REFLECTIONS OF MR. L. EULER ON NEW EXPERIMENTS IN OPTICS, COMMUNICATED TO THE ACADEMY OF SCIENCES BY MR. WILSON

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The substances on which these experiments were performed are known under the name of Phosphori, which have the property that having been illuminated by the rays of the sun or merely exposed to broad daylight, they still retain their glow for some time when one moves them into the dark, the same as if they were still illuminated. It has been a long time since we have recognized this property in Bologna stones, which having been illuminated and carried into a dark place, remain visible for a fairly long while. Since then chemists have found a way to produce similar substances from several other different materials, and Mr. Wilson has pushed this discovery so far as to be able to prepare such substances of all colors, each of which, once illuminated, retains its own color for a long time in a dark room, thereby remaining visible to the observer.

The new experiments that this skilled physicist performed on these different types of phosphoric substances involved different ways of illuminating them. For this purpose he made use of a dark room where, using a prism, one can divide sunrays into its primitive colors, such as the ones one sees on a rainbow; and as one can capture

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whatever color one wants, he arranged his experiments so that the same phosphoric substance of a certain color was successively illuminated by all the different solar rays, and he observed that after this substance was illuminated by rays of its own color, it received only a rather faint glow when viewed in the dark. But the more the ray of light that illuminated the substance differed from its own color, the more it received a radiance with which it shined afterwards in the dark. In this way, when one such red phosphoric substance was illuminated by red rays and then carried into darkness, it maintained only a rather faint light. But after being successively illuminated by yellow, green, blue, and violet rays, the acquired light became brighter and brighter, and the violet rays, which are most contrary to its own natural color, produced the greatest brightness.

As one would undoubtedly have expected rays of the same color as that of the substance to imprint upon it the most vibrant radiance, it would appear extremely strange that precisely the opposite happened in these experiments, and it seems that this phenomenon is in open contradiction to the other known phenomena about light, by which we know that an ordinary opaque substance of a certain color could only be best illuminated by rays of the same color. In this way, a red substance, when red sunrays are directed towards it in a dark room, acquires a very high brilliance, whereas when violet sunrays are directed towards it, it receives almost no illumination, but rather remains almost entirely invisible; and everyone knows that with the blue flame of a lighted spirit of wine all red substances appear extremely somber, while the blue ones appear in their greatest radiance.

However strange this paradox may appear, if we think about it carefully, we shall no longer find it so contrary to the known properties of light. We only need to carefully distinguish between two moments in Mr. Wilson's experiments, the first being the one where he shined his red phosphoric substance with violet sunrays, during which there is no doubt that the substance appeared almost entirely devoid of all color; it is only in the second moment when he carried this substance into darkness that it began to shine of its own red color. From there one sees that the violet rays of the sun did not immediately render the substance visible, but they instead agitated its smallest particles into a certain motion which subsequently made them shine in the darkness with their own natural color. Hence it is clear that it is only a matter of explaining how the violet rays, or all the other rays apart from red, were capable of putting the substance in such a state that after having moved it to darkness, it was able to give off its own rays, which had nearly been suppressed while it was being exposed to the violet rays of the sun. Now I believe that such an explanation will not be very difficult according to the theory that I gave previously on the nature of light and the manner which opaque substances become visible to us.

First it is rather clear, and Mr. Wilson seems to agree himself, that these phenomena are completely contrary to the Newtonian theory of light color; for according to this theory opaque substances could only become visible through the rays reflected from their surfaces. Therefore in order for a red substance, for example, to be perceived by our eyes, there must first be rays that are falling on its surface, and second, that they undergo a certain refraction by which the rays that are not red are absorbed, so that third, only red rays are reflected off its surface. That said, we first observe in these new experiments two circumstances directly contrary to this system, the first being that the red phosphoric substance, even though it was only illuminated by violet rays, only appears to us as red and even with more radiance, as if it had been illuminated by red rays, so that it is impossible to imagine where the red rays, through which this substance becomes visible to us, come from, considering that by this very same theory, red rays could not change their nature. But the second circumstance is even more in contradiction to this theory, since the red substance in question appears to us under this color only some time after it was illuminated by the violet rays; so that at that moment there are no more rays that are falling on its surface and even less could any be reflected. From there we see that the existence of such phosphoric substances could suffice to overturn from top to bottom the Newtonian theory of light and color.

When I previously established my new theory of light and colors, I incontestably proved through several arguments that the great Newton's idea could not in any manner be admitted into physics; it would be superfluous to repeat them here after having expounded on it in great detail in the first part of my *Opuscula* published in Berlin in 1746 under the title *Nova Theoria lucis et colorum* and then also in my *Letters to a German Princess.* The foundation of this theory consists in my supposing that the origin of light is similar to that of sound, such that just as sound is produced through a vibrational motion of air, so too is light caused by a similar vibrational motion transmitted by the ether, whose elasticity is several thousand times greater than air, while it is also several times more subtle, happily explaining for the first time the incredible speed at which these rays of light must reach us from the sun. Then I showed very clearly that the different colors are only produced through the different degrees of speed in the vibrational motion, in the same way that the sound of an octave in music each correspond to a certain number of vibrations rendered in a second.

But regarding the new experiments more closely, I demonstrated that it is absolutely false that opaque substances become visible to us through the reflected rays as it was generally imagined previously; but it must absolutely be that the smallest particles on the surface of this substance are put into a certain vibrational motion that are faster or slower according to the color that the substance requires, considering that to each color there corresponds a certain number of vibrations achieved in a second. For then this same motion produces similar vibrations in the surrounding ether, resulting in rays of the same color. From there it is clear that the rays, by which we see the opaque substances, are produced in their own surface in accordance with the degree of elasticity which the smallest particles there are imbued. In order to put these particles into such a vibrational motion, it is necessary that some light rays fall there, which by their action excites the particles into such a motion, in the same way that a musical cord at rest, having been exposed to a sound that is loud enough, begins to tremble and itself yield a sound that corresponds to its degree of tension

Having stated thus, a red phosphoric substance such as what Mr. Wilson examined could not become visible to us unless the smallest particles on its surface were excited into a vibrational motion that goes with its color. So it would not be doubted that red rays would be the ones most suitable to reproduce in these particles such a vibrational motion, which, by the phosphoric nature of these substances, will still be maintained for some time after the incident rays will have ceased acting there, but in a much more feeble manner than when the red rays were actually acting there. Let's see now what effect the violet rays must produce on this same red phosphoric substance. First, it is clear that the violet rays could not bring the substance's least particles into a vibrational motion, due to the incompatibility which prevails between the vibrations of the violet rays and those which the substance's own particles are disposed to receive. For this reason, the sole effect of these violet rays will be reduced to pushing the particles of the substance towards a certain degree of tension, without reproducing in them any actual motion. Therefore as soon as the substance is removed from the action of these rays, its smallest particles will begin to free themselves from their state of tension and will receive the same vibrational motion that is appropriate to its nature and from there they will give off red rays which will be themselves even stronger due to the higher degree of tension than if the same substance had been exposed to red rays. Finally, by the nature of a phosphorescent substance, this vibrational motion will be able to endure, to a greater or lesser extent, according to the degree of phosphorescent character the substance itself posseses. From all this, we easily understand that these new experiments, however paradoxical they seemed at first, are perfectly well in agreement with my theory of light and colors, and they could even serve to increase its certainty, if it had not yet been sufficiently established.