LETTERS TO THE EDITOR.

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[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

Sunlight Colours.

WILL you permit me to say, in relation to the very interesting lecture on Sunlight Colours, reported in NATURE, vol. xxxv. p. 498, that Capt. Abney does not seem to have quite apprehended my meaning, when he represents me as stating in a previous lecture at the Royal Institution, that the sun was "really blue outside our atmosphere," for I nowhere in the lecture used those words, nor intended to convey the idea which, without qualification, they must give the reader.

I recognize, however, that if my actual words conveyed it to so fair-minded a critic as Capt. Abney, they must have been open to misconstruction, and I therefore ask permission to recall in explanation an important fact referred to in the lecture, to which he does not allude. It is that the sun is surrounded by an atmosphere of its own, and that the prime modification of its actual colour at the photosphere takes place *there*. Only the secondary change of colour takes place in the earth's atmosphere. "Outside our atmosphere," accordingly, we see, not the absolute colour of the photosphere, but one already greatly modified toward white. I meant, then, when formally defining the colour of the sun outside our atmosphere, to use such qualified phrases as "tends toward blue," or "bluish," and it was for the colour of the sun itself, *i.e.* at the photosphere, and before any absorption, that I meant to reserve the word "blue." Let me hasten to add that I also tried—even to iteration—to insist that "blue" here does not and cannot mean a monochromatic blue, but a combination of all the spectral colours, in which those of the blue end appear in such immense predominance that this is the dominant effect.

Capt. Abney also says: "he" (I) "surmised the result from experiments made with rotating disks of coloured paper. He did not, I think, try the method of using pure colours."

Capt. Abney will, I think, agree on consideration that these words may be liable to convey to most readers a wrong impression of labours which began nearly fifteen years ago, with studies on the absorption of the sun's atmosphere, resting on direct and elaborate photometric comparisons of the light of its centre and edge. These have been followed by confirmatory measures with the bolometer, giving the relative proportions of the pure colours in the normal spectrum, and the tint has not been surmised, but experimentally shown by the actual combination of pure spectral colours.

The solar studies were supplemented in the four years preceding my lecture by almost unintermittent investigations on the absorption of the earth's atmosphere, in which (though considerably over 20,000 galvanometer readings were recorded) I do not recall ever making any observation by the aid of "rotating disks of coloured paper." The paper disks have been often employed in explanation of my method, to roughly show the principles involved, and to *illustrate* results, but certainly not as means by which these results were surmised or discovered.

In a communication to the British Association, published in NATURE, vol. xxvi. p. 586, after alluding to the antecedent researches of Mr. Lockyer and others, which show that certain rays of short wave-length are more absorbed than those of long, I exhibited charts showing how much each ray had grown. One of these, which suffered some curtailment at the hands of the engraver to fit it to the height of the page, was reproduced in the report of the lecture (NATURE, vol. xxxii. p. 42), and it is possibly from this that Capt. Abney derives his impression as to my results in other respects. I can only conjecture that it may be so, since in my professional memoirs there are, not only more accurate charts, but with them warnings that the figures representing the relation of the blue and red end in such drawings, or even in the tables whence they are taken, necessarily give minimum values of the blue.

The fact that this blueness was first predicated from a long and careful study of the absorption of the sun's atmosphere is a distinct one, and I am entirely disposed to admit that this point was not explained at sufficient length in my lecture, in which I had but an hour to describe the work of twelve years. Being forced to confine myself to an account of some limited portion of this long research, I chose that part of it which dealt with the absorption of the earth's atmosphere, as illustrated by the expedition to Mount Whitney, but I thought the facts just stated about the influence of the sun's atmosphere too important to go without explanation altogether, and rehearsed them substantially in other words before entering at length on the subject of the telluric absorption.

As the observations on the sun's atmosphere are still unpublished, it may be of interest if I give here, in anticipation of the final reductions, the approximate results of some made at Allegheny in 1882, and which were supplemented by others which I was enabled to make at South Kensington in the same year by the kindness of Mr. Lockyer.

This table gives the reduction to the normal spectrum at the points indicated in the first line, where λ designates the wave-length and μ = one micron = 1/1000 of one millimetre. The second line gives the approximate transmission by the solar atmosphere (not alluded to in Capt. Abney's lecture). The third line gives the approximate transmission by the earth's atmosphere alone (numbers nearly concordant with those he seems to employ for this secondary effect); and the fourth, the combined effect of the two. It is from such numbers as those in this fourth line that we have deduced the true colour of the sun at Allegheny, by methods to be presently alluded to, and which authorize us to state that its dominant tint before any absorption is not so much "bluish" as "blue."

	μ 0·40	μ 0·45	μ 0·50	μ 0·55	μ 0·60	μ 0·65	μ 0·70	μ 0·75
Transmission by solar atmosphere	·16	·24	·30	·35	·38	·41	·43	·45
Transmission by terrestrial	·31	·44	·53	·61	·68	·74	·79	·83
Resultant transmission by both atmospheres	·05	·11	·16	·21	·26	·30	·34	·37
Reciprocal of last, showing approximate brightness before any absorption.....	20·2	9·5	6·3	4·7	3·9	3·3	2·9	2·7

Thus we see that of the extreme blue or violet light, whose wave-length is 0·4 μ, 16 per cent. (*i.e.* less than $\frac{1}{6}$) only is transmitted by the solar atmosphere, and of this 16 per cent. 31 per cent. only is transmitted by the earth's atmosphere. It is of this latter alone that Capt. Abney here takes account, but in consequence of the absorption by both atmospheres, only about 5 per cent. of the original violet light reaches us; or in other words, before the double absorption there was over twenty times as much of this sort of blue in the sun as what we now see. On the other hand, of the deep red light whose wave-length is 0·75 μ as much as 45 per cent. is transmitted by the solar atmosphere, and of this again 83 per cent. by the earth's; so that after the action of both atmospheres on this ray 37 per cent. is transmitted as against 5 per cent. of the violet. If we take the reciprocal of the numbers in this fourth line we have those of the fifth, which evidently show the relative intensity of the colours at the photosphere (*i.e.* before any absorption), as compared with that of common daylight. I employed in 1882 an optical arrangement, suggested by Mr. Very of the Allegheny Observatory, by which we passed from these figures to the production of the actual resultant tint of the solar photosphere; not by using pigments or revolving disks, but by the direct combination of pure spectral colours in the above proportions. The resultant colour cannot, I repeat, be exactly defined by any one spectral one, as it was not monochromatic; but the tint was, to my eye and that of others, best technically defined as that of Herschel's lavender, with perhaps a suggestion of purple; and certainly I think now, as I thought then, that "blue" is the nearest familiar word to describe it.

It was with all these facts, and many more, in my possession, that I used the language in question.

I hope after this statement that I may conclude that Capt. Abney and I have really no serious ground of difference as to the propriety of the term "bluish," or as to what it here means. I would only say that by no latitude of interpretation do I take it as meaning *white*.

S. P. LANGLEY.

Smithsonian Institution, Washington, D.C., May 2.