XXI. *Note relative to the supposed Origin of the Deficient Rays in the Solar Spectrum; being an Account of an Experiment made at Edinburgh during the Annular Eclipse of 15th May 1836. By* JAMES D. FORBES, *Esq. F.R.SS. L. & E. F.G.S. &c., and Professor of Natural Philosophy in the University of Edinburgh.*

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THE occurrence of the late solar eclipse, which was annular at Edinburgh, suggested and offered a simple method of conducting the following inquiry.

The deficiency of rays of light of certain definite degrees of refrangibility in the solar spectrum, was discovered by Dr. WOLLASTON*, but excited little attention until its rediscovery by M. FRAUNHOFER†. Since that period it has been a frequent subject of inquiry whence that deficiency proceeds. We first are tempted to suspect that the deficient rays may have been lost in passing through the prism used. But as in most cases the dark lines are the same, whatever be the material of the prism, and whatever the length of the path described by the light within it, this supposition is not tenable‡.

If these lines were all or principally owing either to the absorptive action of any matter which may exist in the planetary spaces, or to the effect of the earth's own atmosphere, we should have the same lines exhibited in the spectra of the fixed stars as in that of the sun. Sir DAVID BREWSTER indeed states§ that he has been able to discover certain lines of the spectrum which are due to the action of the earth's atmosphere alone, since they are seen at small angular elevations of the sun above the horizon, and disappear when its altitude is greater. But these are not very numerous or important compared to the great mass of lines. Sir DAVID BREWSTER having also observed that the lines produced by the absorption of nitrous acid gas upon artificial light are in many respects similar to those existing in the solar rays, is naturally led to attach considerable probability to the idea that the solar light is originally complete, and that the deficient rays have been stopped in passing through the sun's own atmosphere‖. This atmosphere might be supposed to contain nitrous acid, or some similar gas, as a constituent.

* Philosophical Transactions, 1802.

† Memoirs of the Bavarian Academy; SCHUMACHER's Astronomische Abhandlungen, 1823; GILBERT's Annalen, 1823.

‡ RUDBERG, Bibliothèque Universelle, Janvier 1836.

§ Edinburgh Transactions, xii. 528.

‖ I do not know with whom the idea of the absorptive action of the sun's atmosphere originated. The

It occurred to me that an experiment might be made upon the light coming from different parts of the sun's surface which should decide this question. For supposing the sun to be surrounded by an atmosphere which his light must traverse, it is clear that the absorptive action must be greatest upon the light which reaches us from the edges of the sun (those points in whose horizon the earth appears), and least for that which traverses his atmosphere vertically (or to which the earth appears in the zenith). It results from this that the light derived from the extreme circumference of the solar disc might be expected to present more numerous and broader bands than when obtained from its whole surface, since the more complete spectrum derived from its central parts would fill up the gaps left in the spectrum of the lateral rays and conceal their deficiencies.

As the occurrence of the annular eclipse of the 15th of May suggested the inquiry, so it also afforded a very satisfactory mode of putting it to the test of experiment.

With a view to fix the aspect of the spectrum more accurately on my memory, I examined it the day before very carefully with the telescope of a theodolite placed about thirty feet from a vertical slit about one fiftieth or one sixtieth of an inch wide, upon which the solar rays were thrown by a heliostat. In front of the telescope was a flint-glass prism by DOLLOND, which exhibited the lines very satisfactorily. This apparatus was also arranged previously to the eclipse, and I satisfied myself that no minute changes of adjustment in the parts of the apparatus, such as the angle of incidence on the prism, the distance from the slit, the breadth and verticality of the slit, the quantity of light reflected by the heliostat, whether from single or double reflecting surfaces, &c., made any serious difference in the distinctness or general appearance of the spectral lines*. As the eclipse proceeded, and consequently the proportion

editors of the London and Edinburgh Philosophical Magazine (December 1836) have, however, referred me to the mention of it in Sir JOHN HERSCHEL's writings, particularly his Elementary Treatise on Astronomy, from which I extract the following remarkable passage. "The prismatic analysis of the solar beam exhibits in the spectrum a series of fixed lines totally unlike those of any known terrestrial flame. This may hereafter lead us to a clearer insight into its origin. But before we can draw any conclusions from such an indication, we must recollect that previous to reaching us it has undergone the whole absorptive action of our atmosphere, as well as of the sun's. Of the latter we know nothing, and may conjecture everything. . . . . It deserves inquiry whether some or all of the fixed lines observed by WOLLASTON and FRAUNHOFER, may not have their origin in our own atmosphere. Experiments made on lofty mountains or the cars of balloons on the one hand, and on the other with reflected beams, which have been made to traverse several miles of additional air near the surface, would decide this point. The absorptive effect of the sun's atmosphere, and possibly also of the medium surrounding it (whatever it be), which resists the motion of comets, cannot be thus eliminated." HERSCHEL's Astronomy, p. 212 *note*. See also his Essay on Light, Encyclopædia Metropolitana, art. 505. The object of the experiment now described is to show a method of elimination which applies, at least, to the sun's atmosphere.

* An erroneous impression seems to have been prevalent both as to the magnitude of the apparatus employed by FRAUNHOFER and as to the imperious necessity of these minute adjustments. Though the philosopher of Munich used a telescope of four inches aperture, and a prism of the same diameter, for observing the spectra of faint objects, such as stars, it appears that his map of the solar spectrum was made with a theodolite tele-

of *lateral* to *central* light increased, I continued to examine the whole length of the spectrum; but I particularly fixed upon three parts of it for more accurate comparison,—the neighbourhood of the line B in the red, the beautiful system of lines between E and *b* in the green, and the group marked G in the indigo. Notwithstanding the diminution of light I had no difficulty in pursuing my observations during the annular period; and at no time could I perceive any difference in the number, position, or thickness of the dark bands. I conceive that this result proves decisively that the sun's atmosphere has nothing to do with the production of this singular phenomenon.

Nor need this result surprise us. Spectra from artificial flames present bright and dark bands occasionally, without giving us any reason to suspect absorptive action; and the electric light presents its proper dark rays*. The solar light may also be primitively incomplete.

Had the weather proved unfavourable for viewing the eclipse, I intended to have tried the experiment by forming an image of the sun by using a lens of long focus, stopping alternately, by means of a screen, the exterior and central moiety of his rays, and restoring the remainder to parallelism by means of a second lens, then suffering these to fall upon a slit as before. The result of my experiment during the eclipse seemed however so decisive as to no *marked* change being produced at the sun's edges, that I have thought it unnecessary to repeat it.

As I do not intend to prosecute this subject at present, if the experiment just described should seem to the Royal Society worthy of being recorded, I should feel honoured by this slight communication receiving a place in the Philosophical Transactions.

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scope of only thirteen lines in diameter. His prisms, no doubt, were very perfect, but these may be replaced by hollow prisms filled with highly dispersive oils. I have frequently used oil of cassia, but on the present occasion preferred DOLLOND's flint glass, because the oil of cassia affected the distribution of colours in the spectrum, and was not otherwise very superior. I may observe in passing, that by viewing the direct solar light from a narrow slit by the *naked eye*, placed at some distance behind a good large hollow prism filled with oil of cassia, a very great number of the lines may be admirably seen. I take this opportunity of adding my anxious wish that Sir DAVID BREWSTER should publish the details of his laborious experiments on the constitution of the solar spectrum, and his new maps of the solar lines.

* Above a year ago I made some careful experiments on the spectrum produced by the oxyhydrogen blowpipe directed upon lime. I was then unable to detect any irregularities of illumination.

Edinburgh, 21*st May*, 1836.