

THE NATURE OF LIGHT

Isaac Newton

Opticks

FOURTH EDITION

London, 1730

Qu. 28. Are not all Hypotheses erroneous, in which Light is supposed to consist in Pression or Motion, propagated through a fluid Medium? For in all these Hypothesis the Phaenomena of Light have been hitherto explain'd by supposing that they arise from new Modifications of the Rays; which is an erroneous Supposition.

If Light consisted only in Pression propagated without actual Motion, it would not be able to agitated and heat the Bodies which refract and reflect it. If it consisted in Motion propagated to all distances in an instant, it would require an infinite force every moment, in every shining Particle, to generate that Motion. And if consisted in Pression or Motion, propagated either in an instant or in time, it would bend into the Shadow. For Pression or Motion cannot be propagated in a Fluid in right Lines, beyond an Obstacle which stops part of the Motion, but will bend and spread every way into the quiescent Medium which lies beyond the Obstacle. Gravity tends downward, but the Pressure of Water arising from Gravity tends every way with equal Force, and is propagated as readily, and with as much force sideways as downwards, and trough crooked passages as through strait ones. The Waves on the Surface of stagnating Water, passing by the sides of a broad Obstacle which stops part of them, bend afterwards and dilate themselves gradually into the quiet Water behind the Obstacle. The Waves, Pulses or Vibrations of the Air, wherein Sounds consist, bend manifestly, though not so much as the Waves of Water. For a Bell or a Cannon may be heard beyond a Hill which intercepts the sight of the sounding Body, and Sounds are propagated as readily through crooked Pipes as through streight ones. But Light is never known to follow crooked Passages nor to bend into the Shadow. For the fix'd Stars by the Interposition of any of the Planets cease to be seen. And so do the Parts of the Sun by the Interposition of the Moon, *Mercury* of *Venus*. The Rays which pass very near to the edges of any Body, are bend a little by the action of the Body, as we are shew'd above; but this bending is not towards but from the Shadow and is perform'd only in the passage of the Ray by the Body, and at a very small distance from it. So soon as the Ray is past the Body, it goes right on.

To explain the unusual Refraction of Island Crystal by Pression or Motion propagated, has no hitherto been attempted (to my knowledge) except by *Huygens*, who for that end supposed two several vibrating Medium within that Crystal. But when he tried the Refractions in two successive pieces of that Crystal, and found them such as is mention'd above; he confessed himself at a loss for explaining them. For Pression or Motion, propagated from a shining Body through an uniform Medium, must be on all sides alike; whereas by those Experiments it appears, that the Rays of Light have different Properties in their different Sides. He suspected that the Pulses of *Æther* in passing through the first Crystal might receive certain new Modifications, which might determine them to be propagated in this or that Medium within the second Crystal, according to the Position of that Crystal. (pag. 336- 338)

[...]

And it is as difficult to explain by these Hypotheses, how Rays can be alternately in Fits of easy Reflexion and easy Transmission; unless perhaps one might suppose that there are in all Space two *Æthereal* vibrating Mediums, and that the Vibrations of one of them constitute Light, and the Vibrations of the other are swifter, and as often as they overtake the Vibrations of the first, put them into those Fits. But how two *Æthers* can be diffused through all Space, one of which acts upon the other, and by consequence is re-acted upon, without retarding, shattering, dispersing and confounding one anothers Motions, is inconceivable. And against filling the Heavens with fluid

Mediums, unless they be exceeding rare, a great Objection arises from the regular and very lasting Motion of the Planets and Comets in all manner of Courses through the Heavens. For thence it is manifest, that the Heavens are void of all sensible Resistance, and by consequence of all sensible Matter. (pag. 339)

Qu. 29. Are not the Rays of Light very small Bodies emitted from the shining Substances? For such Bodies will pass through uniform Mediums in right Lines without bending into the Shadow, which is the nature of the Rays of Light. They will also be capable of several Properties, and be able of conserve their Properties unchanged in passing through several Mediums, which is another Condition of the Rays of Light. Pellucid Substances act upon the Rays of Light at a distance in refracting, reflecting, and inflecting them, and the Rays mutually agitate the Parts of those Substances at a distance for heating them; and this Action and Re-action at a distance very much resembles an attractive Force between Bodies. If Refraction be perform'd by Attraction of the Rays, the Sines of Incidence must be to the Sines of Refraction in a given Proportion, as we shew'd in our Principles of Philosophy: And this Rule is true by Experience. The Rays of Light in going out of Glass into a *Vacuum*, are bent towards the Glass; and if they fall too obliquely on the *Vacuum*, they are bent backwards into the Glass, and totally reflected; and this Reflexion cannot be ascribed to the Resistance of an absolute *Vacuum*, but must be caused by the Power of the Glass attracting the Rays at their going out of it into the *Vacuum*, and bringing them back. For it the farther Surface of the Glass be moisten'd with Water or clear Oil, or liquid and clear Honey, the Rays which would otherwise be reflected will go into the Water, Oil, or Honey; and therefore are not reflected before they arrive at the farther Surface of the Glass, and begin to go out of it. If they go out of it into the Water, Oil, or Honey, they go on, because the Attraction of the Glass is almost balanced and rendered ineffectual by the contrary Attraction of the Liquor. But if they go out of it into a *Vacuum* which has no Attraction to balance that of the Glass, the Attraction of the Glass either bends and refracts them, or brings them back and reflects them. And this is still more evident by laying together two Prisms of Glass, or two Object-glasses of very long Telescopes, the one plane, the other a little convex, and so compressing them that they do not fully touch, nor are too far asunder. For the Light which falls upon the farther Surface of the first Glass where the Interval between the Glasses is not above the ten hundred thousandth Part of an Inch, will go through that Surface, and through the Air or *Vacuum* between the Glasses, and enter into the second Glass, as was explain'd in the first, fourth, and eighth Observations of the first Part of the second book. But, if the second Glass be taken away, the Light which goes out of the second Surface of the first Glass into the Air or *Vacuum*, will not go on forwards, but turns back into the first Glass, and is reflected; and therefore it is drawn back by the Power of the first Glass, there being nothing else to turn it back. Nothing more is requisite for producing all the variety of Colours, and degrees of Refrangibility, than that the Rays of Light be Bodies of different Sizes, the least of which may be take violet the weakest and darkest of the Colours, and be more easily diverted by refracting Surfaces from the right Course; and the rest as they are bigger and bigger, may make the stronger and more lucid Colours, blue, green, yellow, and red, and be more and more difficultly diverted. Nothing more is requisite for putting the Rays of Light into Fits of easy Reflexion and easy Transmission, than that they be small Bodies which by their attractive Powers, or some other Force, stir up Vibrations in what they act upon, which Vibrations being swifter than the Rays, overtake them successively, and agitate them so as by turns to increase and decrease their Velocities, and thereby put them into those Fits. And lastly, the unusual Refraction of Island-Crystal looks very much as if it were perform'd by some kind of attractive virtue lodged in certain Sides both of the Rays, and of the Particles of the Crystal. For were it not for some kind of Disposition or Virtue lodged in some Sides of the Particles of the Crystal, and not in their other Sides, and which inclines and bends the Rays towards the Coast of unusual Refraction, the Rays which fall perpendicularly on the Crystal, would not be refracted towards that Coast rather than towards any other Coast, both at their Incidence and at their

Emergence, so as to emerge perpendicularly by a contrary Situation of the Coast of unusual Refraction at the second Surface; the Crystal acting upon the Rays after they have pass'd through it, and are emerging into the Air; or, if you please, into a *Vacuum*. And since the Crystal by this Disposition or Virtue does not act upon the Rays, unless when one of their Sides of unusual Refraction looks towards that Coast, this argues a Virtue or Disposition in those Sides of the Rays, which answers to, and sympathizes with the Virtue or Disposition of the Crystal, as the Poles of two Magnets answer to one another. And as the Magnetism may be intended and remitted, and is found only in the Magnet and in Iron: So this Virtue of refracting the perpendicular Rays is greater in Island-Crystal, less in the Crystal of the Rock, and is not yet found in other Bodies. I do not say that this Virtue is magnetical: It seems to be of another kind. I only say, that whatever it be, it's difficult to conceive how the Rays of Light, unless they be Bodies, can have a permanent Virtue in two of their Sides which is not in their other Sides, and this without any regard to their Position to the Space or Medium through which they pass.

What I mean in this Question by a *Vacuum*, and by the Attraction of the Rays of Light towards Glass or Crystal, may be understood by what was said in the 18th, 19th, and 20th Questions.

(pag. 345-349)