

XXXVIII. *A Letter from Mr. T. Melvil to the Rev. James Bradley, D. D. F. R. S. With a Discourse concerning the Cause of the different Refrangibility of the Rays of Light.*

S I R,

Read March 1,
1753.

TH^O I have not the honour of your acquaintance, I have presumed to address the inclosed paper to you, relating to optics and astronomy. The unwearied zeal which you have shewn, Sir, for the improvement of these sciences, made me conclude, that whatever has an appearance of truth or novelty on such subjects, tho' inconsiderable in itself, might not be unacceptable to you. Besides, among all the societies of the learned in Europe, I could think of no abler judge to consult on these matters, than the author of the "Aberration of Light, and of the Variation of the Precession of the Equinoxes:" the two greatest discoveries, without doubt, that have been made in astronomy for half a century. Perhaps you may be able, Sir, from the many accurate observations you have already made, to decide the question relating to the velocity of light; or, at least, to determine, whether the observation proposed be practicable: for I am very sensible, that many observations, which appear easy in speculation, cannot be put in execution.

If you find any thing in the inclosed worthy of the public view, you are at liberry to lay it, in whole, or
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in part, before the Royal Society, or to make what use of it you please. I am,

S I R,

Geneva, Feb. 2,
1753.

Your most obedient humble servant,

T. Melvill.

Concerning the Cause of the different Refrangibility of the Rays of Light, by Mr. T. Melvill.

Read March 8, 1.
1753.

IN order to account for the different refrangibility of the differently-colour'd rays, Sir Isaac Newton †, and several of his followers, have supposed, that their particles are of different magnitudes or densities; but if there be any analogy between the refractive power and gravity, it will produce equal velocities in all particles, whatever their magnitude or density be; and so all sorts of rays would be equally bent from their right-lined direction.

2. It seems therefore a more probable opinion, which others have advanced, that the differently-colour'd rays are projected with different velocities from the luminous body; the red with the greatest, violet with the least, and the intermediate colours with intermediate degrees of velocity; for, on this hypothesis it is manifest, that they will be differently refracted

† Newton's Optics, Query 29.

refracted in the prismatic order, according to observation.

3. On supposition, that the different refrangibility of light arises solely from the different velocities of the rays before incidence, these velocities must be to one another nearly as their sines of refraction. — I say nearly; for their exact proportion cannot be discovered, but by the solution of the following problem, which I take this opportunity of proposing to the learned:

If two bodies fall, in equal angles of incidence, on a space terminated by parallel planes, in which any power acts perpendicularly to the planes (according to the hypothesis in Prop. 94, Lib. I. of the *Principia*) the ratio of the sines of emergence to the common sine of incidence, and consequently to one another, being given, to determine the proportion of their velocities at the time of their incidence on the first plane.

4. Their velocities in any given medium (suppose air) being once determined, their velocities in any other may be easily discover'd; for they are to those in air as the sine of incidence to the sine of refraction, when the ray passes from air into the other medium †.

5. While the differently-colour'd rays are supposed to move with one common velocity, any pulses, excited in the æthereal medium, must overtake them at equal

† *Principia*, Phil. Nat. Prop. 95, Lib. I.

equal distances; and therefore the intervals of the fits of reflexion and transmission, if they arise in this manner, as Sir Isaac conjectures, would be all equal: but if the red move swiftest, the violet slowest, and the intermediate colours with intermediate velocities, it is plain, that the same pulses must overtake the violet soonest, the other colours in their order, and last of all the red; that is, the intervals of the fits must be least in the violet, and gradually greater in the prismatic order, agreeably to observation.

6. Let c denote the velocity of the æthereal pulses, V the velocity of red light, and U that of violet; I and \mathcal{J} the intervals of their fits, and D the distance between two succeeding pulses: it is plain, from the nature of Newton's hypothesis, that I is to D , as V to $C-V$: and again, D to \mathcal{J} as $C-U$ to U : therefore, *ex æquo*, I is to \mathcal{J} , as $CV-VU$ to $CU-VU$, from which we have the equation $C = \frac{I - \mathcal{J} \times VU}{I \times U - \mathcal{J} \times V}$

Therefore, as the proportion between the intervals of the fits in red and violet, can be assigned by experiment, and the proportion of their velocities in any medium likewise, by Art. 4. the velocity of the æthereal pulses may be easily computed. The velocities of the red and violet in air are nearly as 78 and 77. In the celestial spaces they are less, but almost in the same proportion; the intervals of their fits are by experiment as 100 and 63 †, from whence, by the canon now laid down, the velocity of the æthereal pulses in the celestial space is found to be to that of red

† Newton's Optics, Lib. II. Part I. Obs. 14.

red light as 79763 to 78000. As light moves from the sun to us, by Dr. Bradley's accurate estimation, in 8' 12" (*a*), the pulses of the æthereal fluid must be propagated thro' the same space in about 8' 1".

7. Hence also may be determined, in known measures, the distance between two succeeding æthereal pulses for $D = \frac{CI - VI}{V}$.

8. Upon the hypothesis of the different velocities of different colours, we may understand, at least in general, the reason of the strange analogy, discover'd by Sir Isaac, between the intervals of the fits, and the spaces occupied by the several colours in the spectrum (a thing hitherto unexplained (*b*); since, from the velocities of the several rays, upon which depend the intervals of the fits, as has been now explained, arise likewise their several degrees of refrangibility.

9. But, as it is of great consequence in philosophy, to distinguish between facts and hypotheses, however plausible, I observe, that the various refrangibility, reflexibility, and inflexibility, of the different colours, and their alternate dispositions, at equal intervals, to be reflected and transmitted, which are the whole ground-work of the Newtonian system, are to be consider'd as undoubted facts, deduced from experiment; but that the velocities of different rays are different in the manner now describ'd, is no more than probable conjecture: and tho' this point should be decided, by a method that we are now to propose,
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(*a*) Eames's Abridg. Transact. Vol. VI. p. 157.

(*b*) Compare Newt. Opt. Book I. Part 2. Prop 3. with Book II. Part 3. Prop. 16.

it would still remain uncertain, whether the fits of reflexion and transmission consist in an alternate acceleration and retardation of the particles of light, or in something else. For instance, it might be supposed, that every particle of light has two contrary poles, like a loadstone; the one of which is attracted by the parts of bodies, and the other repell'd; and that, besides their uniform rectilineal motion, the particles of differently-colour'd rays revolve in different periods round their centers; for thus their friendly and unfriendly poles being alternately turned towards the surfaces of bodies, they might be alternately disposed to reflexion and transmission, and that at different intervals, in proportion to the periods of their rotation. Lastly, tho' it were proved, that the fits do proceed from an alternate acceleration and retardation of the particles of light, it would still be no more than probable conjecture, that this is brought about by pulses excited in the æthereal medium. Nay there are some circumstances in these phænomena, that seem hardly intelligible by that hypothesis alone: as, Why the intervals of the fits are less in denser mediums (*a*); and, Why they increase so fast, and in so intricate a proportion, according to the obliquity of incidence (*b*).

10. By Dr. Bradley's beautiful theory of the aberration of light, the stars appear to be removed from their true place to a certain distance, according to the proportion which the transverse motion of the spectator's eye bears to the velocity of light. It is plain therefore,

(*a*) Newt. Opt. Book II. Part 3. Prop. 17.

(*b*) Prop. 15. *ibidem*.

therefore, that, on our hypothesis, any star must have a different apparent place for every different colour; that is, its apparent disk must be drawn out by the aberration into a longitudinal form, resembling the prismatic spectrum, having its red extremity nearest its mean place. In the stars situated about the pole of the ecliptic, its length should continue always the same, tho' directed along all the different secondaries of the ecliptic in the course of a year: but in those which lie in or near the plane of the ecliptic, it should be greatest at the limits of the eastern and western aberrations, the star recovering its colour and figure, when the true and mean places coincide. But there is no hope of discovering, whether our system be true or false, by this consequence of it: for the greatest length of the dilated disk being to the whole aberration, as the difference of the velocity of the red and violet to the mean velocity of light, *i. e.* but about a 77th part of it, cannot much exceed the fourth part of a second.

11. The time which the extreme violet light takes in arriving from any distance to the eye, will be to that which the extreme red takes in coming from the same, as 78 to 77. If Jupiter be supposed in a quadrature aspect with the sun, in which position the eclipses of his satellites are most commodiously observed, his distance from the earth being nearly equal to his distance from the sun, light takes about 41' in passing from him to the earth; therefore the last sensible violet-light, which the satellite reflects before its total immersion into Jupiter's shadow, ought to continue to affect the eye for a 77th of 41'; that is, about 32'' of time after the last sensible red light is gone. It is therefore a certain consequence of our

hypothesis, that a fatellite, seen from the earth, ought to change its colour about half a minute before its total immerfion, from white to a livid greenish colour; thence into blue, and at laſt evaniſh in violet. I need hardly obſerve, that the ſame phænomenon muſt take place in the time of emerfion by a contrary ſucceſſion of colours, beginning with red, and ending in white.

12. If this phænomenon be perceived by aſtronomers, we ſhall have a direct proof of the different velocities of the differently-colour'd rays, and, conſequently, a mechanical account of their different degrees of refrangibility; for I ſee not, to what other cauſe ſuch an appearance could be reaſonably aſcribed. If it be not, we may conclude, that rays of all colours are emitted from the luminous body with one common velocity.

Geneva, Feb. 1, 1753.

T. Melvill.

This paper was delivered to Mr. Short, in order to attend to the particular obſervation of Jupiter's fatellites recommended by Mr. Melvill, who after ſome time made the following report to the Society.

EVER ſince this paper of Mr. Melvill's was put into my hands, I have carefully attended the emerfions of Jupiter's firſt fatellite thro' a reflecting telescope of four feet focal length, and with a proper magnifying power; but I have not perceived the leaſt alteration in the colour of the light reflected by the fatellite,

satellite, except in quantity. It may indeed be observed, that these emerfions are feen fooner or later thro' telefcopes of different lengths, and by eyes of different goodnefs: and it may therefore be alleged, that there is a certain quantity of time elapfed between the very firft emerfion of the fatellite, and the instant when it is perceived by the very beft eye, affifted by the beft telefcope; and that, during this interval, the fucceffion of colours, above-mention'd, is perform'd. But our author, in confequence of his hypothefis, fays, that this fucceffion of colours may be perceived for the fpace of 32" after the firft emerfion of the fatellite; and I am fully fatisfied, from repeated obfervations, that the quantity of time elapfed from the very firft emerfion of the fatellite, till it is perceived by a good eye, affifted by a good telefcope, can amount only to a very few feconds. So that, upon the whole, we may conclude, that it does not appear, by the obfervations of the emerfions of the firft fatellite of Jupiter, that the rays of different colours move with different degrees of velocity.

But our author's conclufion, that, if the rays of light emitted from Jupiter's fatellites, at the time of their immerfion and emerfion, fhould not be found of different colours, the rays of all colours emitted from luminous bodies will have one common velocity, feems only to hold good, on a fuppoftion, that light is propagated by a continued motion, in the manner of a projectile.

Dr. Knight, in his treatife on attraction and repulfion (Prop. 69.) has confider'd the propagation of light, as performed by vibrations in an elastic fluid, in the fame manner as found is produced by vibrations

vibrations in the air: and he thinks, that it is as easy to conceive how the velocities of the particles of light may be different, and yet take up equal times in propagating their motion from one to another through a given space, as to explain how sounds of different tones move with equal velocities. In accounting for both, he shews, that, in a series of particles, which mutually repel each other, the greater their velocity, the nearer they will approach other, in communicating their motions from one to another; and consequently each of them must move thro' a greater space in so doing: wherefore the same time may be spent in propagating a successive motion thro' a series of particles, whose velocity is greater, if each particle has to move thro' a greater space, as is spent, where the velocity of each particle is less, but is continued thro' a less space. The dilemma, to which our author's reasoning seems to have reduced the doctrine of refrangibility, may therefore be consider'd as a probable argument for adopting this hypothesis of the propagation of light thro' an elastic medium.

XXXIX. *The Case of the Operation for the Empyema, successfully performed by Joseph Warner, F. R. S. and Surgeon to Guy's Hospital.*

Read June 28, 1753. **O**N the 19 of March 1752, I did myself the honour of communicating to the Royal Society the case of John Hines, on whom I had performed the operation for the empyema