

In my 1st lecture I showed that in
 the crystals of the aromatic compounds ~~the~~
~~the~~ magnetic properties data gave us much
 useful information ~~about~~ in orientation of
~~the~~ ^{benzene ring} ~~molecules~~ ~~is~~ in the crystal lattice.
 Optical data also ~~can~~ ^{should} serve the
 same purpose, ~~in view of the fact~~ ^{as}
~~the~~ the benzene ring is ~~optically~~ ^{optically} strongly
 anisotropic ~~optically~~. But there is
 this important difference between the two
 magnetic & the optical problem. Whereas
 the magnetic ~~of~~ ^{of} the crystals depends only
~~on~~ on the axes for the constituent ~~molecules~~
 & their orientation in the ~~crystal~~ ^{crystal} lattice,
 their positions in the lattice being of no
 consequence, the optical susceptibility
~~of the crystal~~ ^{of the crystal} depends ~~not~~ on the molecular positions
 as well. This is because due to the
 following circumstances. Whereas the dipole
 moments induced in a molecule
 are so feeble that their ~~total~~ ^{total} mutual
 influence is negligible in the optical
 problem, in ~~optical~~ ^{optical} ~~problems~~ ^{problems} ~~the~~ ^{the} influence
 of their neighbors is appreciable. To be more precise, the influence of the neighbors
 is appreciable.

~~411~~
~~3~~

which ~~theoretically~~ ~~shows~~
this bear ~~to the~~ ~~influence~~ of the ~~internal~~ ~~field~~
which is ~~not~~ ~~only~~ ~~of~~ ~~the~~
a ratio $\frac{4\pi}{3} \chi = 1$

~~This bear to the~~
will bear to the influence of the ~~external~~
applied field, the magnetic field or the electric
field of the liquid wave as the case may be,

the ratio is roughly ~~equal to~~ $\frac{4\pi}{3} \chi \approx 1$. In
diamagnetic crystals χ is ~~of the order of~~
usually less than 1×10^{-6} , so that the
ratio is 4×10^{-6} which is quite negligible.

On the other hand in the optical case
 $4\pi \chi = n^2 - 1$ where n is the ref. index and is
therefore quite large. This makes the

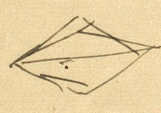
correlation of the optical moments induced
in the crystal with the moments
induced in the free molecules rather
complicated.

But even here is the advantage
in favour of the optical method, as
the optical ~~data~~ ~~can~~ ~~be~~ ~~obtained~~ ~~by~~ ~~means~~ ~~of~~ ~~an~~
much more easy to make, and can
be done ~~at~~ ~~under~~ the microscope with
very thin crystals, and operates even a
rough idea of the ~~of~~ ~~molecular~~ ~~orientation~~,
for example for a choice between two

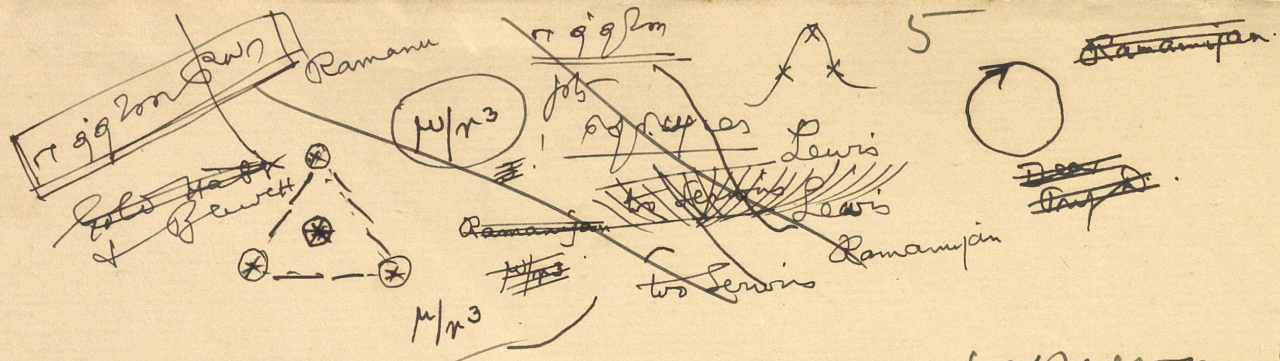
1.25
45
 $\frac{4\pi}{3} \chi$

I shall mainly deal with the
 absorption and fluorescence properties
 of some aromatic compounds, with
 polarized light. The benzene ring is
 truly remarkable for its ~~structure~~
 its ^{its} anisotropy of its properties. Closely associated
 with it is its ~~anisotropy~~ ^{anisotropy} ~~in its~~
 and it is found that the absorption
 and its ~~fluorescence~~ ^{fluorescence} of these compounds
~~depends strikingly~~ ^{depends} ~~strongly~~ on the direction
 of the electric vector of the incident
 light, ~~in the plane~~ ^{in the plane}
 of the benzene rings or other ~~is~~
 normal to the rings. I shall
 first deal with absorption.

12-50
 20/1/24

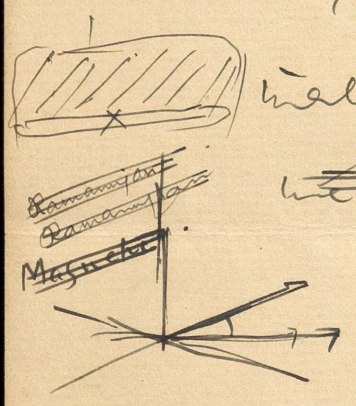


Many of the simple polybenzene
 nuclear compounds, ~~in~~
 I shall confine myself mainly to
 simple polybenzene nuclear compounds
 like anthracene, fluorene, phenanthrene, chrysene
 etc. They all crystallise in the form of
 thin plates. In the plane of the plate
 the molecules are ~~to~~ ^{be} ~~the~~ ^{the} ~~direction~~ ^{direction}
 of extension at ~~the~~ ^{the} ~~of~~ ^{of} ~~each~~ ^{each} ~~ring~~ ^{ring}, and



in all the crystals it happens, lie-
 the benzene planes are nearly all
 inclined at a ~~90~~ large angle
 to the plane of the plate,

only in all these crystals it happens
 that the benzene planes of
 the ~~crystals~~ ~~plate~~ are nearly perpendicular
 to the



it happens that in all these
 crystals one of the ^{at exhibition} directions is near
 along the plane of the benzene rings,
 and the other near along the
 normal to the benzene planes; so the
~~the perpendicular~~ ^{is absorbed} of the crystals
~~the~~ ^{in light} planes along the one or the
 other of the directions, one can infer
 about the behavior of the molecules
 themselves for light vibrating in the
 plane of the benzene ~~is~~ ^{why} ~~to~~ the
 normal to the plane.

which appear in the one also appear in the
 other but with a different intensity. ^{I may say about}
 vibration ~~is~~ in lower ~~pitch~~ ^{with the} ~~conformity~~
 to higher vibrating predominantly in the
 plane of the ~~benzene~~ benzene rings,
 while the upper half corresponds to the
 vibrations along the normal. ~~If you~~

~~take the representative picture, practically~~
~~As I mentioned already, we don't~~
 benzene planes are not ~~rigorous~~
 exactly // and \perp to the ~~the~~ extrusion
 direction, so that what we are

getting here is to some extent a
 diluted effect. If ^{benzene planes} ~~we~~ were rigorously
 \perp and \perp to the ^{two} ~~directions~~ ^{we} should expect
 lower absorption to be ^{even} sharper than what

it is, and ~~we~~ weaker to be ~~seen~~
 weaker than what it is. ~~At present~~
~~it would be interesting to know~~
~~whether it~~ whether ^{the} ~~whole~~ of the

weaker component ^{is} ~~is~~ ^{then} ~~always~~ ^{dis} ~~appear~~
 is ~~more~~ ~~than~~ ~~it~~ ~~can~~ ~~be~~ ~~the~~ ~~where~~
 to say. ~~If~~ ~~it~~ ~~does~~ ~~it~~ ~~would~~ ~~be~~
~~at~~ ~~most~~ ~~whether~~ ~~actually~~ ~~the~~ ~~point~~ ~~is~~

of ^{case} ~~whether~~ it is ~~not~~ clear. ^{that} ~~what~~
^{precisely} ~~the~~ ^{while} ~~absorption~~, if ~~not~~ ~~exactly~~
^{exactly} ~~the~~ ^{while} ~~absorption~~, is confined to

8 i.e. electric vector
to light vibrations in the plane of the benzene rings of the molecule.

2 (11)

I ~~shall show~~ the next slide shows similar absorption features for phenanthrene + fluorescein. Here you strike contrast. when you see in absorption. Then again in the ~~infrared~~ ~~absorption~~ ~~corresponds~~ to ~~the~~ light-normal line vibrations predominantly along the plane of the benzene ring. ~~As the crystal~~

The next two slides show microphotometric records of these spectra I showed just now. Fluorescence you can see how even in finer details, as exactly reproduced in the lower showing that all the bands are common to both, only in one of them they are much steeper.

3 (14)
4 (15)

Apart from the ~~structural~~ spectroscopic interest of such an ~~infrared~~ absorption by the benzene ring which is confined predominantly or wholly to the plane of the benzene ring, this property can be utilized to locate the orientation of the benzene ring in a molecule unknown by itself of an organic compound.

apply

I shall ~~be~~ deal with this aspect,
but I ~~shall~~ there is just one aspect
which is of interest.

~~On crystallization~~ The first
picture which I showed ~~is that of~~
~~you~~ is that of synthetically prepared
pure chrysene; ~~but if we start with~~
~~ordinarily pure~~ of this substance is almost
colorless. But if we start with ordinary
pure chrysene, prepared from coal tar
products it usually contains small
traces of naphthalene which are not
easily removed even by repeated
crystallization. The small trace I mention
is of the order of 1 part in a million
or less, but still is enough to

give the crystal a greenish tinge,
as observed in ^{the next} day ~~it fluoresces~~
and in the blue light - ~~it fluoresces~~
of the near, as fluoresces into a
beautiful green, whereas pure
chrysene does not fluoresce in
this region. If we now show the
absorption of such a crystal of chrysene

containing a trace of naphthalene,
now as ^{the next} day ~~it fluoresces~~
the ~~can~~ ^{absorption bands appear}
prominently, and what is of great

5 VII

interest - these absorption bands also
 are confined ^{which are stronger for the lower} to ~~the~~ ^{vibrations:}
~~which~~: As the ~~ultra~~ ~~red~~ ~~and~~
 appear more strongly in the lower vibration
 than in the upper. The lower vibration
 is really the one which is absorbed
 more strongly by the main crystal
 also, as will be seen from the contrast
 of the absorption bands in the ultraviolet.

6 VIII

This shows that in ~~single~~ molecules of
 nap. present a trace of impurity in
 the crystal ^{have} ~~are~~ taken up ^{orientation}
^{the next} ^{the} ^{micro} ^{phenomena}
 record which has not previously in
 difference between the two absorptions.
 Ordinary anthracene also ~~is~~ is contained
 in a trace of naphthalene, and hence
 its greenish colour. Really pure anthracene
 is more violetish. Here again we see
 the same phenomenon.

Calculation
 can be put
 in terms
 as an
 impurity
 in anthracene
 fluorescence
 spectra
 so into
 so
 and shows
 again same
 the
 polarized
 absorption

I may say here a few words about
 the identification of ~~these~~ ^{organic} ~~bands~~ ^{materials} ^(the positions of) ^{their} ^{absorption}
~~by~~ ~~naphthalene~~ ^{of} ^{the} ^{position}
 bands. As you can easily see the position
 depends to a considerable extent on
 the ~~same~~ ^{medium} in which it is present.

Take the case of ν nix two pictures of
~~the~~ naphthalene also. The upper is in
 chrysolite + the lower is in anthracene. The
 positions are not identical. ~~It depends on~~
 the position depends to a large extent
 on the medium.

if
 solid soln
 vapour

The next two pictures show the
 positions of ν bands for solid, solution
 (alcohol) and in vapour. You can see
 the shift toward ν red as the
 med gets denser. Even in solid
 the position depends on the solvent.

11

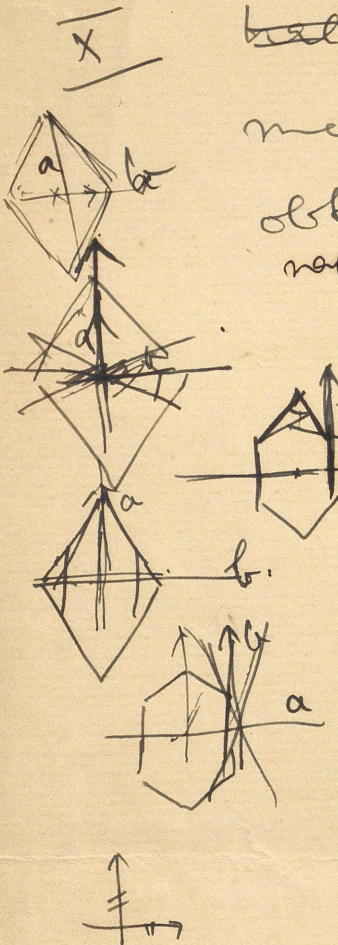
The same applies also to the positions
 of the fluorescence band. For proper identifi-
 cation of the bands ~~and content~~ ^{and content} ~~in the~~ ^{in the} ~~solid~~ ^{solid} ~~state~~ ^{state} ~~is~~ ^{is} ~~not~~ ^{not} ~~enough~~ ^{enough}
 to identify the bands. Comp back to the oriented
 molecules, the fact that the

~~positions of the bands are~~ ~~the~~ ~~is~~ ~~not~~ ~~enough~~
 at all. It might be supposed that the
 naphthalene is present as a thin organic
 on the chrysolite crystal. Since both media
 crystals are flat, such an over growth is
 not in ~~possible~~ ^{possible} and ~~even~~ ~~the~~ ~~molecule~~
 planes in the crystals may even be
 oriented. But this explanation

is ruled out as the position of these
 absorption bands ^{of naphthalene} ~~is different in~~ ~~antia~~ appear
 in chryse & anthracene are very different,
 and ~~appear~~ ^{just} differ in the position of bands
 in this naphthalene. I say anthracene
 some of the results ^{in figure} which I shall
 describe presently, and mention that
~~antia~~ ^{anthracene} naphthalene does not fluoresce strongly,
 whereas this naphthalene does - a important
 in chryse & anthracene is intensely blue
 of the fluorescence, ~~appear~~ ^{used} as viewed under
 the microscope appears quite homogeneous.
 The fluorescence bands align on at
 diff. position for ~~naphthalene~~ the
 substance present in anthracene and in
 naphthalene* of naphthalene

~~These~~ These orientated molecules are
 very convenient for studying fluorescence,
 as ~~angle of crystal~~ ~~as we can~~
 the concentration is ~~very~~ small, and
 can, to some extent, be adjusted, as we
 are not troubled by strong absorption.
 as in ~~single crystals of naphthalene~~
 We can excite fluorescence by infrared
 near || to the benzene plane, or also by

normal, and show no fluorescence
but for its polarization. I shall
merely give here some of the results
obtained in a crystal of anthracene which
reproduces as in figure.



Anthracene crystal is a plate
have a rhombic form; hexagonal
form. One of the lengths
is $\frac{1}{2}$ to the other
sides; which I saw is the
Cycloparaphic 'b' axis; the
The other direction is I saw
is 'a'. The 'a' axis is

The molecular planes are inclined like
that, so that the 'b' direction
will be close to the molecular planes
whereas the other will be nearly
at right angles to the planes.
This explains the results.

These results can all
be consistently explained if we assume
that light vectors vector is in the plane
of the molecule it excites fluorescence
high, as the fluorescence vector also
is polarized by the same direction

On the other hand if the electric vector is along the normal to the plane it is very little absorbed.

I shall leave in organic crystals for the present, and consider one of the inorganic crystals which has interesting optical properties. namely KNO_3 .

~~I shall deal with organic crystals and shall leave for you to deal with inorganic crystals. I shall deal with organic crystals and shall leave for you to deal with inorganic crystals. I shall deal with organic crystals and shall leave for you to deal with inorganic crystals.~~

In this crystal we have a NO_3 ion in the crystal lattice. The NO_3 ion has a planar structure, with three O's at the corners of an equilateral triangle and the N at the centre. The NO_3 planes are all oriented parallel to one another in the crystal.

and the simple structure of the ion is an advantage if we wish to correlate the optical properties with the structure.

So the crystal is a double crystal for the NO_3 ion. The absorption band is at $2000 \text{ m}\mu$ and the next one is at 3000 A .

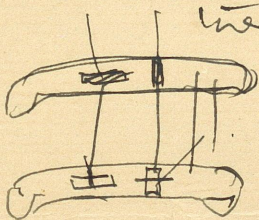
its max. at about 2500 Å. The latter is also band is very much steeper than the former. Both of them are found to be 8258 polarized, ~~the absorption~~ as in the case of absorption band of azobenzene, ~~the absorption~~ the absorption is much greater when the ~~the~~ ^{the} vector is in the plane of the wave than when it is at right angles.

~~Now the position of the absorption~~
 In solution also the same two absorption bands appear. The ~~two separate peaks~~ of the bands are such that they can ~~be~~ ^{be} legitimately be attributed to a photo-dissociation of NO_2 into NO and an oxy. in the ground state and in the excited state respectively. ~~It has been~~ found

a photo-diss. has been observed ~~with this~~ ^{with this} ~~in the~~ ^{in the} region of the steeper absorption band. It now ~~the~~ ^{the} absorption is due to photo-dissociation, ~~the~~ ^{the} for the observed polarization of the absorption bands in KNO_3 crystal for example one ~~can~~ ^{can} conclude that the ~~greater~~ ^{greater} efficiency of photo-diss. and is greater

when in the water. and in the place of
the NO_2 in water when the nitric oxide is
removed to the plane.

~~Actually~~ This is found to be always
the case. The experiment is performed in this
manner. The light of a ^{quartz} mercury ~~arc lamp~~
~~apparatus~~ is allowed to pass through
a quartz double image prism and
is then projected on a screen so
that the two images are one a



~~On one side the two pieces are tall.~~

~~A number of pieces from the~~

two single pieces, broken from the

same crystal are placed in the two

images. The dissociation is tested

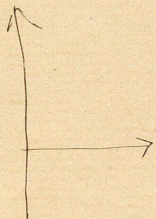
by the polar. iodine starch test.

~~One is much more~~

readily dissociated than the other.



Sub-dissociation



σ

Some 30 yrs ago Cotton and Mouton made
 the first ~~survey~~ ^{observation} ~~was~~ - almost a liquid
 when placed in a strong magnetic field
 behaves optically like a uniaxial crystal;
 its ref. index for light vibrating along the
 direction of the magc. field ~~is the same~~ differs
 slightly from that for \perp vibrations. The
 experimental arrangement for the study of this
 double refraction is very simple. The liquid
 is ~~placed~~ ^{contained} in a long ^{narrow} tube which is kept between
 the pole-pieces of a large electromagnet,
 the pole-pieces being specially designed to
 give a large uniform field which is everywhere
 normal to the length of the tube. The
 double refraction produced ~~in the liquid by~~
~~the field~~, is detected in the usual manner
 by viewing the liquid between crossed
 nicols, and is measured with the help of a
 suitable compensator. ~~The simplest and~~
~~most convenient type of compensator is~~
~~that~~. The double refraction ~~produced~~ is quite
 feeble; and is several thousand times ~~smaller~~
 smaller than ~~the~~ ^{the} ~~small~~ double refraction ^{may} exhibited by ~~some~~ ^{many} crystals.
 For ex in order to give you an idea of

the magnitude of the effect. I may mention
 that benzene is ~~one of the~~ ^a liquids which
 exhibits this phenomenon strongly. With a
 field of $\approx 25,000$ gauss, which should be
 considered fairly large, the ~~path~~ difference
 of phase ~~produced by the field~~ ^{between the two principal} ~~per unit length of path~~
~~in the liquid~~ vibrations is ~~of~~ ^{about} $1/3000$ of a wave length,
 per cm. of length of path. For many liquids
 it is much smaller. For example for
 pentane, in the above field it will be only $1/100,000 \lambda$.
 or water it is $1/150,000$, and even in
 30 cm. length of path, ~~in these liquids~~ ~~which should~~
~~be considered quite large~~ ~~the~~ ~~the~~ difference
 of path is small - to only $1/5000$ of a
 wavelength, whereas for most crystals the
 this length of path the difference will be
 several wavelengths.

With liquids like
 cyclohexane &
 is smaller still

For calcite 10,000
 quartz 2,000

~~So one needs a rather sensitive~~
~~unifera~~ ~~the~~ ~~I~~ ~~no~~ ~~incident~~ ~~membr~~ ~~not~~
 here that the extinction of light by Xed
 nicols is so perfect that even these feeble
 with a thin source of light these feeble
 double refraction would have to be
 easily detected.
 The double refraction very feeble nature

neutral zone. If the strip of glass is ~~now~~ viewed betⁿ X & W mirrors, with this ~~angle~~ ^{plane glass} at 45° to the vertical, the neutral zone will be black, & ~~will be gradually~~ ~~rotation of light~~ and the ~~will be~~ ^{of light} greater & greater ~~rotation~~ ^{refraction} as we move away from the ~~to~~ zone. If ~~there is~~ ~~an~~ ~~angle~~ ~~between~~ the X & W mirrors ~~and~~

~~in~~ ~~addition~~ ~~to~~ ~~the~~ ~~view~~ ~~glass~~ ~~having~~ ~~we~~ ~~introduce~~ ~~the~~ ~~liquid~~ ~~in~~ ~~the~~ ~~field~~ ~~column~~ ~~in~~ ~~the~~ ~~dark~~ ~~ref.~~ ~~column~~ ~~of~~ ~~the~~ ~~map~~ ~~rendered~~ ~~triangular~~ ~~of~~ ~~the~~ ~~negative~~ ~~field~~, ~~then~~ ~~the~~ ~~neutral~~ ~~band~~ ~~will~~ ~~shift~~ ~~up~~ ~~or~~ ~~down~~ ~~to~~ ~~a~~ ~~place~~ ~~where~~ ~~the~~ ~~dark~~ ~~ref.~~ ~~of~~ ~~the~~ ~~show~~ ~~glass~~ ~~is~~ ~~just~~ ~~equal~~ ~~to~~ ~~white~~ ~~to~~ ~~the~~ ~~position~~ ~~in~~ ~~the~~ ~~liquid~~;

~~the~~ ~~band~~ ~~shifts~~ ~~the~~ ~~shift~~ ~~the~~ ~~quality~~ ~~of~~ ~~the~~ ~~ref.~~ ~~power~~ ~~of~~ ~~the~~ ~~lens~~ ~~can~~ ~~be~~ ~~readily~~ ~~altered~~, ~~and~~ ~~by~~ ~~measuring~~ ~~By~~ ~~measuring~~ ~~the~~ ~~shift~~ ~~we~~ ~~can~~ ~~calculate~~ ~~the~~ ~~know~~ ~~the~~ ~~dark~~ ~~ref.~~ ~~of~~ ~~the~~ ~~liquid~~, ~~if~~ ~~the~~ ~~show~~ ~~plate~~. ~~It~~ ~~is~~ ~~easy~~ ~~to~~ ~~calibrate~~ ~~the~~ ~~if~~ ~~the~~ ~~glass~~ ~~had~~ ~~been~~ ~~calibrated~~ ~~already~~ ~~when~~ ~~the~~ ~~observed~~ ~~shift~~ ~~of~~ ~~the~~ ~~band~~ ~~gives~~ ~~a~~ ~~measure~~ ~~of~~ ~~the~~ ~~refraction~~ ~~of~~ ~~the~~ ~~liquid~~.

will presumably be anisotropic ~~also~~
optically, ^{also} ~~we~~ such an orientation of the

molecules in solution ~~produce~~ ^{lead to} a feeble
double refraction of the liquid. The double is ~~not~~ ^{absorption}
~~anisotropic~~ ~~and~~ ~~the~~ ~~double~~ ~~is~~ ~~not~~ ~~due~~ ~~to~~ ~~the~~ ~~anisotropy~~ ~~of~~ ~~the~~ ~~molecules~~ ~~themselves~~ ~~but~~ ~~to~~ ~~the~~ ~~anisotropy~~ ~~of~~ ~~the~~ ~~medium~~ ~~in~~ ~~which~~ ~~they~~ ~~are~~ ~~placed~~

~~as~~ ~~general~~ ideas underlying Larmor's theory have ~~been~~
~~fully~~ received ~~general~~ ^{strong} experimental support, especially
during recent years. ^{In particular} the conception of an
optical anisotropy for the molecule has ~~been~~
proved very fruitful ^{especially} in explaining
~~many~~ ~~some~~ ~~of~~ ~~the~~ ~~phenomena~~ ~~connected~~ ~~with~~ ~~molecular~~
~~scattering~~ ~~of~~ ~~light~~. If we pass a parallel beam
of light through a gas or vapour and ~~the~~
the light ^{transmits} scattered by it, ~~we should expect~~
~~the~~ ~~scattering~~ ~~to~~ ~~be~~ ~~com~~ ~~the~~ ~~light~~ ~~instead~~ ~~of~~
being ^{completely} polarised, as we should expect if the
molecules were all optically isotropic, it shall
found to ~~be~~ ~~have~~ be only ~~of~~ partially polarised.
This defect for ~~complete~~ perfect polarisation is
due to the anisotropy of the molecules; ~~and~~
can indeed, as Lord Rayleigh has shown, be
~~made~~ ~~a~~ ~~measure~~ ~~of~~ ~~the~~ ~~in~~ ~~fact~~ ~~in~~ ~~large~~
the ^{opt} anisotropy in greater would be the
~~defects~~ the depolarisation of the ~~transversely~~
scattered light. In fact this depolarisation
offers the most convenient method for
determining the optical anisotropy of the molecules

~~In~~ For simple molecules like benzene or any of the paraffins, which may be presumed to have an axis of ~~optical~~ symmetry, i.e. whose ^{optical} ellipsoid ~~can be~~ is a spheroid, ~~if~~, the principal optical polarisabilities of the molecule can be readily calculated in this manner.

~~If~~ ~~as~~ I ~~have~~ mentioned ~~above~~,

the magnetic double refraction of a liquid depends on ~~the~~ both the optical and magnetic anisotropy of the molecule, and if the latter can be calculated, at least for simple

molecules for the ~~separation~~ ^{refraction} of light scattered or Kerr effect, we can utilize the

exptal data for magnetic double refraction ~~to give us~~ ^{for obtain} information ~~regarding~~ ^{about} the magnetic anisotropy of the molecules.

As far as I know we have measured the double refraction of a large no. of liquids, and they now have been measured recently ~~in~~ at Calcutta; ~~but~~ ^{most organic compounds} in the liquid state, and in the solid state which at room temp are molten at high temps or ~~at~~ in the solid state in suitable ^{substances} ~~materials~~.

There are also other phenomena which depend on the optical anisotropy of molecules, eg. the Kerr effect for which close to can be estimated experimentally.

It is found in this case for the magnetic double refraction of benzene is also true for other substances.

The double refraction is 4 times ^{that of benzene} ~~that of benzene~~ in
triphenyl ~~in the opt.~~ ^{is shown} ~~the~~ ^{the} ~~refr.~~ ^{refr.} ~~is~~
anis ^{is} ~~is~~ and so the double refr. is
of this. and so on.

4) ~~of the condensed benzene~~ When the rings
are not discrete, but are of the condensed
type as in naphthalene or anthracene etc,
the magnetic anisotropy is greater
the ~~that of the condensed benzene~~ for a
molec. contains the same no. of discrete
benzene rings.

5) There is another feature of these rings
condensed ring compounds which ~~is not~~
~~mentioned~~ should also be mentioned here, as I have
in occasion to use it later on, viz
that in spite of the ~~sharp~~ geometrical
asymmetry of shape in the plane of the
benzene rings, the line is parallel to some
along different directions in the plane. [and
of course much smaller ^(numerically) than the normal
to the plane.]

If such ^{magnetically} anisotropic molecules are
packed together as in a crystal, then ~~obviously~~
the crystal ^{is} a whole and in general ~~is~~
anisotropic, the magnitude of the anisotropy

depending on the anisotropy of the constituent molecules and their relative orientations in

the crystal lattice. Let us take a very simple case where all the molecules ~~are~~ in the crystal lattice are oriented α° to one another, as for example in the crystal of hexamethyl benzene ^{whose structure} ~~which~~ has been ^{determined} ~~calculated~~ by Mrs. Lonsdale. The anisotropy of the crystal ~~should~~ ~~then~~ be the same as that of the molecule.

The positions of the molecules in the lattice will have no ~~effect~~ ^{effect}, as the diamagnetic moments induced in the molecules ~~will~~ are so feeble that their mutual influence will be negligible. To be more precise the mutual influence of the moments will bear to the influence of the applied magnetic field a ratio ^{whose order of magnitude will be} ~~approximately~~ $\frac{4\pi}{3} \chi^2$ ~~the influence~~ ^{numerically} less than 10^{-6} .

Since χ is ~~small~~ ^{isotropic}, this is a great advantage, as the suscep. of the crystal about any given given direction is then given ~~merely~~ by the sum of the contributions along that direction for the individual molecules.

anisotropy; and as I mentioned previously since the methyl groups ~~do not~~ contribute to the ~~anisotropy~~ ~~the~~ ~~may~~ ~~be~~ ~~seen~~ as practically isotropic, the anisotropy of hexamethyl benzene crystal should be nearly the same as that

It is a great pleasure ~~to~~ to
me to have this opportunity
of speaking at the Roy. Instn.
and I will set within and
my activities. The choice of
training in rel. ~~to~~
as an subject of an lecture
at the R. ~~to~~ ~~has~~ ~~been~~
is still an open ~~of~~ ~~the~~
~~subject~~ ~~of~~ ~~the~~ ~~subject~~ ~~of~~
its development ~~has~~ ~~been~~ ~~the~~
development in this
has grown ~~from~~ ~~this~~ ~~stage~~
at and ~~all~~ ~~about~~ ~~the~~ ~~stage~~
of its ~~own~~ ~~development~~ ~~way~~
with ~~the~~ ~~subject~~ ~~of~~ ~~its~~ ~~development~~ ~~it~~ ~~is~~
is ~~so~~ ~~interesting~~ ~~with~~
in the ~~in~~ ~~subject~~ ~~at~~
was shown in his lecture ~~of~~ ~~growth~~
by ~~the~~ ~~stage~~ ~~of~~ ~~its~~ ~~development~~
of ~~the~~ ~~stage~~ ~~of~~ ~~its~~ ~~development~~

as the subject, at the
stage of its growth
has ~~been~~ has grown
almost exclusively in this
laboratory; ~~the~~ ~~idea~~ was ~~on~~
her and the ~~rest~~ of the
work on the magnetic
part of crystals was ~~done~~
has ~~been~~ carried on here, and
almost the whole of our
present work of the ~~structure~~
of organic crystals, ~~also~~
which I shall speak ~~of~~ ~~later~~
has come out of this laboratory

Comp to the yoh. papers

~~In the~~ ~~the~~ crystal is nearly uniaxial optically, with a large negative birefringence; which is ^{almost} wholly due to the NO_3 group; the refractivity for ~~light~~ vibrations in the plane of the ion being much less than for vibrations along the normal to the plane. This has been explained very elegantly by Pay. by no group name.

In ~~the~~ ~~the~~ ~~plane~~ ~~the~~ ~~set~~ ~~of~~ ~~calculating~~ ~~refractivities~~ ~~of~~ the NO_3 group may be attributed to the three doubly ionised oxygen atoms, the central N atom which has lost all its valency electrons contributing practically nothing. If the three O's were far removed from one another, the refractivity of the ~~NO~~ NO_3 group will be merely three times that of each O^{--} .

$3 \times \alpha E$

~~Let us suppose~~ The moment induced in each oxygen will be αE , where E is the elec. field of the equi-wave and α is its polarizability of the atom per unit field. ~~If~~ The total polarization will be $3 \alpha E$. ~~Let us now~~ suppose that the ~~two~~ ~~low~~ oxygens have been brought to their actual places, and let the field E be induced along the normal to the plane of the oxygen. ~~If~~ ~~now~~ ~~for~~ ~~it~~ The moment induced in each of the oxygens will no more be equal to αE .

but will be given by μE

$$\mu E = \alpha \left[E + \frac{2\mu E}{r^3} \right]$$

$$\mu_{\parallel} = \frac{\alpha}{1 + \frac{2\alpha}{r^3}}$$

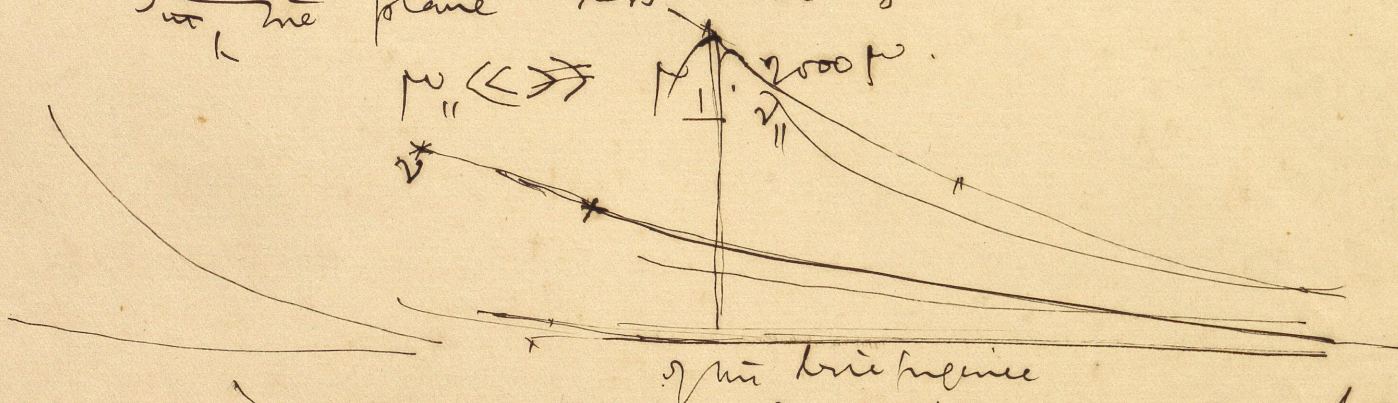
Similarly

$$\mu_{\perp} = \frac{\alpha}{1 - \frac{\alpha}{r^3}}$$

can be estimated

~~μ_{\parallel} will be greater than~~

So that due to the mutual influence the refracting for vibration in the plane of the NO_3 group is greater than it would be for the isolated oxygen, and for vibrations in the plane less than for



The variation with frequency can be

predicted easily. If we know α .

Explanation in terms of frequencies

1) we should expect strong polarization change of ref. index. This is expected.

the μ is about 2 above. one very feeble