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argument on it against the Newtonian Law (*Exercices d'Analyse*, p. 304). But that the second solution is the true one, will appear from considering that it only changes a circular function into an exponential one, which will, in general, not appear in the operations from its *coefficient* being zero.

2. But we have an argument against the solution, or rather an assertion, that the appearance of an exponential in place of a circular function "*violates the hypotheses* on which the reductions and transformations in the former part" (I should like to know what part) "of my paper are effected." If they mean those in p. 158, and which they refer to, I reply, so does *Newton's* problem of central forces violate his hypothesis of motion in an ellipse about the centre. But if these gentlemen assert that exponentials cannot be used for circular functions, and *vice versâ*, I refer them to the memoir of Cauchy just quoted, where nothing but exponentials are used, and to my 'Theory of Heat,' p. 156. I may add that this objection is so vaguely and cautiously stated, that I do not imagine the writers seriously entertain any belief in its force, but rather throw it out as a probable difficulty.

XIX. *On the Action of the Rays of the Solar Spectrum on the Daguerreotype Plate. By Sir* J. F. W. HERSCHEL, *Bart., K.H., F.R.S., &c.*

To the Editor of the Philosophical Magazine and Journal.

SIR,

1. PROFESSOR Draper of New York having, in his communication to the Philosophical Magazine for November last (Art. LXII.), referred to a specimen of a Daguerreotyped impression of the solar spectrum obtained by him in the south of Virginia as having been forwarded by him to me through your obliging intervention, I should hardly be doing justice, either to his urbanity or to the beauty of the specimen itself as a joint work of nature and art, were I to forbear acknowledging its arrival and offering a few remarks on it. And I do so the more readily, because, though forced to differ with him in some of the conclusions he has drawn from it, I recognize in him a zealous and effective contributor to this most interesting branch of scientific inquiry, and the only one, so far as I am aware, besides myself who has attacked it in the only mode in which it can lead to distinct and definite results, that of prismatic analysis.* It can never be too often repeated, that the use of coloured glasses

* Since this was written, M. Becquerel's interesting paper on the Spectrum, read to the French Academy, June 13, 1842, has come into my hands. M. Becquerel has also used the prism, and with excellent effect,

in such inquiries, as a substitute for such analysis, in the present state of our knowledge of the absorptive powers of such glasses, serves only to confuse and mislead. In illustration of this proposition I need only refer to the statements of Professor Moser* as to the action of the green and yellow rays on the iodide of silver, in his papers on the process of vision and on invisible light; statements which, embodying, at least in intention, the results of elaborate and no doubt most carefully conducted experiments, are rendered perfectly unintelligible to one who has studied the subject with the aid of the prism, by his continual (and as it would almost appear systematic) substitution of the apparent (or absorptive) colours of glasses for the *prismatic* colours of rays, which he appears to assume that such glasses insulate in a state at least approaching to purity; an assumption unwarranted by the whole tenor of the phænomena of absorption, and in the case of *yellow* glasses most particularly open to objection, as any one may readily satisfy himself by looking through such a glass at a prismatic spectrum, and by referring to Art. 103. of my paper "On the Chemical Action of the Rays of the Solar Spectrum," &c. (Phil. Trans., 1840), and repeating the experiments there described.

2. Professor Draper's specimen consists of a Daguerreotype silver plate, about 3½ inches by 3 inches, on which is exhibited the impress of the spectrum in the form of a streak 3·3 inches, or thereabouts in length, and 0·08 inch in breadth, the edges being perfectly rectilinear and sharply defined throughout the whole length until within about a third of an inch from either termination, where they curve into an elliptic form so as to terminate the impression with two very elongated semiellipses, which are also very faintly and feebly marked. This, together with the very high proportion of 41 to 1 between the length and breadth of the photographic spectrum, sufficiently indicates it to have been formed by a non-achromatic lens, inclining the surface of the plate forward so as to bring that part on which the more refrangible rays fall nearer the lens than that which receives the less, thus compensating the shortening of the focus for the former rays. And as such (though not stated in respect of this individual specimen) appears to have been Dr. Draper's usual practice; and as in another of his papers he formally recommends it as securing "the great advantage of elongating the total length of the spectrum, and

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though he seems to have read with rather cursory attention what had already been published on this subject in England.—Note added during the printing.

* See Translation in Scientific Memoirs, part 11. (vol. iii.), p. 422.—Ed.

therefore increasing the measures" (Phil. Mag., Dec. 1842, p. 456.), I cannot help observing, that not only is no real advantage gained by such elongation, but the very reverse. For, in a spectrum formed on a surface so inclined, each of the coloured solar images, of whose succession it consists, is not only defective in its individual definition everywhere but at two points in its circumference, but also, instead of being circular as it would be were the surface perpendicularly exposed, is dilated into an ellipse, having its longer axis in the direction of the length of the spectrum, and the overlapping of the contiguous ellipses being necessarily dilated in the same proportion, every abrupt change in the intensity of photographic action becomes softened and smoothed down as it were by being spread over more space, and rendered, by consequence, less salient to the eye than it otherwise would be. In the case of ioduret of silver, indeed, this is not quite of so much moment, because the change of intensity in the action of the spectrum is, as I have shown in Article 129 of the paper already cited, and in Articles 214, 215 of its continuation (Phil. Trans. 1842), so excessively abrupt at the point of union of the blue and violet rays, that it is not in the power of such dilatation materially to mask it. But in innumerable other cases where consecutive maxima and minima occur, these features (*which are always characteristic of the ingredients used*, and on that account especially interesting and important) cannot fail to be grievously marred by thus as it were flattening them down. It is this consideration which decided me, from the very beginning of my inquiries on this subject, always to use an achromatic lens for forming my spectra (unless in cases where the use of *two kinds* of glass is objectionable); and when it has been required to increase the proportion of their length to their breadth for peculiar purposes (as in Article 69 of the above-cited paper), to do so, not by increasing the length, but by diminishing the breadth of the spectrum in the manner there described, so as, at the same time, to preserve the circularity of the sun's image, and also to diminish the overlapping of successive images, and thereby increase the homogeneity of the light at each point of the length. And here I must take occasion also once more to insist (whatever may have been said to the contrary) on the indispensable necessity of using achromatic lenses for photographic practice with the camera obscura *by those who desire perfection*; being myself fully convinced that we have hitherto seen nothing comparable to what photography is capable of performing when the camera shall come to be studied and improved with a view to this especial purpose, as the telescope has been for its own. And I earnestly recommend the subject to our mathematicians and artists as highly deserving their attention.

3. But to return to Dr. Draper's specimen. The ground on which it is projected is *dimmed* by the vapours of mercury settling on the parts where dispersed light has fallen, so as to be rendered much less specular, not only than the unattacked part of the silver surface, but also than the impression of the spectrum itself, which for the most part yields a much more powerful and regular reflexion than any part of the contiguous ground.

4. With respect to the phænomena offered by the ground, it is that of the Daguerrotype in general, and being produced by *mixed* rays, I shall defer its consideration, remarking only at present, that it appears dark in certain lights, white in others, and iridescent with a faint halo-like pink tint in the transition from one light to the others, especially towards its borders.

5. The spectrum itself is extremely remarkable and beautiful. It is divided, on a superficial inspection, into several very distinct compartments, which however, with one exception, are found on close examination to graduate imperceptibly into each other, though with so high a degree of abruptness of transition as may justify our regarding it, in description, as consisting of differently characterized regions. The apparent outlines of these regions are represented in the figure annexed (Plate II. fig. 1), though only a coloured drawing could properly render the general effect and delicate graduation of the several regions (indicated by the letters) into each other.

6. The aspects of the spectrum, as has been observed of the ground, are very different in different lights, assuming the one or the other of two opposite characters, according as it is viewed *by specular reflexion* or by *side light*. These aspects it will be necessary to describe separately.

7. When viewed by specular reflexion, as when viewed at a nearly perpendicular incidence with the back to an open window, or when laid on a table by candle-light and the ground glass or paper shade of a lamp seen clearly by reflexion on the general surface, while no side light is suffered to fall on it; the ground, as above observed, is dark in comparison with the unattacked silver surface. On this ground the terminal regions A, E appear bright and specularly white, though materially less so than the unattacked silver. The region B is black, though not absolutely so: fully as dark however as the ground. This is immediately followed by C, which is white at its outer edges, but very gradually passes inwardly into pale yellow, yellow, and at last terminates in an oval

space, in which the tint rises to a brownish or reddish orange, the terminal edges of the oval being a very little paler than the middle. Immediately, and with absolute suddenness, as if coming out from under this oval, reappears at D the blackness of the region B, but apparently more intense (as if the same quantity of blackness had here been crowded into a narrower space), and with an evident bluish cast. Within the coloured space C, and around a point *m*, which may be regarded as their common focus, the isochromic ovals may be considered as arranged, which, crowded together undistinguishably towards D, elongate in the direction of B, as indicated by the dotted lines. A feeble ash-gray oval train G, barely perceptible, appears to come out again as it were from under D, or to form a kind of tail to it, leaving a slight indentation H on either side, occupied by the specularly white continuation of the portion E. Those who are accustomed to the analysis of such cases will easily perceive here the effect of an abruptly terminal solar image at *m* overlapping and concealing a sudden descent to a minimum, or perhaps to a total absence of photographic action at H.

8. The borders of the elliptically terminated portions A, B, inclose and overpass one another as represented in the figure. For instance, the border of the portion A extends not merely beyond the blackened space B, but even somewhat beyond the extremity of C, thinning away there to an exceedingly delicate line, as does also that of the portion B itself. No traces of these borders however can be followed down the whole length of C.

9. In the order of tints above described as prevailing from the more refrangible end of the spectrum to the maximum of tint *m*, we recognize without difficulty the Newtonian series of colours of the first order of the reflected rings; modified however in its first stages by a cause which seems to have shifted the initial black of that series to a higher point in the scale of thicknesses of the producing film, or to have displaced the whole series by the intrusion of a white commencement. For, the Newtonian reflected tints of the first order are, black, very feeble and hardly perceptible blue; brilliant white; yellow; orange (at which point the series breaks off). And if we suppose these tints (so modified) repeated again in reverse order, and consent to attribute the more intense apparent blackness of the region D beyond that of B to the effect of contrast produced by the greater abruptness of transition in that region (an effect which is very striking in many optical phænomena), the whole spectral impression from end to end will come to be accounted for by a film, homogeneous in its

composition, and varying in thickness according to the law of the curve represented in fig. 2, where the abscissa being the distance from the end of the spectrum to any point in it, the ordinate will represent the thickness of the film at that point, where it will be observed that in using the word *film*, I by no means mean to imply the notion of its *continuity*, as opposed to that of a scattering over the surface of lamellar particles of the requisite thickness.

10. In what manner we are to conceive the above-mentioned intrusion of a white member at the commencement of the series and the further modification of its subsequent members, by dilution to a certain degree of the black, and deadening the extreme brilliancy of the white of that series, seems a point of difficulty which I am not disposed to dissemble. At one time I imagined that it might be accounted for by the intermixture of the transmitted or complementary series of colours reflected from the silver below, on the hypothesis of a high absorptive action in the film itself, which would progressively diminish the influence of such intermixture as the thickness increased, so as to allow the higher tints their full intensity. I am not aware that the subject of the Newtonian rings, as formed by absorptive films, has ever been theoretically treated. But it is easy, without going regularly into it, to see that, since the intensity of any given homogeneous ray is diminished by absorption in geometrical progression while the sum of the thicknesses traversed by it increases in arithmetical—and moreover, since the transmitted series of tints so brought to the eye by reflexion must have traversed (by the theory of their formation) four thicknesses* of the film, while the interfering ray which produces the reflected series has to traverse only two—*therefore* the ratio of intensity of the transmitted to the reflected tint, in the state in which it reaches the eye, will continually diminish in geometrical progression as the tint ascends in the scale, so that the higher orders of tint will be progressively purer, at least so far as this cause is concerned.

But against this there is one obvious objection, viz. that the succession of tints as they stand cannot be allowed to commence with the zero of thickness and go on according to the Newtonian law, unless we assume *that the whole extent of the spectrum, and not merely its terminal portions, as Dr.*

* I here for simplicity lay out of consideration the circumstance that the transmitted tint so conveyed to the eye consists of an infinite series of rays all in one phase of undulation, forming a decreasing geometrical progression of intensity, owing to having traversed respectively 4, 6, 8, 10, &c. thicknesses.

Draper supposes, has been protected from the action of dispersed light: and this is the difficulty which, as I have already stated, I do not wish to dissemble, and which Dr. Draper's negative rays introduced at the ends of the spectrum will not, I conceive, fully get over. The form of the curve, fig. 2, is fully in unison with what I have described and figured respecting the action of the spectrum on iodu-retted papers (Phil. Trans. 1842, Article 214—216). And if we have regard to the breadth as well as the length of the spectrum, its law of intensity will be represented by the vertical coordinate of a solid surface represented in front and lateral projection in figures 3, 4, and if each such coordinate be regarded as expressing the proportional thickness of the deposited film at that point, the solid itself will represent on a very exaggerated scale (of perhaps a million to one in height) the actual form of that film, supposed continuous.

11 In this view of the subject the deposited film must be regarded as homogeneous. *i. e.* one and the same chemical substance (whatever that substance be) in its whole extent: granting this, all is one phænomenon regulated by a mathematical expression into which a parameter varying only with the refrangibility of the ray, the time of its action and the intensity of the light, enters. And here I would observe, that the lateral gradation, which is of course due solely to varying intensity, is produced by two very distinct causes, both which it is well in such experiments to bear always in mind as accounting for various singular phænomena of internal ovals and reversed action *along the axis* of the spectrum as exhibited on photographic papers, &c. For, first, at the *edges* of the spectrum there is no overlapping of images, which overlapping from zero at that point goes on increasing to the axis. From this cause originates a progressive scale of intensity proportional to the chord of the sun's circular image, measured in a direction parallel to the axis. And, secondly, it is placed beyond a doubt, both by Mr. Airy's and my own observations, that the central portions of the sun's disc are very much more luminous than the borders, which if it be due (as I have elsewhere stated I conceive it to be) to the absorption of a solar atmosphere extending beyond the luminous surface, would also act on the photographic powers of the rays unequally, and so produce a variation in the lateral rate of photographic action, of which at present we have no measure, but which may possibly be thus brought within our range of investigation, and be rendered obvious by direct examination of the sun's *white* image simply projected on photographic paper, an experiment I propose to try on a favourable occasion.

In reference to the "protecting" rays of Dr. Draper, assuredly the first aspect of the phænomena is favourable to their existence; yet I must observe, that when the spectrum is made to act on ioduretted paper in the mode described in the memoir above referred to, the general ground of the paper is affected by the dispersed light *in the same manner* but *to a less degree* than the spectrum-portion, nor is there any sign of the occurrence about the region of the extreme red and beyond it of that sort of protection from the action of dispersed light which I have described in Phil. Trans. 1840, and to which Dr. Draper refers, as due to the action of *negative rays* stated by me to exist in that region. I have however (as will be seen on referring to Article 90 of that paper) been very cautious in ascribing to them any such decidedly *negative* quality. An effect *of some kind*, conservative of the whiteness of papers variously prepared while under the influence of dispersed light, does undoubtedly take place in the region of the extreme red, and to a certain distance below it. But I have of late learned to regard that effect (which at first I confess had very much the appearance of a negative action) as at least in part a secondary one, and due to a cause which has no existence when silver plates are used, viz. the maintenance of the paper at those particular parts *in a state of superior dryness* to the surrounding parts, by which its sensibility is materially diminished—a certain slight degree of moisture being exceedingly favourable to photographic action in many cases, as I especially find it to be in that of muriated papers overkept, in which the conservative effect is occasionally so remarkable as to extend *over the whole* visible or luminous spectrum. And in one instance (recorded in Article 95 of that paper) we have an instance very much in point, and the more valuable as having been marked as an anomaly at the time, while yet the phænomena of the thermic spectrum, as manifested in the drying of paper, were unknown to myself. For in that article it is recorded that in a certain paper (which had it appears been kept some time before using) the conservative action in question was limited to a circular well-defined solar image beyond the extreme red, and was due, I have now no doubt, to the action of the heat-spot β (see Article 136) either drying the paper, or exerting, it may be, some peculiar effect due to the chemical nature of its heat. For I would wish to be understood as by no means limiting the cause of conservation to this secondary mode of action, or to deny the exercise of an influence which may *so far* be regarded as negative, i. e. as opposed to photographic agency by that portion of the *thermic* spectrum which lies within and immediately adjoining to the luminous one. The thermic rays belonging to this region possess singular and remarkable properties, of which more presently. And if such conservation be in any way ascribable to *thermo*graphic opposition to *photo*graphic action, it seems not unreasonable to argue from the absence of observable white conjugate images on the discoloured ground in all the very numerous cases where it has been witnessed (with the single exception of that above noticed), that such action is limited to these peculiar thermic rays, and does not extend to the purely calorific ones remote from the spectrum. This subject, however, will require more attention, which on the return of a summer sun I purpose to give it.

To return, however, to Dr. Draper's spectrum. The specular colours of the portion C lower very perceptibly in the scale of tints when viewed in a very oblique incidence, a circumstance agreeing with the analogy of the colours of thin plates. On the other hand, if the incident light be so managed as not to return by specular reflexion to the eye, but merely to illuminate the plate strongly, while all other specularly reflected light is eliminated by a proper adjustment of dark objects in the neighbourhood, the character of the phænomena undergoes a singular and striking reversal. The terminal regions A, E become *dark*, though less so than the unattacked silver; the half black space B becomes strongly white, and the violet-black space D very brilliantly so, showing like frosted silver; while on the other hand the coloured portion C becomes extremely dark, somewhat dull in its aspect, and of a hue which, so far as its great obscurity will permit it to be distinguished as a tint, may be termed steel-gray or bluish. By candle-light a tendency to green may be perceived. This tint, and the blackness it relieves, hardly undergo any variation over the whole space C, except just where it graduates into whiteness at its union with B.

In this succession we recognize, with very slight deviations, the series of Newtonian transmitted rays *undiluted* with the white light which accompanies them when formed by a film of air or glass, and (like those of the reflected series) advanced by the intrusion of a *black* member at their commencement. But it must be noticed as a fact of great moment in their theory, that *they are not the complements of the tints seen by specular reflexion* at the same points of the spectrum. In fact they go no higher than to *one-half* the extent of the series so seen, since the black ring of the first order of transmitted rings corresponds, not to the first black ring, but to the white of the first order, in the reflected series. Here is no doubt another unexplained difficulty. While on the one hand it is obvious that the dispersed colours arise in a totally different manner from the specular ones, and cannot be regarded as directly connected with them; on the other it does not appear by what superficial structure, by what form and law of distribution of laminæ adhering to it, or by what hypothesis respecting their crystallization, &c., any such colours can be explained. One thing, I think, seems clear, that they cannot be produced by any lamination *parallel* to the surface of the plate; and another, that the laminæ (if any) which do produce them must be disposed indifferently in all azimuths, and (within certain limits) at all angles of inclination to the general surface, since they are seen in all directions.

The absence of the diluting white light which mingles with the pure tints in Newton's transmitted rings, is also a very peculiar character, and would almost incline us to a suspicion of the origin of these dispersed colours being to be sought within the domain of double refraction and polarization, were it not extremely difficult to conceive any structure in which such a mode of production can be realized.

It is not improbable that this obscure part of the subject will receive elucidation from the halo-colours which appear on the white ground, and on the white portions of the spectrum when illuminated by rays nearly approximating to the direction of specular reflexion. In such incidences only they appear, and then only at the borders of the ground where the action of dispersed light has been feeble, and along the region A and the faint train G, which, when the illuminating light is remote from specular incidence, are very faintly illuminated, but, as it approaches that incidence, seem to open out as it were from B and D in brighter light, coloured with faint pink. In the same manner the frosted ground under these circumstances dilates in breadth, so as to cover a much larger portion of the whole plate. Its borders gleam with the pink tint, while its internal portion passes into dark gray, which increases up to the specular incidence; the order of tints in this situation being precisely the first order of colours of the Lunar corona, or of the halos exhibited by a candle seen through a glass breathed on.

These observations may seem unnecessarily minute, but I am persuaded that they are essential to the right understanding of the Daguerreotype phænomenon, when we shall arrive at one. Already we see in our reference of the phases of this phænomenon to the colours of thin plates (with whatever difficulties that reference may be encumbered) a very simple explanation of the change from positive pictures to negative, by mere continuance of illumination, which has excited surprise in some, but which is a perfectly natural consequence of this view of the matter; while in the opacity or strong absorptive power of the film producing these tints, we see reason to conclude that no increase of thickness which long exposure would give to it, would ever develope in it the complete succession of the Newtonian colours beyond the first or second order; and that in consequence the subsequent longer continued action of the light would fail to produce distinct alternations of positive and negative pictures, though it might give rise to fluctuations of intensity, ending ultimately however in general and total blackness. Many of the intricate phænomena described by Prof. Moser, in his papers above alluded to, will be found divested of much of their enigmatical character by these and similar considerations.

I shall close what I have to say on the subject of Dr. Draper's specimen, by mentioning that about the time when that specimen was produced*, I was myself engaged in forming Daguerreotype impressions of the spectrum. My experiments were made in the last week of July and the first two or three days of August 1842. Want of habitude in the manipulations of the Daguerreotype process (which I had never before executed), and by no means want of sun, prevented my obtaining anything like so fine impressions; but I remained satisfied at that time, and by those experiments,—1st, that the tints of the coloured portion C were those of the Newtonian reflected series, more or less modified by the high refractive power and opacity of the film; 2ndly, that the law of intensity of action in proceeding from end to end of the spectrum, on the Daguerreotype plate, so far as I observed it (for I did not obtain the "negative" terminal portions A or E), is identical with that exhibited on blackened argentine paper (free from nitrate) under iodic influence, and especially the place of the abrupt maximum, which is so characteristic of iodine as a photographic element, proved (by actual measurement) to be precisely the same in both ways of operating. This identity, I should observe, is somewhat difficult to recognize in Dr. Draper's plate, where the maximum would appear to occur somewhat lower on the spectrum; but this, if it be really a point of difference between us, and not merely owing to a different nomenclature of colours, or to the effect of inclining the plate to the incident ray, may and probably has arisen, not from any difference in quality of sunshine in Virginia and England, *but from difference in the law of photographic dispersion in the prisms used.*

* The specimen bears date July 27, 1842.

I further satisfied myself, 3rdly, in the experiments alluded to, that the law of photographic action on a bromuretted silver plate is in like manner identical in respect of intensity, with that exhibited on paper prepared with bromuret of silver in Mr. Talbot's method; the action being carried down in both cases *to*, and considerably beyond, the extreme red ray. But no appearance of protection from the action of dispersed light, which is so conspicuous on the paper, was observed on the silver plate. [This plate I did not mercurialize.]

I had intended to conclude this communication with some remarks in detail on Professor Draper's "Tithonic rays," but having already extended it to I fear an inadmissible length, I must limit myself to throwing in a general caveat against the adoption of *a new name* (and that a most fanciful one) for *an old idea*. The notion of *chemical rays* as distinct from those both of light and heat, is so perfectly familiar to every photologist, as hardly to need insisting on. The extension of chemical action to every part of the spectrum, and considerably beyond the extreme red, is fully demonstrated in my first memoir on this subject; where also the *independence* of the rays in which that action resides, and the simply luminous and colouring ones, is clearly proved by decisive experiments on the absorption of coloured media, perfectly analogous to those brought forward by Dr. Draper, and which I am somewhat surprised he has not noticed, as he has evidently read that memoir.

Should Dr. Draper succeed in establishing those points of analogy between the photographic chemical rays and those of heat, viz. that they are capable of accumulating in or on bodies exposed to them, thence radiating away in the manner of obscure heat (after undergoing such a change as to be no longer capable of traversing colourless glass), but with this marked distinction from such heat, that they are not *conducted* in this their new state by metallic bodies, no one will hesitate to regard him as having attached a new idea to the old one of chemical rays, and as entitled to impose on them a name. But I hope I shall not be considered as undervaluing the really interesting experiments he has brought forward in support of these propositions, if I profess myself as yet unconvinced by them. My own impression is, that there are two distinct kinds of chemical action; exercised, if we choose so to consider the subject, by two distinct and independent classes of rays (not opposed, but different), the one class being those which have been hitherto commonly called chemical, but which, being in this view of the subject not a distinctive name, I shall for the present call them photographic rays;

the other a very peculiar class, which are not only analogous to, but identical with, some at least of the rays conducted by and darted forth from obscurely hot metallic bodies,—which reside (at least in their greatest prevalence) in the less refrangible portion of the spectrum (from the yellow *to*, and perhaps somewhat *beyond*, the extreme red),—which possess chemical properties not participated in at all, or not in anything like so great a degree by the purely calorific rays which lie far beyond the spectrum,—which as they exist where no light is manifested (as in hot mercury), are no way entitled to be called light (for against such a term as *invisible light* I must enter my protest),—and which as they lie in a region of the spectrum, where heat is known to exist abundantly, and produce there the chemical effects above spoken of, apparently by means of a peculiar kind of heat developed by them, *are* entitled to be regarded as heat. To such rays (the existence of which I think I have demonstrated by experiments admitting of no other interpretation), the name parathermic rays may, I conceive, be very properly assigned. And I mention the subject here in order pointedly to mark the difference between *these* rays, in my mode of conceiving them, and the *Tithonic rays* of Dr. Draper, which seem to be *the photographic rays generally*, with certain alleged additional properties which may very properly form the subject of further experimental inquiry.

I have the honour to be, Sir,

Your most obedient,

Collingwood, Jan. 11, 1843. J. F. W. HERSCHEL.

P.S. Added Jan. 20, 1843.—If we generalize our notion of radiating or *Actinic* influence so as to include the several phænomena of light, heat and chemical power operating molecular transformations, and conceive (as M. Becquerel seems disposed to do) that these several manifestations of such influence refer themselves rather to the powers, qualities and limits of the recipient than to original differences in the agent; (a view which may assuredly be taken, whether we regard that agent as an undulation mechanically propagated through a fluid, or in Sir William Hamilton's more refined point of view, as an influence transmitted, wave-fashion, but yet without motion of material particles,) it will still be absolutely necessary to have names distinctive of such very different forms of manifestation as heat, light, and chemical transformation, and rays will still continue to be spoken of as luminous, thermic, chemical, and perhaps by many more epithets, as science advances, without prejudice to any general views we may form as to causes.