Draft of the 'Discourse Concerning Light and Colors'

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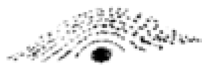
[1] Obs: 1. Compressing two Prisms hard together that their sides (which were a little convex) might somewhere touch one another, I found the place in which they touched to become absolutely transparent as if they had there been one continued pei of glasse. For when the light fell so obliquely on the Air which in other places was between them, as to be all reflected yet in that place of contact it was wholly transmitted. Insomuch that when looked upon it appeared like a black or dark spot by reason that no light was reflected from thence as from other places; & when looked through it seemed, as it were, a hole in the Air that was formed into a thin plate by being compressed between the glasses, & through this hole objects that were beyond might be seen distinctly which could not at all bee seen through other parts of the glasses where the Air was interjacent. Although the glasses were a little convex yet this transparent spot was of a considerable breadth, which breadth seemed principally to proceed from the yeilding inwards of the parts of the glasses by reason of their mutuall pressure. For by pressing the glasses very hard together it would become much broader then otherwise.

Obs: 2. When the plate of Air by turning the Prisms about their common axis became so little inclined to the incident rays that some of them began to be transmitted, [& thereby to exhibit the blew Bow described in the second Experiment: as that Bow approached to the transparent spot] there arose in it many slender arcs of colours which at first were shaped almost like the Conchoid as you see them here delineated.



And by continuing the motion of the Prisms these arcs increased & bended more & more about the said transparent spot till they were completed into circles or rings incompassing it, & then they continually grew more & more contracted.

The parts of these circles at their first appearance [within the blew Bow] were of a vivid violet & blew, & between them were white arcs of circles which presently became a little tinged in their inward limbs with red & yellow, & to their outward limbs the blew was adjacent . So that the order of these colours from the centrall dark spot was at that time**{,}** White, Blew Violet; Darknesse; Red, Orange, Yellow, White, Blew, Violet; &c. But **{**the**}** yellow & Red were much fainter then the Blew & Violet. T

The motion of the Prisms about their axis being continued these colours contracted more & more shrinking towards the whitenesse on either side of it, & untill they totally vanished into it [so soon as the blew Bow was a little past them.] And then the circles in those parts appeared black and white without any other colours intermixed. But by further inclining the Prisms, the colours <519v> again emerged out of the whitenesse, the violet & blew at its inward limb & at its outward limb the red & yellow. So that now their order from the centrall spot was, white, yellow, red; black: violet, blew, white, yellow, red; &c contrary to what it was before.

Obs: 3. When the circles or some parts of them appeared onely black & white, they were very distinct & well defined, & the blacknesse seemed as intense as that of the centrall spot. Also in the vicine places, where the colours began to emerge out of the whitenesse they were pretty distinct, which made them visible to a very great multitude. I have sometimes numbered abobe thirty successions (recconing every black & white circle for one succession) & seene more of them which by reason of their smallnesse I could not number. But in other positions of the Prisms when the circles became coloured I could not distinguish above 8 or 10 of them, & the exteriour of those too were very confused & diluted.

In these two observations, to see the circles distinct, & without any other colour but black & white I found it very necessary that I held my eye at a good distance from them. For by approaching nearer, although in the same inclination of my eye, yet there emerged a blewish colour out of the white which by dilating it selfe more & more into the black rendered the circles lesse distinct, & left the white a little tinged with red & yellow. I found also that by looking through a slit or oblong hole which was narrower then the pupill of my eye & held close to it parallel to the Prisms, I could see the circles much distincter, & freer from colours & visible to a far greater number then otherwise.

Obs. 4. To observe more nicely the orders of the colours which arose out of the white circles as the rays became lesse & lesse inclined to the plated Air; I layd the aforesaid Object Glasses one upon the other, & pressing them slowly together to make the colours successively emerge in the middle of the circles, where being of a considerable breadth, I could more easily discerne them, I found their succession & quantity to be as followeth.

Next to the pellucid ,centrall spot made by the contact of the glasses, succeded Violet, Blew, white, Yellow, & Red. The Violet & blew were so very little in quantity that I could not discerne them in the circles made by the Prisms, but the Yellow & Red were pretty copious & seemed about as much in extent as the white, & foure or five times more then the Blew & Violet. The next circuit of colours immediately incompassing these was Violet Blew, Green, Yellow, & Red. And these were all of them copious excepting the green which was very little in quantity & much more faint & dilute then the other colours. The third circuit was <520r> also Purple, Blew, Green, Yellow & Red; in which the Purple seemed a little more reddish then the Violet in the former circuit, & the Green was much more conspicuous, being as brisque & copious as any of the other colours except the yellow But the Red began to be a little faded inclining very much to purple. After these succeded a reddish Purple & with a little or no blew, & then followed Green which was very copious & far more lively then any other colour in this fourth circuit, but the Yellow & Red were very dilute, & the succeding colours became more & more diluted till after thre or four more revolutions they ended in perfect whitenesse.

Obs: 5. By measuring the diameters of the first six circles & squaring them I found their squares to be in Arithmeticall Progression. Namely the thicknesse at the middle of the limb of the first white circle being supposed one part, the thicknesse at the yellowish green in the second circle was three of those parts, & at the yellowish green in the third circle it was five of those parts, & so on. I measured also the diameters of the dark or faint circles between the more lucid colours, & found their squares to be in arithmeticall progression of the eaven numbers 2, 4, 6, 8, &c. And it being very nice and difficult to take these measures exactly, I repeated them divers times at divers parts of the glasses, that by their agreement I might be confirmed in them. And the same method I used in determining some others of the following Observations.

Obs: 6. The diameter of the sixt circle at its most lucid or yellow orbit was $\frac{58}{100}$ parts of an inch, & consequently the thicknesse of the Air or Aereall intervall of the Glasses at that yellow circle was $\frac{1}{14554}$ of an inch, the eleventh part of which ($\frac{1}{160094}$) is the thicknesse of their intervall at that part of the first circle where the yellow would be most vivid were it not mixed with other colours in the white. And this doubled gives the difference of their intervalls which are at the yellow in all the other circles viz $\frac{1}{80047}$, or to use a round number, the eighty thousanth part of an inch.

Obs: 7. These dimensions were taken when my eye was placed perpendicularly over the glasses in or neare the axis of the circles, but when I viewed them obliquely they became bigger continually swelling as I removed my eye further from their axis. And partly by measuring the diameter of the same circle at severall obliquities of my eye, partly by other meanes, as also by making use of the two Prisms for very great obliquities; I found its diameter, & consequently the thicknesse of the plate of Air at its perimeter in all those obliquities to be very nearely in the proportions which I have expressed in this Table.

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The angle of incidence on the Plate of Air	0^{d}, $0'$.	6^{d}, $26'$.	12^{d}, $45'$.	18^{d}, $49'$.	24^{d}, $30'$.	29^{d}, $37'$.	33^{d}, $58'$.	35^{d}, $47'$.	37^{d}, $19'$.	38^{d}, $33'$.	39^{d}, $27'$.	40^{d}, $0'$.	40^{d}, $11'$
The angle of refraction made into that Air	0^{d}.	10^{d}.	20^{d}.	30^{d}.	40^{d}.	50^{d}.	60^{d}.	65^{d}.	70^{d}.	75^{d}.	80^{d}.	85^{d}.	90^{d}.
Then diameter of the coloured circle	10.	$10\frac{1}{13}$	$10\frac{1}{3}$	$10\frac{3}{4}$	$11\frac{3}{7}$	$12\frac{1}{2}$	14	$15\frac{1}{3}$	17	19	$22\frac{1}{2}$	$26\frac{1}{2}$	3{5}
The thicknesse of the Air at the perimeter of that circle	10	$10\frac{1}{6}$	$10\frac{2}{3}$	$11\frac{1}{2}$	13	$15\frac{1}{2}$	20	$23\frac{1}{2}$	29	37	50	70	120

Obs 8. The dark spot also in the middle of the circles increased alittle by the obliquation of the eye, although almost insensibly. But between the Prisms its increase was more manifest when viewed so obliquely that no colours appeared about it. It was least when the rays were incident most obliqeluy on the plated Air, & increased more & more untill the coloured circles appeared, & then decreased again but not so much as it increased before. And hence it is evident that that transparency was not onely at the absolute contact of the glasses, but also where they had some little intervall. I have sometimes observed the diameter of that spot to be between half & two fift parts of the diameter of the exterior perimeter of the Red in the first circle when viewed almost perpendicularly; whereas when viewed obliquely it hath wholly vanished & become opake. Whence it may be collected that the glasses did then scarcely or not at all touch one another, & that their intervall at the perimeter of that spot when viewed perpendicularly was about a 5^{t} or 6^{t} part of their intervall at the perimeter of the said Red circle.

Obs 9. Wetting the Object glasses a little at their edges, the water crept in slowly between them, & the circles thereby became lesse & the colours more faint: In so much that as the water crept along one half of them at which it first arrived would appeare broken of from the other half & contracted into a lesse room. By measuring them I found the proportion of their diameters to the diameters of the like circles made by air to be about seven to eight, & consequently the intervalls of the glasses at like circles caused by those two Mediums are about thre to four. Perhaps it may be a generall rule, that if any other Medium more or lesse dense then water be compressed between the glasses, their intervall at the circles caused thereby will be to their intervall caused by interjacent Air, as the sines are which measure the refraction made out of that Medium into Air.

Obs. 10. When the water was between the glasses if I pressed the upper glasse - variously at its edges to make the circles nimbly move from one place to another, a little bright spot would follow the center of them, which upon creeping in of the ambient water into that place would presently vanish. Its appearance was such as inter <521r> jacent Air would have caused, & it exhibited the same colours. But it was not Air, for where any aereal bubbles were in the water they would not vanish. The reflexion must rather have been caused by a subtiler Medium which could recede through the glasse at the creeping in of the water.

Obs: 11. Wetting plates of Muscovy glasse whose thinnesse made the like colours appeare, the colours became more faint especially by wetting the plate on that side opposite to the eye, but I could not perceive any variation in their species. So that the thicknesse of a plate requisite to produce any colour depends onely on the density of the plate & not of the ambient Medium. And hence by the 9^{th} observation may be known the thicknesse of watry bubbles, or plates of muscovy glasse or of other substances which they have at any colour produced by them.

Obs: 12. A plated body which is denser then its ambient Medium, exhibits more brisque & vivid colours then that which ir rarer; as I have particularly observed in Glasse & Air. For blowing glasse very thin at a lamp Furnace, those plates incompassed with Air did exhibit colours much more vivid then those of Air plated between two glasses.

Obs: 13. By looking through the two contiguous object glasses without any water between them, I found that the interjacent Air exhibited coloured circles as well by transmitting light as by reflecting it. The centrall spot was white, & from it the order of the colours were Yellow, Red, Black; Violet, Blew, white, Yellow, Red;

Violet, Blew, Green, Yellow, Red, &c. The first Yellow, & Red like the blew & violet in the 4^{th} Obs were so little as scarcely to be discerned, & all the other colours were exceeding faint & dilute, unlesse when the light was trajected very obliquely through the glasses. For by that meanes they became pretty vivid. Comparing the coloured circles made by reflexion with these made by transmission of the light, I found that White was opposite to Black, Red to Blew, Yellow to Violet, & Green to a compound of Red & Violet. That is, those parts of the glasse were black when looked through which when looked upon appeared white, & on the contrary. And so those which in one case exhibited Blew, did in the other case exhibit Red. And the like of the other colours.

These observations were made in the open Air. But further to examin the effects of coloured light falling on the glasses, I darkened the Room, & viewing them by reflection of the colours of a Prism cast on a sheet of white paper I made the following observations.

Obs: 14. Appointing an Assistant to move the Prism to & fro <521v> about its axis that all its colours might successively fall on the same place of the paper & be reflected from the circles to my eye whilst I held it immoveable; I found the circles which the red light made, to be manifestly bigger then those which were made by the blew. And it was very pleasant to see them gradually swell or contract accordingly as the colour of the light was changed. The intervall of the glasses at any of the Rings when they were made by the utmost red light, was to their intervall at the same Ring when made by the utmost Violet, greater then 3 to 2 & lesse then 5 to 3. By the most of my observations it was as 9 to 14. And this proportion seemed the same in all obliquities of my eye, but in very great obliquities I have not yet observed it.

Obs 15. And that intervall of the glasses which was an arithmeticall mean between these two, the light was of a middle colour between green & yellow; & the extent of the red was almost double to that of the Violet: contrary to what happens in the colours made by the refraction of a Prism, where the Red is most contracted, the violet most expanded, & in the midst of them is the confine of green & blew.

Obs: 16. These Rings were not of various colours like those in the open air, but appeared all over of that Prismatick colour onely with which they were illuminated. And by projecting the Prismatick colours directly upon the glasses I found that the light which fell on the dark spaces between the coloured Rings, was transmitted through the glasses without any variation **{.}** For on a white paper it would paint Rings of the same colour with those which were reflected, & of the bignesse of their intermediate spaces. And from hence the origins of these Rings is manifest, namely that the aereall intervall of the glasses according to its various thicknesse, is disposed in some places to reflect & in others to transmit the light of any colour, & in the same place to reflect one colour where it transmits another.

Obs 17. The circles were here distincter & visible to a greater number then in the open Air. Obs: 18 And by making them all successively emerge in the middle, that I might more nicely compare the quantity of their light; the reflexion seemed to be something stronger from that circle which next incompassed the contact of the glasses, then from the exterior circles. And so in the open Air the whitenesse reflected from the first or inmost circles was stronger then the whitenesse or light reflected from the glasses at those parts which were without the circles, as I could very manifestly distinguish by viewing them at distance. And the same thing is observable of the outmost rings of the colours which appeare in thin plates of Muscovy-glasse in a contrary order, being caused by fissures or cavities within the glasse which are thinnest at their edges.

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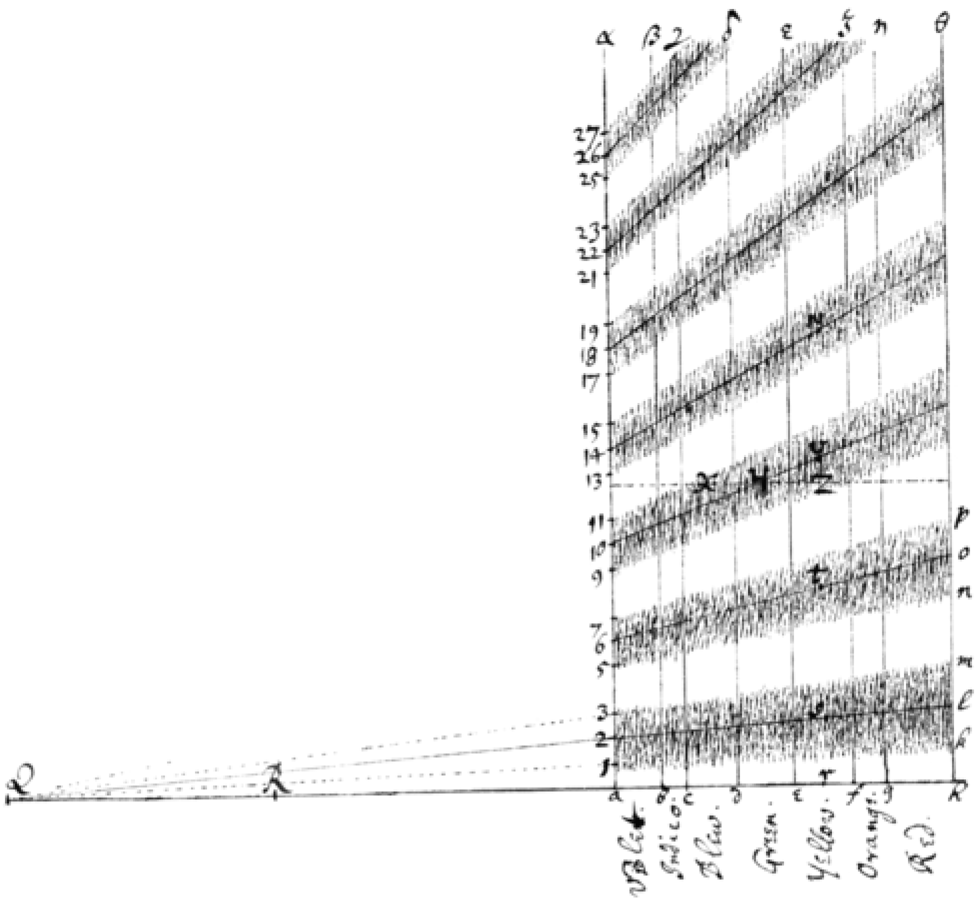
Having given you my Observations on these colours it will not be difficult by some of them to unfold the causes of the others. To which end the 5^{t}, 7^{th}, 14^{th}, 15^{th} & 16^{th} Observations doe principally conduce. And first to show how the colours in the 4^{th} & 13 Observations are produced, let there be taken in any right line, the lengths QR Qa & Qh in proportion as 4, 9 & 14, & between Ra & Rh eleven meane proportionalls, of which let Rb be the 2^{d}, Rc the 3^{d}, Rd the 5^{t}, Re the 7^{th}, Rf the 9^{th} & Rg the 10^{th}. And at the points a, b, c, d &c erect perpendiculars aα, bβ, cγ, &c. by whose intervalls the extent of the severall colours set against them is to be represented. Then divide the line aα in such proportion as the numbers 1, 2, 3;



5, 6, 7; 9, 10, 11; &c set at the points of division denote, & through those divisions from Q draw occult lines 1k, 2l, 3m; &c. crosse the perpendiculars, & let the intervalls between 1k & 3m, 5n & 7p &c be shaddowed faintly at the edges & more intensely towards the middle to represent there the strongest reflexion of each colour.

Now if a2 be supposed to represent the thicknesse of any plated body at which the deepest violet is most copiously reflected in the first ring or series of colours, then by the 14th Observation hl will represent its thicknesse at which the deepest or extreame Red is most copiously reflected in the same series. Also by the 5t & 14th Observations a6 & ho will denote the thicknesse at which those extreame colours are most copiously reflected in the second series, & so on. And the thicknesse at which any of the intermediate colours are reflected most copiously, will be defined by the intermediate parts of the lines 2l, 6O, &c; according to the 15th Observation

But further to define the latitude of these colours in each ring or series, let a1 designe the least thicknesse & a3 the greatest thicknesse at which the extreame purple in the first series is reflected, & let hk & hm designe the like limits for the extreame red, & the intermediate colours be limited by the intermediate parts of the lines 1k,& 3m. And in the second series let those limits be the lines 5n & 7p; and so on.

This being premised, to know what colour must in the open Air be exhibited at any thicknesse of a plated body, let a ruler be applyed parallel to ah, at that distance from it by which the thicknesse of the <522v> plate is represented: & the shaddowed spaces which it crosseth will denote the reflected originall colours of which the colour exhibited in the open Air is compounded. Thus if the constitution of the green in the third series of colours be desired; apply the Ruler as you see at XZ, & by its passing through some of the blew at X & yellow at Z, as well as through the green at Y, you may conclude that the green exhibited at that thicknesse of the plate, is principally constituted of originall green but not without a mixture of some blew & yellow.

By this meanes you may know how the colours from the center of the rings outwards ought to succeed in order as they were described in the 4th Observation. For if you move the Ruler gradually from ah through all distances, it will first arrive at 1 the violet, & then very quickly at the blew & green which together with that violet compound blew, & then at the yellow & red by whose further addition that blew is converted into whitenesse, which whitenesse almost continues during the transit from k to 3, & after that by the successive deficience of its component colours it turnes first to compound yellow & then to red, & last of all the red ceaseth at m. So that in this first series the colours on either side the white are compounded much after the same manner with those of the Prism explained in the 8th Experiment, but the violet & blew are here but very little in proportion to the red & yellow. Then begin the colours of the second series which succeed in order between 5 & p, & are more lively then before, because more expanded & severed. And for the same reason instead of the former white there intercedes between the blew & yellow a mixture of orang, yellow, green, blew, & some blewish violet, all which together ought to exhibit a dilute & imperfect green. So the colours of the third series all succeed in order, first the violet which a little interferes with the red of the second Order, & is thereby inclined to a reddish purple; then the blew & green which are lesse mixed with other colours & consequently more lively then before, especially the green; then follow the yellow & red which are mixed with the violet & blew of the 4th series, whereby various degrees of yellow, & Red inclining to purple are compounded, & the blew is much diminished being almost mixed with the former Red by the mixture of red. Then follows a pretty copious green which is the most eminent & conspicuous colour in that 4th series; & after that the severall series interfere more & more & their colours become more & more intermixed till after 3 or 4 more revolutions (in which the Red & Blew predominate by turnes) all sorts of colours are in all places pretty equally blended compound an eaven whitenesse.

And since by the 16th Observation one colour is transmitted where another is reflected, the reason of the colours made by the transmitted light in the 13th Observation is also hence evident.

But further to explain the Phænomena of the 2d & 3d Observations <523r> that is how the colours may (by turning the Prisms about their common axis the contrary way, to that expressed in those observations) be converted into white & black rings, and afterwards into colours again in an inverted order: it must be remembered that those colours are dilated by the obliquation of the rays to the plated Air, & that according to the table in the 7th observation, their dilatation or recession from their common center is most manifest & speedy when they are obliquest. Now the rays of yellow being more refracted by the first superficies of the Air which intercedes the Glasses then those of red, are thereby made more oblique to the second superficies at which they are reflected to produce these colours. And consequently the yellow in each ring will be more dilated then the red, & the excesse of its dilatation will be so much the greater by how much the greater is the obliquity of the rays. untill at last it become of equall extent with the red of the same ring. And for the same reason the green blew & violet will be also so much dilated by the still greater obliquity of their rays as to become all very nearely of equall extent with the red, that is, equally distant from the center of the rings. And then all the colours of the same series must be coincident, & by their mixture exhibit a white ring. And these white Rings must have black or dark rings between them because they doe not spread & interfere with one another as before. And for that reason also they must be distincter & visible to far greater numbers. But yet the violet being obliquest will be something more dilated in proportion then the other colours, & so very apt to appeare at the exterior verges of the white.

Afterwards by a greater obliquity of the rays, the violet & blew become sensibly more dilated then the red & yellow, & so being further removed from the center of the rings, the colours must emerge out of the white in an order contrary to that which they had before, the violet & blew at the exterior limbs of each Ring & the red & yellow at the interior. And the violet by reason of the greatest obliquity of its rays being in proportion most of all expanded, will soonest appeare at the exterior limb Ring , & become more conspicuous then the rest. And then the severall series of colours by their unfolding & spreading will begin again to interfere, & thereby render the rings lesse distinct & not visible to so great numbers.

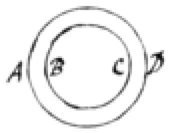
There is yet another circumstance of these experiments to be considered, & that is why the black & white Rings which when viewed at distance appeare distinct, should not onely become confused by viewing them neare at hand, but also yeild a violet colour at both the edges of every white Ring. And the reason is that the rays which **{**let**}**the eye at severall parts of the pupill, have severall obliquities **{illeg}** **{**the**}** <523v> Air which is between the Glasses, & those which are the most oblique, if considered apart would represent the circles bigger then those which are the least oblique. Whence the breadth of the perimeter of every Ring is expanded outwards by the obliquest rays & inwards by the least oblique. And this expansion is so much the greater by how much the greater is the difference of obliquity, that is, by how much the pupill is wider, or the eye nearer to the glasses. And the breadth of the violet must be most expanded because the rays apt to excite a sensation of that colour are most oblique to the further superficies of the plated Air at which they are reflected, & have also there the greatest variation of obliquity, which makes that colour soonest emerge out of the edges of the white. Also as the breadth of each circle is thus augmented, the dark intervalls must be diminished untill the neighbouring rings become continuous & are blended, the exterior first, & then those nearer the center, so that they can no longer be distinguished apart, but seem to constitute an eaven & uniforme whitenesse.

These are the principall Phænomena of thin Plates or Bubbles whose explications depend on the properties of light that I have heretofore delivered, & these you see do necessarily follow from them, & punctually agree with them even to their very least circumstances; & not onely so, but very much tend to their proof. For considering the multitude of rings & other circumstances in the 3^{d} & 17^{th} Observations nothing can be more evident then that although in the 4^{th} Observation there appeare no more then 8 or 9 rings of colours yet there are really a far greater number which so much interfere & mingle as after those 8 or 9 revolutions to dilute one another wholly & constitute an eaven & sensibly uniform whitenesse. And consequently that whitenesse must be allowed a mixture of all colours.

To make this more fully appeare I shall tell you another very odd experiment which these considerations not long since suggested to me, & upon tryall succeded somthing beyond my first expectations. And it is that when the two Object-glasses, as in the said 4^{th} Observation were layd one upon the other so as to make the coloured rings appeare, though with my naked eye I could not discerne above 8 or 9 of those rings yet by viewing them through a Prism I have seen a far greater multitude, insomuch that I could number more then fourty besides many others that were so very small & close together that I could not keep my eye so steddy, on them severally as to number them. But by their extent I have sometimes estimated them to be more then a hundred, & I beleive the experiment may be improved to the discovery of far greater numbers. For they seem to be really unlimited, though visible onely so far as they can be separated by the refraction. <524r> I have sometimes so layed one Object-glasse on the other that to the naked eye they have all over seemed uniformely white without the least appearance of any of the coloured rings, & yet by viewing them through a Prism great multitudes of those rings have discovered themselves. And in like manner plates of Muscovy-glasse & bubbles of water & of glasse blown at a lamp furnace which were not so thin as to exhibit any colours to the naked eye, have through the Prism exhibited a great variety of them ranged irregularly up & down the plate in the forme of waves. From whence it deserves to be considered that out of light or whitenesse in appearance uniform, & without any termination with shaddow or darknesse colours may be made to emerge by viewing it through a Prism. And that the refractions of a Prism which render almost all things confused that to the naked eye appeare distinct should make these rings appeare exceedingly distinct which to the naked eye are so confused & blended together as not at all to be discernable apart. By the first consideration the whitenesse must be allowed a heterogeneall mixture or confusion of those coloured circles which emerge. By the second it is manifest that the refractions of each ray considered apart are regularly performed without spreading or dissipating it into any diverging parts. For admitting such an irregularity it would be impossible for refractions to render those circles so very distinct & well defined. And from both the said considerations it follows that the rays of severall colours made as well by plated bodies as by the refractions of Prisms have severall degrees of refrangibility whereby those of each order which at their reflexion are intermixed with those of other orders, are separated from them by refraction, & associated together so as to become visible by themselves

But before I further give you the reason of these Phænomena tis convenient that I describe their circumstances more particularly, the principall of which are these. That it was but one side of the rings made by the two Object glasses, namely that towards the angle of the Prism comprehended by the refracting planes, which by the refraction was rendered distinct, & the other side became more confused then to the naked eye, in so much that there, I could not discerne above one or two & sometimes none of those rings of which I could discerne 8 or 9 with my naked eye. Also the order of the colours neare the center on that side towards the distinct arcs was usually inverted. And if the refraction was too great the middle part of those arcs became confused so as to constitute in appearance an uniforme whitenesse, whilst on either hand the ends of those arcs, as also the whole arcs furthest from the center became distintc**{**test**}** <524v> And the arcs where they appeared distinctest, were onely white & black successively without any other colours intermixed. So that if I first held the Prism very neare the object glasses & then gradually removed it further of towards my eye, the colours of the 2^{d}, 3^{d}, & 4^{th} rings &c shrunk towards the white that emerged between them untill they wholly vanished into it at the middle of the arcs & afterwards emerged again in a contrary order. to that at the ends.

Having told you these circumstances the reason of them you will perceive by supposing the concentrick circles AD & BC to represent the red & violet of any order or revolution of the colours. For these being viewed through a Prism the violet circle BC will by a greater refraction be further translated from its place then the red AD, & so approach nearer to it on that side towards which the refractions are made.



For instance if the red be translated to ad, the violet may be translated to bc so as to approach nearer to it at c then before & if the red be further translated to ad, the violet may be so much further translated to bc as to convene with it at c, & if the red be further translated to αδ, the violet may be still so much further translated to βγ as to passe beyond it at γ & convene with it at e & f. And this being understood not onely of the red & violet but of all the other intermediate colours & also of every revolution of those colours, you will easily perceive how those of the same revolution or order by their nearnesse at cd & δγ, & their coincidence at cd, e & f ought to constitute pretty distinct arcs of circles (especially at cd o**{illeg}** at e & f) & that they will appeare severally at cd, at cd exhibit whitenesse by their coincidence, & again appeare severally at δγ, but yet in a contrary order to that which they had before & still retain beyond e & f. But on the other side at ab, ab, or αβ these colours must become much more confused by being dilated & spread so as to interfere with those of other orders. And the same confusion will happen at δγ between e & f if the refraction be very great, or the Prism very distant from the object-glasses, in which case no parts of the ring will bee seen save onely two little arcs at e & f, whose distance from one another will be augmented by removing the Prism still further from the object glasses. And these must be distinctest & whitest at their middle, & at their ends where they begin to grow confused they must be coloured. And the colours at one end of every arc must be in a contrary order to those at the other end, by reason that they crosse in the intermediate white. Namely their ends which verge towards δγ will be red & yellow on that side <525r> next the center, & blew & violet on the other side, But their other ends which verge from δγ will be on the contrary be blew & violet on that side towards the center, & on the other side red & yellow.

For confirmation of all this I need allege no more then that it is mathematically demonstrable from my former Principles. But yet I shall add that they which please to take the paines may by the testimony of their senses be assured that these explications are not Hypotheticall but infallibly true & genuine . For in a dark Room by viewing these rings through a Prism by reflexion of the severall Prismatick colours which an Assistant causes to move to & fro upon a wall or paper from whence they are reflected, whilst the spectators eye, the Prism, & the object-glasses (as in the 14th Observation) are placed steddy: the position of the circles made by the severall colours successively, will be found such in respect of one another as I have described at abcd, or abcd, or αβδγ. ✝

Concerning small fragments of glasse plates there is this further observable, that if they lying flat upon a table be turned about their centers, whilst they are viewed through a Prism; the most of them will in all positions exhibit waves, & that for the most part appearing almost all over the glasse, [& parallel or almost parallel to the length of the Prism]. ✝ The reason is that the superficies of such plates are not eaven but have many cavities & swellings which how shallow soever do a little vary the thicknesse of the plate . And by the severall sides of those cavities there must be produced waves in severall postures of the Prism. Now though it may be but some very small & narrow parts of the glasse whereby these waves for the most part are caused yet they may seem to extend themselves over the whole glasse, because from the narrowest of those parts there are colours of severall orders confusedly reflected which by refraction of the prism are unfolded & dispersed to severall places so as to constitute so many severall waves as there were divers orders of the colours promiscuously reflected from that part of the glasse.

[2] I come now to the last part of this designe, which is to consider how the Phænomena of thin transparent Plates stand related to those of all other naturall bodies, the usuall objects of our senses; ✱ that we may be in some measure enabled to understand what constitutions are requisite in those bodies to make them appeare of various colours. And this I shall endeavour in the following propositions.

1. That the small parts of all naturall bodies (those of metalls perhaps & some other ponderous minerall substances which are of a mercuriall originall being excepted) are transparent. And to this they that have been conversant with Microscopes will easily assent.

2. That between the parts of coloured or opake bodies are many intervalls replenished with Mediums of other densities; as water between the tinging corpuscles wherewith any liquor is impregnated, Air between the **{illeg}** globules that constitute clouds or mists most part spaces voyd of both Air & water but yet perhaps replenished with some subtiler Medium between the parts of naturall bodies And this also will easily be **{illeg}** by them that have contemplated bodies by the assistance of a Microscope or <525v> by chemicall examinations observed their heterogeneous constitution or taken notise how they may be pervaded by Menstruums, & Metalls by Quicksilver. But yet for further assureance you may remember that according to the 1st Observation there is no reflexion made in the superficies of homogeneall parts of pellucid bodies where they are contiguous; but if they be of different densities there will be a reflexion proportionall to that difference. As may be tryed in glasse which reflects lesse when contiguous to water then when to Air, & still lesse when contiguous to spirit of wine or oyle of vitrioll. So that to render bodies very opake tis either requisite that their density differ very much from the density of the adjacent Medium, Or that multitudes of reflecting superficies succede one another, the latter of which may interrupt the rays which passe through the former. From the first of these causes may arise the opacity of Quicksilver which seems to reflect all the light incident on its outmost superficies; & from the last must be derived the opacity of bodies which are not so dense as to have their least parts opake. And that this is a sufficient cause you will easily apprehend by considering that the most transparent substances may by separating their parts be rendered sufficiently opake, as water by being formed into many small bubbles, or glasse by being reduced to powder or otherwise flawed And that by the 18th Observation the reflexions of very thin transparent substances are considerably stronger then those made by the same substances of a greater thicknesse. And also by the 12th Observation that the colours of a denser substance incompassed with a rarer are more strong & lively then those of a rarer substance incompassed with a denser. To which I may add that if something conduces to the reflexion of solid bodies that the interstices of their parts are voyd of Air. For that for the most part they are so is reasonable to beleive, considering the ineptitude which Air hath to pervade small cavities, as appeares by the ascention of water in glasse pipes, paper, cloth & other such like substances whose pores are found too small to be replenished with Air & yet large enough to admit water; & by the difficulty wherewith Air pervades the pores of a bladder through which water finds ready passage. And according to the 10th Observation, the cavities thus voyd of Air will cause the same kind of effects as to reflexion which those do that are replenished with it, but yet something more manifestly because the Medium in relation to refractions is rarest when most empty of Air as Mr Hook hath proved in his Micrographia. In which book he hath also largely discoursed of these two Propositions, & delivered many other very excellent things concerning the colours of plated & other naturall bodies, which I have not scrupled to make use of so far as they were for my purpose.

3. The parts of bodies & their interstices must not be lesse then of some definite bignesse to render them opake or coloured. F the opakest bodies if their parts be very subtily divided (as metalls by being dissolved in acid Menstruums &c) become perfectly transparent. And you may also remember that in the 8th Observation there was no reflexion at the superficies of the Object-glasses where they were very neare one another though they did not absolutely touch. On these grounds also I <526r> conceive it is that water, salts, glasse; stones & such like substances are transparent. For upon divers considerations they seem to be as porous as other bodies, but yet their pores too small to cause any opacity.

4. The transparent parts of bodies according to their severall sizes must reflect rays of one colour & transmit those of another, on the same grounds that plated bodies doe reflect or transmit those rays. And this I take to be the ground of all their colours. For if a plated body which being of an eaven thicknesse appeares all over of one uniform colour; should be broken into fragments of the same thicknesse with the plate; I see no reason why a heap of those fragments should not constitute a pouder of the same colour which the plate exhibited before it was broken. And the parts of all naturall bodies being like soe many fragments of a plated body, must on the same grounds exhibit the same colours. Now that they doe so will further appeare by the affinity of their properties. As that the infusion of Nephritic Wood & many other substances reflect one colour & transmit another, like plated bodies in the 13 Observation That the colours of silks, cloaths, & other substances which water or oyle can intimately penetrate, become more faint & obscure by being immerged in those liquors & recover their vigor again by being dryed, much after the manner declared of plated bodies in the 9th & 11th Observations. And That some of those coloured pouders which Painters use may have their colours a little changed by being very elaborately & finely ground. Where I see not what can be justly pretended for those changes besides the breaking of their parts into lesse parts by that contrition, after the

same manner that the colour of a plate is changed by varying its thicknesse. For which reason also it is that many flowers by being brused become more transparent then before or at least in some degree or other change their colours. Nor is it much lesse to my purpose that by mixing divers liquors, very odd & remarqueable productions & changes of colours may be effected, of which no cause can be more obvious & naturall then that the saline corpuscles of one liquor doe variously act upon or unite with the tinging corpuscles of another liquor so as to make them swell or shrink, (whereby not onely their bulk but their density also may be changed) or to divide them into smaller corpuscles, or make many of them associate into one cluster. For we see how apt those saline Menstruums are to penetrate & dissolve substances to which they are applyed & some of them to precipitate what others dissolve. In like manner if we consider the various Phænomena of the Atmosphære, we may observe that when vapors are first raised, they hinder not the transparency of the Air, being divided into parts too small to cause any reflexion in their superficies. But when in order to compare drops of rain they begin to coalesce & constitute globules of all intermediate sizes; those globules when they become of a convenient size to reflect some colours & transmit others, may constitute clouds of colours according to their sizes. And indeed I see not what can be rationally conceived in so transparent a substance as water for the production of these colours besides the various sizes of its parcells, which seem to affect a globular figure most, but yet not without some instability in the smallest **{**of them**}** by reason that those are most easily agitated by heat or any **{illeg}** <526v> in the Air.

5. By meanes of the 4^{th}, 5^{t}, 6^{t}, 9^{th} & 11^{th} Observations, we may be inabled in some measure to guesse at the bignesse of the parts of a body by its colour, provided that those parts must be of the same thicknesse with a plated body of equall density to exhibit the same colour. And to this end I have in the following table expressed the thicknesse of plated Air, Water, & Glasse requisite to produce the severall colours of each order. The method which I used to determine it was by moving a streight Ruler over the precedent scheme parallel to the line ah, as I told you. In which scheme suppose st, tv, vw &c to represent the difference of the thicknesses of plated Air exhibiting the severall orders of yellow that is $\frac{1}{80000}$ of an inch according to the 6^{t} Observation; & rs will be half that difference or $\frac{1}{160000}$. Which being known, the thicknesse requisite to exhibit any other colour is easily determined by that scheme.

And since by the 9^{th} Observation the thicknesse of plated Air is to that of plated water exhibiting the same colour, as 4 to 3, & to that of plated glasse as 31 to 20; the thicknesse of those plated Mediums at which they represent any colour will on the same grounds be also determined. And these thicknesses at which each colour is most intense & specific in the foure first orders, I have in the following Table expressed in parts of an inch divided into ten hundred thousand parts.

		The	thicknesse	of
		Air	Water	Glasse
	Violet	$2\frac{1}{2}$	2	$1\frac{2}{3}$
The Colours	Blew	3	$2\frac{1}{4}$	2
Of the	White	6	$4\frac{1}{2}$	4
first Order	Yellow	$8\frac{3}{4}$	$6\frac{1}{2}$	$5\frac{2}{3}$
	Red	$10\frac{1}{3}$	$7\frac{3}{4}$	$6\frac{2}{3}$
	Violet	$13\frac{1}{3}$	10	$8\frac{1}{2}$
Of the	Blew	$15\frac{2}{3}$	$11\frac{3}{4}$	10
2^{d} Order	Green	17	$12\frac{3}{4}$	11
	Yellow		14	12

		$18\frac{2}{3}$		
	Red	22	$16\frac{1}{2}$	$14\frac{1}{5}$
	Violet	25	$18\frac{3}{4}$	16
Of the	Blew	27	$20\frac{1}{4}$	$17\frac{1}{2}$
3^{d} Order	Green	29	$21\frac{3}{4}$	$18\frac{2}{3}$
	Yellow	$31\frac{1}{3}$	$23\frac{1}{2}$	$20\frac{1}{5}$
	Red	$34\frac{1}{2}$	26	$22\frac{1}{4}$
	Purple	37	$27\frac{3}{4}$	24
Of the	Blew	$38\frac{3}{4}$	29	25
4th order	Green	41	31	$26\frac{1}{2}$
	Yellow	$43\frac{1}{2}$	$32\frac{1}{2}$	28
	Red	$46\frac{1}{3}$	$34\frac{3}{4}$	30

Now since the parts of naturall bodies are supposed to exhibit the same colours with a plated body of equall thicknesse, provided they have the same refractive density; & since their parts seem for the most part to have much the same density with water or glasse, as by many circumstances is obvious to collect: you need onely have recourse to the tables for water or glasse to determin the sizes of these parts. Thus if it be desired to know the diameter of a corpuscle which being of equall density with glasse, shall reflect green of the third order; the number $18\frac{2}{3}$ shows it to be about $\frac{18\frac{2}{3}}{1000000}$ parts of an inch.

It is not impossible but that the sizes of the pores of bodies may sometimes conduce to the production of their colour. And for that reason I have added a table for plated Air whose refractive density is not considerally <527r> different from that of spaces voyd of Air such as I suppose to be the pores of bodies. But yet these pores seem to be of such irregular sizes that I cannot understand how they should all conspire to reflect any one colour much more then another

By the way I cannot but observe another use to be made of this Table which is to determin what colour must be produced by laying two or more plated bodies upon one another so as to compose one plate equalling them all in thicknesse. For instance M^{r} Hook observes that a faint yellow plate of Muscovy Glasse layd upon a blew one constituted a very deep purple. Now the yellow of the first order is a faint one, & the thicknesse of the plate exhibiting it according to the Table is $5\frac{2}{3}$, to which add 10 the thicknesse exhibiting blew of the second order & the summ will be $15\frac{2}{3}$ which most nearely approaches 16 the thicknesse exhibiting the purple of the third order.

But to apply these Tables more particularly to the determining the sizes of the parts of bodies by their colours tis convenient that I now consider to what order the intensest colours are most usually to be referred, which will be easily done by meanes of the fourth Observation as it is explained by the afforesaid Scheme.

And first for Scarlet & other Reds oranges & Yellows, if they be pure & intense they are most probably of the second order. Those of the 1 & 3 order also may be pretty good, onely the Red of the 3^{d} order hath too great a mixture of Blew & Violet.

There may be very good Greens of the 4th order but the purest are of the third. And of this order I conceive the green of all Vegetables to be, partly from the intensenesse of their colours & partly because when they wither some of them turne to a greenish yellow, others to more perfect yellow or Orange, or perhaps to Red passing first through all the aforesaid intermediate colours. changes seem to be effected by the exhaling of the moisture which leaves the tinging corpuscles more dense, & something augmented by the accretion of the oyly & earthy part of that moisture. Now the Green without doubt is of the same order with those colours into which it changeth because the changes are graduall, & those colours though usually not very pure yet for the most part are too pure & lively to be of the fourth order.

As for Blews & Purples they may be either of the second or third order. But the best are of the third. Thus the colour of Violets seems to be of that order, because their **{**Syrup**}** by acid liquors turne red & by urinous or alcalizate turne green Now since it is of the nature of acids to dissolve or alternate & of Alcalies to precipitate or incrassate, if the purple colour of the Syrup was of the second order, an acid liquor by attenuating its tinging corpuscles would change it to a red of the first order, & an Alcaly by incrassating them would change it to a green of the second order, which red & green especially the Green seem too imperfect to <527v> be the colours produced by these changes. But if the said purple be supposed of the third order, its change to red of the 2d & green of the third order may without any inconvenience be allowed.

Whitenesse if it be intense is either that in the first order of colours, (of which sort perhaps is the colour of white Lead,) or else it is a mixture of those succeding the 3r or 4th order, such as is the colour of paper, ffroth, linnen, & most white substances. If corpuscles of various sizes exhibiting the colours of the second & third order be mixed they should rather to constitute an imperfect whitenesse or Grey of which I have already spoken. But yet it seemes not impossible for them to exhibit an intense whitenesse if they be disposed to transmit all the light which they reflect not, & do not retain & stifle some of it. For thus I told you that froth at a distance hath appeared very white & yet neare at hand the severall bubbles of which it was constituted. were seen all over tinged with Rings of colours. of the four or five first orders

Lastly for the production of Black the corpuscles must be lesse then any of those which exhibit colours, because at all greater sizes there is too much light reflected to constitute this colour. But if they be supposed a litle lesse then is requisite to reflect the Blew of the first order they will according to the 8th Observation reflect so very little light as to appeare intensely black by which meanes they will appear black in all positions of the eye without any transparency & yet may perhaps variously refract it to & fro within themselves so long untill it happen to be stifled & lost. And this seemes to be confirmed by these considerations that Glasse ground very elaborately with sand n a Copper plate till it be well polished makes the sand together with what is worne of from the glasse & Copper become very black. That Fire & the more subtile dissolver Putrefaction turne substances to black. And that black substances do the soonest of all others become hot & burne, which effect may procede partly from the multitude of refractions in a little room, & partly from the easy commotion of so very small corpuscles. To which I may add this further consideration that blacks are usually a little inclined to a blewish colour as may be manifestly seen by illuminating white paper by reflexion from black substances, for the paper will usually appeare of a blewish white. And this ought to happen because black bordering on the obscure blew of the first Order, described in the Observation the larger corpuscles of black substances will reflect that colour.

In the **{**thus**}** description of these colours & their origine I have been the more particular I have been the more particular because I hope that Microscopes will at length be improved to the discovery of their colorific corpuscles. For if those instruments can be so far improved as with sufficient distinctnesse to represent objects five or six hundred times bigger then at a foot distance they appeare to the naked eyes, I should hope that wee might be able to discover some of the greatest of those corpuscles. And by one that would magnify two or thre thousand times perhaps they might all be discovered but those which produce blacknesse. In the meane while I see not any thing materiall that can rationally be doubted of excepting this Position, **{**That transparent**}** <528r> corpuscles of the same thicknesse & density with a plated body doe exhibit the same colour. And this I would have understood not without some latitude as well because those corpuscles may be of irregular figures, & many rays must be obliquely incident & so have a shorter way through them then the length of their diameter, as because the straitnesse of the Medium pent in on all sides may a little alter its motions or other qualities on which the reflexion depends. But yet I cannot much suspect the last because I have observed of some small plates of Moscovy glasse which were of an eaven thicknesse, that through a

Microscope they have appeared of the same colour at their edges & corners where the included Medium was terminated, which they appeared of in other places. However it will add much to our satisfaction if these corpuscles can be discovered with Microscopes, which if we shall at length attain to, I feare it will be the utmost improvement of this Sence. For it seemes impossible to see the more secret & noble workes of nature within those corpuscles by reason of their transparency.

[3] If it were now my designe to conjecture at the causes of these Properties which I have ascribed to light, & show whence its rays may have their different dispositions to excite in us the sensation of severall colours, & accordingly differ in refrangibility, & also in their reflectibility from plated bodies of severall thicknesses or corpuscles of severall sizes: it would be necessary for me to pitch upon some Hypothesis. And I find none that so well answers all things as that which Mr Hook hath chosen for me; namely that Light is corporeall & consists of multitudes of very little bodies emitted every way from shining substances. Now these I should suppose to be of different sizes & velocities & accordingly to suffer different refractions in the passing out of one Medium into another; as we may observe that stones being thrown into water, the swiftest are least diverted from their course. Bur further as Air is observed to be of its own accord the thinnest in the smallest cavities, so I should suppose Æther to be thinnest in the densest bodies whose pores I take to be the smallest; & thence it might easily be explicated why refractions made into the denser Medium, are towards the perpendicular, & that in a certain proportion of the sines

As to reflexions I should suppose them to be caused by the rigidnesse of the superficies of Æther such as is found in the superficies of all other fluids. Now when the irradiated corpuscles impinge on these superficies, they must excite an undulation in the Æther, something after the manner that stones thrown into water cause an undulation in its superficies. And in their passage through plated bodies if they arrive at the further superficies at the same time with the compressed <528v> & condensed part of the vibrations excited at the first superficies they are reflected, but if they arrive there with the relaxed & rarefied part they are transmitted. For the rigidnesse of the reflecting superficies must be increased or diminished accordingly as the Æther is comprest or relaxed; not to mention that the contrary motions on contrary sides of the wave may very much conduce to this effect. This I conceive will suffice to explicate how it may depend on the thicknesse of a plate or corpuscle whither light shall be reflected or transmitted, & how light may be reflected at one thicknesse & transmitted at another to an indefinite number of successions. And if it be further supposed that the rays which cause a violet & blew colour excite shorter vibrations in the Æther then those which cause red & yellow, it will also appeare why the first should be reflected at a lesse thicknesse of a Plate then the last.

But further when light is incident on the bottom of the eye it must excite the same vibrations in the Æther which pervades the Retina that it doth in that of all other transparent substances. And those vibrations being propagated in order through the severall fibers of the Optick nreve into the Brain may there affect the soule with a sensation of various colours according to their various proportions, something after the manner that various sounds are produced by various proportions of the vibrations of the Air. The harmony and discord also which the more skilfull Painters observe in colours may perhaps be effected & explicated by various proportions of the æthereall vibrations as those of sounds are by the aëreall. To which end I would suppose the vibrations causing the deepest scarlet to be those causing the deepest violet as two to one; for there would be all that variety in colours which within the compasse of an eight is found in sounds, & the reason why the extreames of colours Purple & scarlet resemble one another would be the same that causes Octaves (the extreames of sounds) to have in some measure the nature of unisons.

I should further suppose that when an irradiated corpuscle of light in passing through a body chanceth to impinge on any of its parts, it will not be reflected but stick fast till by the dissolution of that body, or some new commotion it be again set at liberty. And by this meanes it is that many bodies appeare obscure or black, namely those which refract or reflect light so long to & fro within themselves till it happen to dash against their parts. And to give you an account why they then stick fast, you may consider how Air excluded from between two polished marbles or plates of glasse causeth them strongly to adhhere by compressing them together on the out side. So Æther may cause the suspension of Quicksilver in the Torricellian experiment at a much greater height then 29 inches; for it ought to croud the parts of such bodies together since it is supposed to be more dense & springy without then within them. And this seemes to be the principall cause of the cohesion of the parts of all naturall bodies, composing them for the most part first into those very small clusters which I have hitherto called corpuscles, & then aggregating those clusters into greater **{illeg}**. And much after the same manner it is that when a corpuscle of light <529r> To these I added two other Rules, whereof one was to know the proportion of the sines measuring the refractions of homogeneall rays made out of one Medium into another, by knowing the proportion of the sines measuring the refractions of those rays made out of Air or any third Medium into those two. And the other was to know the difference of the refractions of heterogeneall rays alike incident out of any Medium into any other Medium, by knowing the difference of their refraction out of glasse into Air

The first Rule is, that as the ratio of the given sines of incidence to the ratio of the given sines of refraction, so are the desired sines of incidence & refraction to one another. For instance if the sine of incidence be to the sine of refraction out of Air into water as 4 to 3, & out of Air into Glasse as 31 to 20 to know the refractions out of water into glasse, I say as $\frac{31}{4}$ the ratio of the given sines of incidence to $\frac{20}{3}$ the ratio of the given sines of refraction, that is as 93 to 80, so is the sine of incidence to the sine of refraction made out of water into glasse.

The other Rule is, that if refractions be made out of divers Mediums into one common Medium with equall incidence, the differences between the common sine of incidence & the sines of the refractions of difform rays shall have a given ratio. Suppose for instance the common sine of incidence out of glasse into Air be 44 $\frac{1}{4}$, & the sine of refraction for the utmost purple 69, for the utmost red 68, & for the meane between blew & green (the rays which have a middle degree of refrangibility) $68\frac{1}{2}$. So shall their difference be $24\frac{3}{4}$ $23\frac{3}{4}$ & 24 $\frac{1}{4}$. Suppose further that the sine of incidence out of water into air for the said meane rays between blew & green be to the sine of refraction as 3 to 4. Then say as 1 the difference of these sines to 3 the sine of incidence, so $24\frac{1}{4}$ the difference of the other correspondent sines, to a fourth number $72\frac{3}{4}$, which instead of 3 suppose to be the common sine of incidence out of water into Air, & to it adding $24\frac{3}{4}$, $23\frac{3}{4}$, & $24\frac{1}{4}$, you have $97\frac{1}{2}$, $96\frac{1}{2}$, & 97 the sines of refraction of the afforesaid rays, namely $97\frac{1}{2}$ of the utmost purple $96\frac{1}{2}$ of the utmost red & 97 of the rays exhibiting a middle colour between blew & green.

In like manner to know the refractions of difform rays made out of water into Glasse, suppose their common sine of incidence out of Air into Glasse be 106, & the sines of refraction of the extreame purple 68 of the extreme red 69, & of the middle rays exhibiting a colour between blew & green $68\frac{1}{2}$. Which sines subduct from the sine of incidence, & there remains 38, 37, & $37\frac{1}{2}$. Suppose also that the sine of incidence out of water into glasse for the said middle rays is to the sine of refraction as 93 to 80 & say as 13 the difference of these sines to 93 the sine of incidence so $37\frac{1}{2}$ the difference of the other correspondent sines to a fourth number $264\frac{9}{13}$, which being put the common sine of incidence if you subtract from it 38, 37, & $37\frac{1}{2}$, the remainders $226\frac{9}{13}$, $227\frac{9}{13}$, & $227\frac{5}{26}$ will be the sines of refraction out of water into glasse for the afforesaid difform rays.

[1] Of the colours of plated transparent substances.

[2] Of the Colours of naturall bodies.

[3] An Hypothesis hinted at for explicating all the aforesaid properties of light