% / ~~55~~%
solutions to problems will be passed out
ie can't be turned in afterwards
note: most problems are trivial plug ins
don't worry about the quantity.

Shu's book will be direct ordered from publisher
this saves ~$12.00 But. ~~we need~~ money orders
should be sent by mon/tues to get them soon
kay Caudill 302 keen will collect money orders!

Pass out syllabus.

(1). overview

Stars : structure / evolution, galaxies, cosmology

Astronomy : passive experimental science. (for the most part)

Symbols.

x	= position		vector
v	= velocity	$= \frac{dx}{dt} = \dot{x}$	vector
m	= mass		scaler
c	speed of light	$= 3\times10^8$ m/sec.	scaler
F	force		vector
a	acceleration.	$\equiv dv/dt = \dot{v}$	vector
T	= kinetic energy	$= \frac{1}{2}mv^2$	scaler.

V (or U sometimes) Potential Energy $F_x = -\frac{dV}{dx}$

L Lagrangian $T-V$

H hamiltonian = total energy $= T+V$

$\psi(x,t)$ wave function. (psi)

h planks constant.

$\hbar = h/2\pi$

G gravitational constant.

e charge of an electron

r distance between ~~two~~ objects
or radius.

λ wave length.

f or ν (neu) frequency.

$\beta = v/c$

$\gamma = \frac{1}{\sqrt{1-v^2/c^2}} = \frac{1}{\sqrt{1-\beta^2}}$ (gamma)

K used in 2 ways.
K — constant in electrostatic force law
similar to G in concept.
or wave number $1/\lambda$.

$J = mvr$ = angular momentum.

θ angle. theta.

Ch 1.

Coordinates :

①. constellations

brightest to dimmest $\alpha, \beta, \gamma, \delta$

countries / cities

Cellestial sphere   fixed stars.

north } celestial pole   zenith.
South }

meridian ~~sun~~ great circle connecting zenith to poles.

celestial equator.

longitude latitude

right ascension declination

Sun → ecliptic.

zero right ascension intersection of equator / ecliptic.

② Time.

mean solar day.   meridian crossing to meridian crossing.
average over one year

sidereal day   same but with a particular star.
= 23 hr 56 min 4 sec (solar time).

right ascension = sidereal time.

year. : sidereal yr. sun obscures same star.
365.2564 m solar days.

precession of earth axis.
wobbles celestial sphere not ecliptic.

⇒ intersection of ecliptic/celestial eq. moves around 360° every 26,000 yrs

tropical yr. vernal eq. to vernal eq.
365.2422 days

julius ~~Ceese~~ Caeser 365 1/4.

by Pope Gregory $\boxed{XIII}$ 1582.

vernal equinox off by 10 days.
adds 10 day and.
only centuries divisible by 400 leap yrs.
⇒ 1700 1800 1900 not leap years
2000 is.
Gregorian year 365.2425.

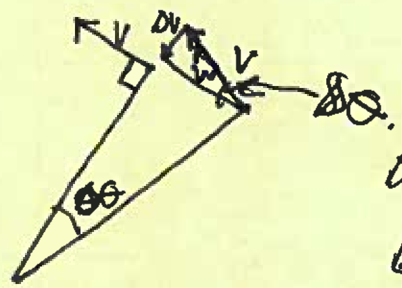
also occaisonal adjustments for wobbles.
ex. 1 extra second was added at end of this last yr 1987

Ch 2.

Newtons laws.

1. principle of inertia concept of mass.
2. $F = ma$ $F = \frac{dP}{dt}.$ $P = mv.$

$a = \frac{dv}{dt} \equiv \dot{v}$



$\Delta v = v\Delta\theta$

$\frac{\Delta v}{\Delta t} = v\frac{\Delta\theta}{\Delta t} \rightarrow v\frac{d\theta}{dt}.$

$v = r\frac{d\theta}{dt} \Rightarrow \frac{v}{r} = \frac{d\theta}{dt}$

centripital acceleration. $\boxed{a = \frac{dv}{dt} = v\frac{d\theta}{dt} = \frac{v^2}{r}}$

light. Electromagnetic wave

Changing electric field cause changing magnetic fie[ld] & vice versa.

(a). Speed of propagation in vaccuum $= C = 3\times10^8$ m/s

(b). wave length.

$f\lambda = c$ $\nu\lambda = c.$

(c) Polarization. transverse wave.

direction of E field $\perp$ to B field $\perp$ to direction of motion.

carries energy.

energy density $= \frac{1}{8\pi}(\bar{E}\cdot\bar{E} + \bar{B}\cdot\bar{B})$

flux. = Poynting's vector

$$f = \frac{c}{4\pi}\left(\bar{E} \times \bar{B}\right)$$

for light $\langle E \rangle_t = \langle B \rangle_t$

$E \perp B$

$$\Rightarrow \frac{c}{4\pi} EB = \frac{c}{8\pi}\left(E^2 + B^2\right) = c \times \text{energy dens.}$$

source are charges ie charged particles

~~force~~ electrons / protons.

$$F_q = q\left(E + \frac{v}{c} \times B\right) \quad \text{Lorentz force.}$$

↑ cross product. right hand rule.

force $\perp$ to v and B.

$\Rightarrow$ particle goes in a circle.

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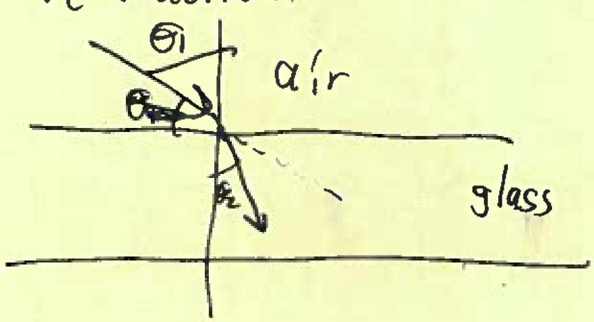
interaction with material (telescopes / spectrum analyzers)

re fraction.



Snells law $\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$

n = index of refraction

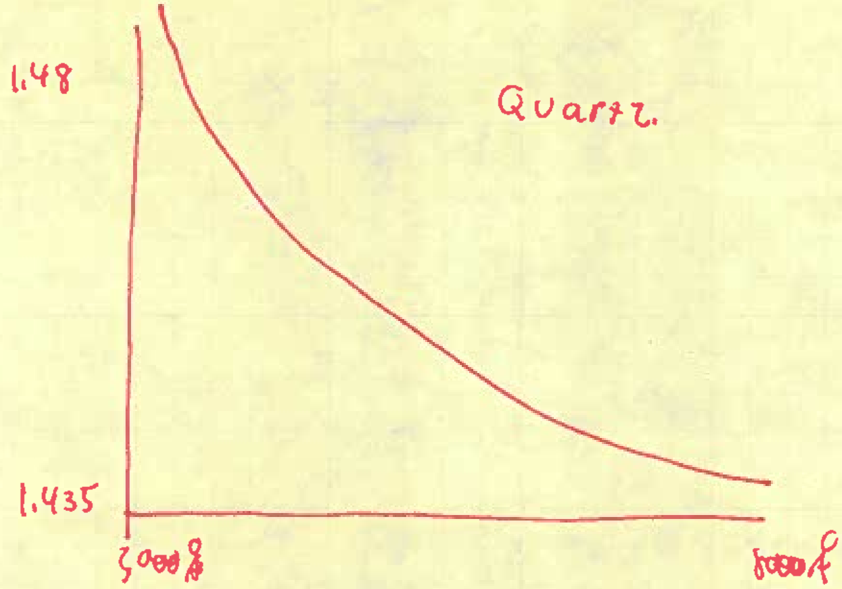
air = vac = 1

water ~~glass~~ ≃ 1.3333

glass 1.5 → 2.

diamond 2.4.

The index of refraction of materials typically depends on wavelength.



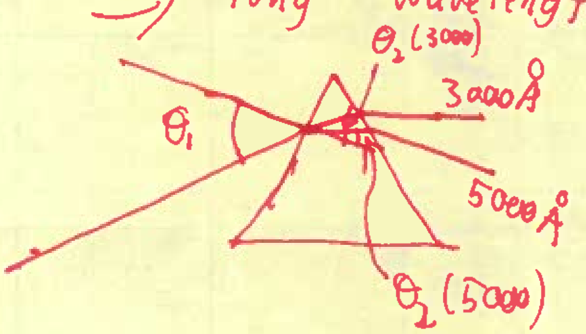
So at the interface of air (= vacuum) (medium 1) and Glass (medium 2)

$$\frac{\sin\theta_1}{\sin\theta_2(\lambda)} = n_2(\lambda)$$

$$\boxed{\text{or} \quad \sin\theta_2(\lambda) = \frac{\sin\theta_1}{n_2(\lambda)}}$$

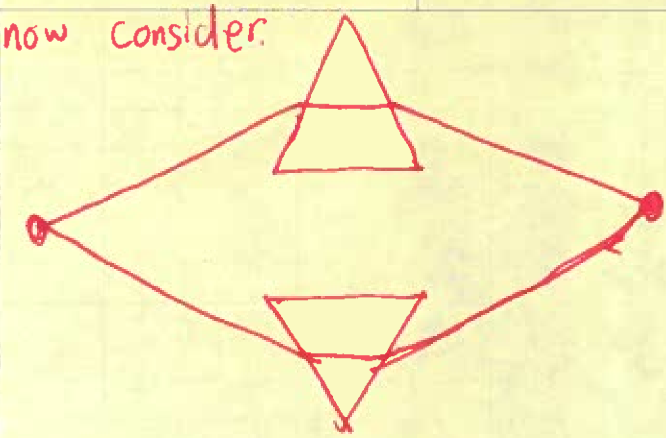
note $n(3000\,\text{Å}) > n(5000\,\text{Å})$

$\Rightarrow$ long wavelengths bend less.

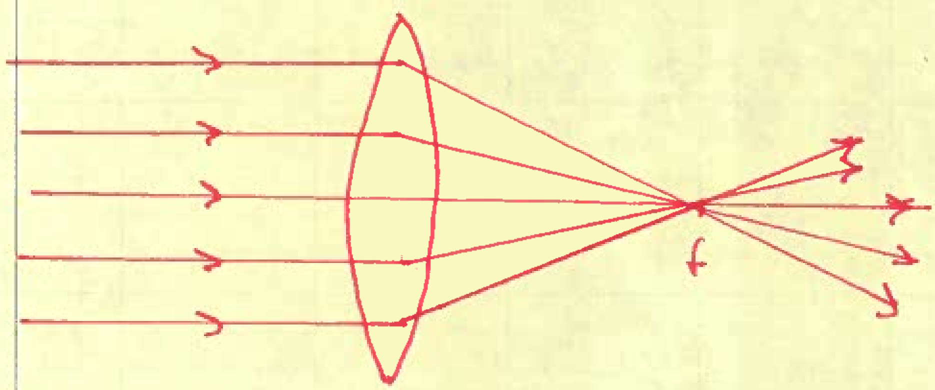


ie refraction can be used to disperse the light spectrum into a rainbow.

now consider.

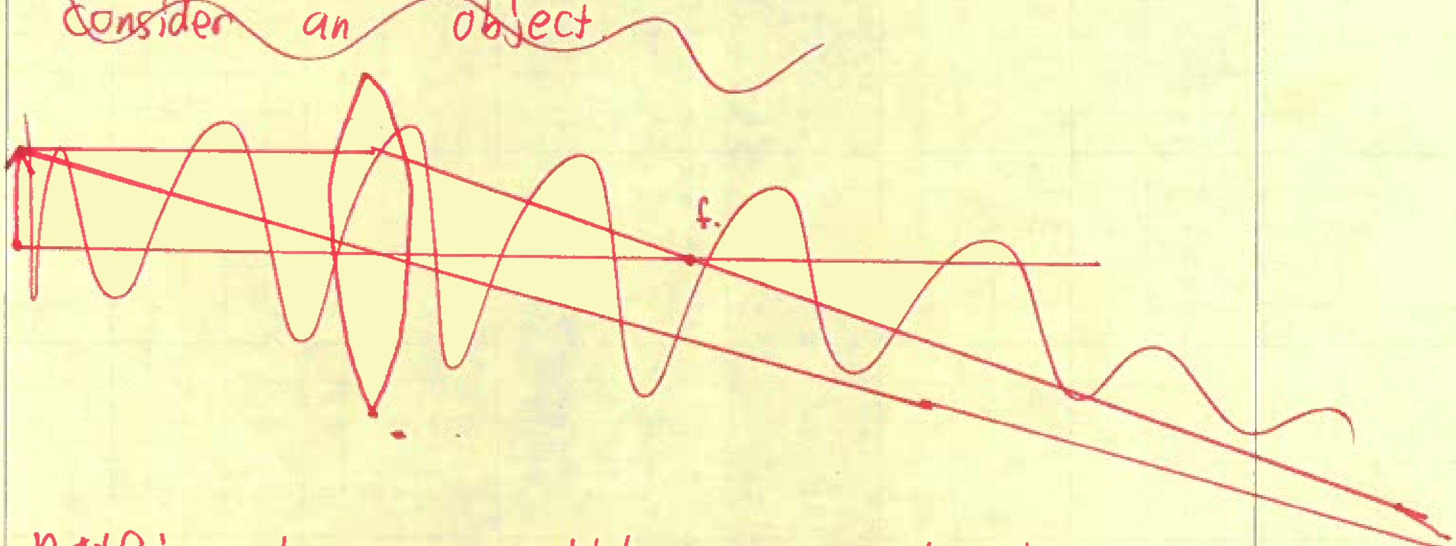


lens. (ray tracing).



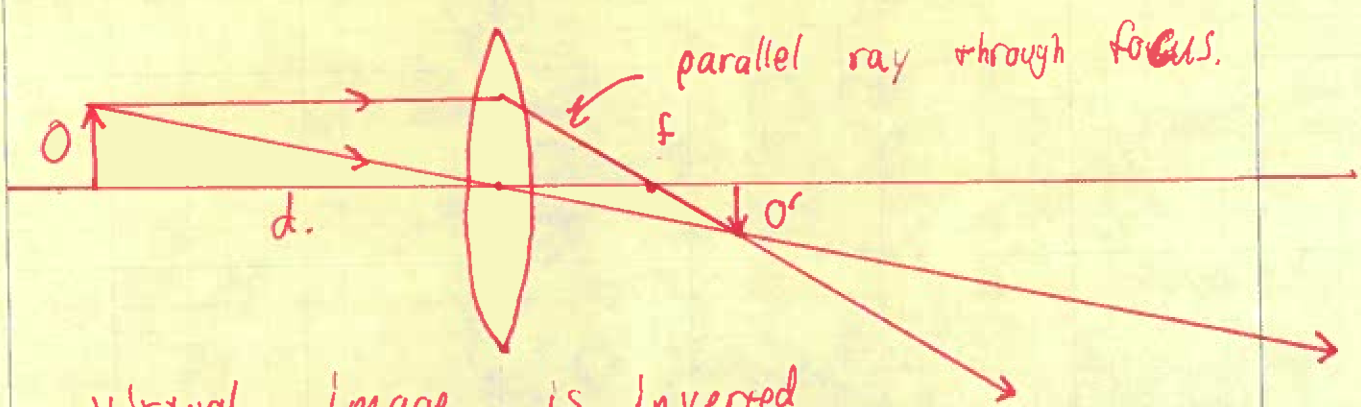
parallel light is all converged on the focus.

consider an object



note: the ray which passes through the center of the lens is undeflected.

$\textcircled{5}$.



virtual image is Inverted

matrix technique of lens systems.

a ray of light is written as a 2 component vector.

$$\begin{pmatrix} x \\ x' \end{pmatrix} \quad \text{where} \quad x' \equiv \frac{dx}{dz} = \text{Slope.}$$

the position of the ray after a distance L is.

$$x(L) = x + x' \cdot L.$$

~~Can be w~~ the slope is still $x' \Rightarrow x'(L) = x'$

this can be written as.

$$\begin{pmatrix} x(L) \\ x'(L) \end{pmatrix} = \begin{pmatrix} 1 & L \\ 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ x' \end{pmatrix}$$

with the matrix being the drift matrix.

the effect of a thin lens is

$$x\,(\text{after lens}) = x\,(\text{before lens})$$ infinitely thin.

$$x'\,(\text{after}) = \frac{x\,(\text{before})}{-f} + x'\,(\text{before})$$

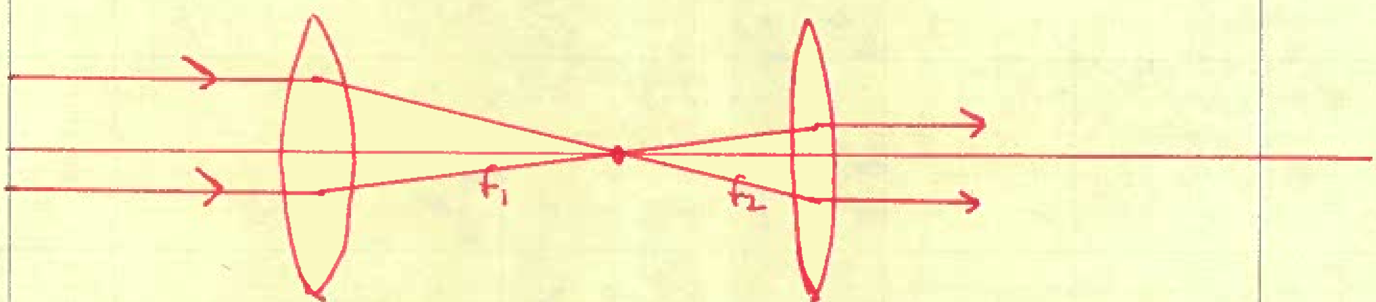
where f is the focal length.

thus, a lens has the effect.

$$\begin{pmatrix} x \\ x' \end{pmatrix}_{after} = \begin{pmatrix} 1 & 0 \\ -\frac{1}{f} & 1 \end{pmatrix} \begin{pmatrix} X \\ X' \end{pmatrix}_{before.}$$

the matrix being the focussing matrix.

consider a compound system



if. $f_1 \gg f_2$ then the parallel light is concentrated ie an infinitely far away object appears brighter to the eye

in matrix notation this would become.

$$\begin{array}{cccc} \text{lens 2} & \text{drift.} & \text{lens 1} & \\ \begin{pmatrix} 1 & 0 \\ -\frac{1}{f_2} & 1 \end{pmatrix} & \begin{pmatrix} 1 & f_1+f_2 \\ 0 & 1 \end{pmatrix} & \begin{pmatrix} 1 & 0 \\ -\frac{1}{f_1} & 1 \end{pmatrix} & \begin{pmatrix} X \\ 0 \end{pmatrix}. \end{array}$$

$$\begin{pmatrix} 1 & 0 \\ -\frac{1}{f_2} & 1 \end{pmatrix} \begin{pmatrix} 1-\left(\frac{f_1+f_2}{f_1}\right) & f_1+f_2 \\ -\frac{1}{f_1} & 1 \end{pmatrix} \begin{pmatrix} X \\ 0 \end{pmatrix}$$

$$\begin{pmatrix} 1-\frac{f_1+f_2}{f_1} & f_1+f_2 \\ \frac{f_1+f_2}{f_1 f_2} - \frac{1}{f_1} - \frac{1}{f_2} & 1-\frac{f_1+f_2}{f_2} \end{pmatrix} \begin{matrix} X \\ 0 \end{matrix}$$

$$\begin{pmatrix} \left(1-\left(\frac{f_1+f_2}{f_1}\right)\right) X \\ 0 \end{pmatrix} = \begin{pmatrix} 1-\frac{f_1+f_2}{f_1} & f_1+f_2 \\ 0 & 1-\frac{f_1+f_2}{f_2} \end{pmatrix} \begin{pmatrix} X \\ 0 \end{pmatrix}$$

The significance of the lower left element being zero is that the outgoing ray's direction is idependent of it's incoming position hence parallel light coming in is parallel light going out though direction may be changed (comment on beam lines / accelerators Quads = lens)

Telescopes can also be made with mirrors like the one we used last night. This is much more common because it is vastly less expensive.

A parabola has the property that it focus' ~~light~~ parallel light at the parabolic focus. This is well illustrated in the book so I won't harp on it. As far as the matrix aproach is concerned mirrors can be treated like lens'. There are a variety on standard reflecting telescope configurations

Prime
newtonian
cassegrain (like the one we used)
Coudé

Two imporant features of telescopes

1. Signal.
   The brightness focussed onto your eye or a camera is proportional to the area of the telescope. ie $B \propto D^2$.

2. resolution

$$\theta_{\text{diff. limit}} \simeq 1.22\, \lambda/D \quad \text{(in radians)}$$
$$= 206265 \cdot 1.22\, \lambda/D \quad \text{(in seconds of arc)}$$

The shorter the wavelength the better the resolution therefore two very close stars will be blurred into one object in the red but resolvable in the blue

The largest optical telescope is in the soviet Union with a diameter of 6 meters. The largest in the west is on Mt. Palomar Calif and is 200 in (~ 5 m.)

the resolution ~~of~~ this device at say 5000 Å

$$\theta_{min} = 2.063 \times 10^5 \cdot 1.22 * \frac{5 \times 10^{-7} m}{5.}$$

$$= .025 \text{ sec of arc.}$$

This cannot be acheived ~~due~~ to atmospheric distortions and the air limits it to

$$\theta_{seeing} \sim .25 \text{ sec of arc.}$$

On Mauna Kea hawaii 14,000 ft.!

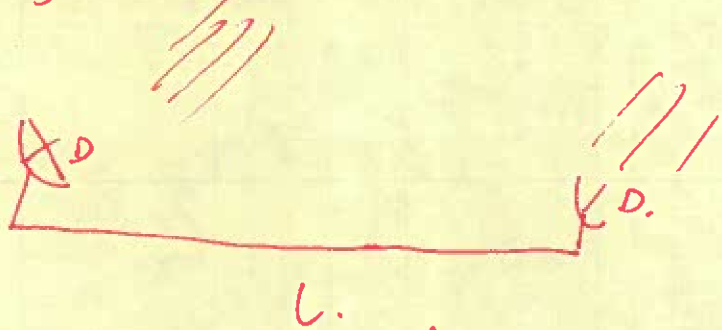
$$\theta_{seeing} \sim .1 \text{ sec of arc.}$$

the space telescope (2.4 m.) which will be above the atmosphere will acheive its theoretical resolution and because it is above the water vapor can be run in the Ultra Violet

$$\lambda \sim 1000 \rightarrow 2000 \text{ Å}$$

appeture Synthesis radio telescopes

telescopes can be made to run at radio wavelengths using metalic parabolic reflectors. The signals can be added electronically presenting the phase information to create the interference pattern which corresponds to focussing. hence.



two telescopes of diameter D sepparated by a length L can have a resolution.

$$\theta = 2.063 \times 10^5 \cdot 1.22 \cdot \lambda / L.$$

and a signal $\propto 2D^2$.

VLA very large array in NM. has
75 25 m dishes spread out
on rail road track 15 miles long
laid out in a Y

At optical wavelengths the frequencies are far ~~too~~ high to play this game but large ~~mirrors~~ telescopes can be made using multiple mirrors to gather more signal.

What can be done is.
moving mirror
Specle interferometry

$1/r^2.$

Ch 3.

forces.

There are four known forces in nature

the gravitational force	10^{-40}
the weak nuclear force	10^{-10}
the electro magnetic force	1
the strong nuclear force	100

To date ~~thes~~ two of these forces (the weak nuclear and electromagnetic forces) have been unified into a single mathematical description. Gravity is described geometrically by general relativity and the strong nuclear force is currently best described by a theory something like electromagnetism but with some major differences

(1). The force mediators (like the EM photon) are "charged." (Non Abelian).

(2) there are three charges instead of one in EM.

Gravity is the force we will mainly be concerned with it has the form,

$$\bar{F}_g = -\frac{G M_1 M_2}{r_{12}^3}(\vec{r}_1 - \vec{r}_2)$$

$$G = 6.67 \times 10^{-11} \ m^3/kg\,sec^2$$

$$6.67 \times 10^{-8} \ cm^3/gm\,sec^2.$$

mechanics has led to certain understandings of the universe among them that there exist certain physical quantities whose values do not change in time. ~~among them~~. These conserved quantities in fact are fundamentally tied to the invariance properties of the universe.

	Conserved quantity	invariance
①	Energy	laws of physics are constant in time
②	momentum	laws of physics are independent of absolute position
③	angular momentum	laws of physics are independent of rotations.

The assigned problem 3.1 is to explicitly show that for gravitation Energy is conserved