	Density of Hydrogenium observed.
When united with palladium	0·854 to 0·872
When united with palladium and platinum	0·7401 to 0·7545
When united with palladium and gold	0·711 to 0·715
When united with palladium and silver.....	0·727 to 0·742

The results, it will be observed, are most uniform with the compound alloys, in which retraction is avoided, and they lie between 0·711 and 0·7545. It may be argued that hydrogenium is likely to be condensed somewhat in combination, and that consequently the smallest number (0·711) is likely to be the nearest to the truth. But the mean of the two extreme numbers will probably be admitted as a more legitimate deduction from the experiments on the compound alloys, and 0·733 be accepted provisionally as the approximate density of hydrogenium.

I have the pleasure to repeat my acknowledgments to Mr. W. C. Roberts for his valuable assistance in this inquiry.

Could the density of hydrogenium be more exactly determined, it would be interesting to compare its atomic volume with the atomic volumes of other metals. With the imperfect information we possess, one or two points may be still worthy of notice. It will be observed that palladium is 16·78 times denser than hydrogenium taken as 0·733, and 17·3 times denser than hydrogenium taken as 0·711. Hence, as the equivalent of palladium is 106·5, the atomic volume of palladium is 6·342 times greater than the atomic volume of hydrogenium having the first density mentioned, and 6·156 greater with the second density. To give an atomic volume to palladium exactly six times greater than that of hydrogenium, the latter element would require to have the density 0·693.

Taking the density of hydrogenium at 0·7, and its atomic volume equal to 1, then the following results may be deduced by calculation. The atomic volume of lithium is found to be 0·826; or it is less even than that of hydrogenium (1). The atomic volume of iron is 5·026, of magnesium 4·827, of copper 4·976, of manganese 4·81, and of nickel 4·67. Of these five metals, the atomic volume is nearly 5 times that of hydrogenium. Palladium has already appeared to be nearly 6 times. The atomic volume of aluminium on the same scale is 7·39, of sodium 16·56, and of potassium 31·63.

VII. "Spectroscopic Observations of the Sun" (continued). By Lieut. J. Herschel, in a Letter addressed to W. Huggins, F.R.S. Communicated by Mr. Huggins. Received June 10, 1869.

Bangalore, May 7, 1869.

My dear Sir,—After what I wrote to you last week you will scarcely be surprised to hear again from me on the same subject; and indeed I feel in some measure bound to communicate without delay results of fur-

ther and more successful observations. Should you think fit to publish them, I hope you will do so, as I cannot command the necessary leisure to follow them up myself to their legitimate conclusion.

On the 3rd instant I learnt (as I informed you) that the spectrum of the solar envelope was visible with the spectroscope at my command, apparently without difficulty. On the following day I saw the same phenomena, and was enabled to form a fair mental picture of the distribution of the luminous regions surrounding the sun. Two very fine prominences were particularly examined, one of which was evidently a large cloud floating 1′ to 2′ above the surface.

On the 5th, while traversing over a new prominence to learn its shape and dimensions, I became aware of a fourth line in the neighbourhood of G. Its position was determined without difficulty with reference to the rest of that crowded group of solar lines. It was identical with the thick line at 2796 of Kirchhoff's chart. I have seen the same line repeatedly since, and have satisfied myself of the identity stated.

It rained pretty heavily on the night of the 5th; and the next morning I was disappointed by seeing no remarkable prominences, and but faint indications, in many parts, of the solar envelope. In the afternoon, however, the air, I suppose, being clearer, I could again see the luminous spectrum in nearly every part. But there were very few elevated masses. Having traversed round the whole circumference, I returned, after perhaps an hour's search, to examine again a moderately striking elevation which I had noticed at setting out; and for this purpose I directed the slit as a tangent to the surface at the place—the most favourable position for getting a good view of the lines.

Immediately I remarked that the red line was very brilliant, and glancing up the spectrum saw that the orange and blue lines were also much more intense than usual. My eye was next caught by a fainter red flash, which I soon succeeded in seeing more steadily. Concluding that it was the line which Mr. Lockyer had seen "occasionally," I only staid to estimate its position, and proceeded to bring the violet end into the field to have another look at the line in that region and to see F to better advantage. In so doing I noticed another line (the sixth) between F and G.

Before going any further I must take the liberty of christening these lines for reference. Leaving α and β for C and F if wanted, I would call the orange line near D δ, the violet one γ, the red line near C ϵ, and the last mentioned ζ. The solar bright-line series is then as follows:—

α = C	Kirchhoff's	694
β = F	,,	2080
δ near D	,,	1014 very nearly.
γ near G	,,	2796
ϵ near C	,,	655 about.
ζ between F and G	,,	2596 nearly.

The position of ϵ is estimated; for there are no visible solar lines between B and C (in my spectroscope), and because by the time I was ready to go back and measure it (ζ having already faded) it was no longer to be seen; and as the other lines had visibly decreased in brilliancy, I could only conclude that I had been a fortunate witness of the effects of a violent and spasmodic action or eruption of vapour lasting only a few minutes. Nor did I see any recurrence of this spectacle, though I watched for some time.

I should here state that I was looking at this time at a very low stratum, and that the line γ is rarely visible except quite close to the sun's limb; F also is not generally brilliant, except near the limb. δ is never (so far as I have seen) so brilliant as either C or F.

I have said that these appearances are to be seen without any defence from excessive light; and this is strictly true, for I have seen them readily, even when the paper cap which I at first used over the object-glass was removed; but as a precaution against the heating-effects of the sun's image, I have latterly used metal diaphragms, one of $\frac{1}{2}$-inch diameter, 12 inches, and a second of $\frac{1}{4}$*-inch diameter, $1\frac{1}{2}$ to 2 inches distant from the slit. When these had been inserted I dispensed with any cover for the object-glass. I was in hopes that, by carefully stopping out all unnecessary light in this way, I should be able to dispense with a slit, and view the monochromatic images of a protuberance on the white background (so to speak) of the atmospheric illumination. But so far I have been disappointed. Nevertheless I still believe that whoever will go a step further and use *a red glass prism without a slit* will see the *actual* "red flames." [When writing my eclipse-report I was under the impression that the orange was the principal light (v. § 43).] This much of foundation I have for this belief, that I actually have seen the *form* of a solar cloud through a widely distended slit—not a luminous line of varying length and position, but a view such as you may obtain through a partly open shutter by moving the head slightly to and fro, only that the movement was in this case effected by a gentle pressure up and down of the telescope itself—a movement rendered possible by the absence of perfect rigidity of the instrument. In this way I could see clearly that the solar clouds were very similar to terrestrial ones, fleecy, irregularly shaped, and illuminated, &c., just as eclipses have told us they are. The opening through which I viewed them was about $\frac{1}{4}$ of a minute in width, and the height and length of the mass $1\frac{1}{2}$ and 3 minutes respectively, or thereabouts.

After this I need not describe the appearances of the lines, the less so as I fully expect that, once the ready visibility of these appearances becomes realized, numerous accounts of such eruptions as I saw yesterday, as well as of the real forms and appearances which they present, will be forthcoming from observers who can better spare the necessary daylight hours.

* This is too large.

May 8.—This morning I received, and read with deep interest, your article in the 'Journal of Science.' Had I received it a week ago, my note of the 3rd would have been differently worded. On the other hand, it is clear that some of the facts I have stated above are still legitimate subjects for communication, and will probably lead to further discoveries. The new lines may or may not have been since seen by Mr. Lockyer. In the former case the corroboration will be worth something—the more so as his secondary red line, as mentioned in Mr. Crookes's article in the January No. of the 'Journal of Science,' is apparently misplaced. This line, as also those I have called δ and ζ, does not appear to coincide with any known solar line. The elementary substances to which these belong remain yet to be declared. As for γ, I suppose the strong solar line to which it corresponds belongs to some known element.

I have not remarked any tendency in F to vary in width.

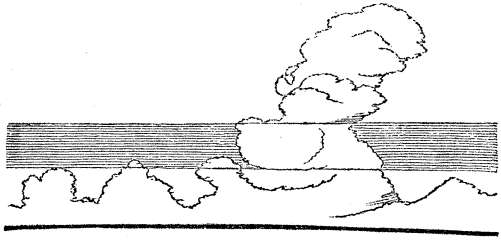
It cannot but be considered strange that no traces have been seen of M. Rayet's and Major Tennant's green lines. I have watched that part of the spectrum very closely on purpose, but, even where the four principal lines were more than ordinarily bright, I have failed to distinguish even the slightest fading of the strong magnesium lines, or of others in that neighbourhood. This *fading* invariably precedes the substitution of a bright for a dark line: thus, if the slit admits to view the tops of several adjacent prominences, the line F (for instance) is broken into detached bright portions, between which there is in each case a more or less complete hiatus, which may or may not amount to the original dark solar line. The dark line, being only a *less intense light*, is susceptible of all degrees of darkness, just as the bright line, being only a *more* intense light, may appear of all lower degrees of brightness. This intermediate condition between dark and bright is constantly to be recognized, more or less strongly marked, within the sun's border; but I cannot say I have seen a continuation of the bright line inwards. I often see this absence of the dark line γ when the light is not intense enough to show it as a "bright" line. So far, then, as regards the *magnesium* element I have strong negative evidence, which is strengthened by the consideration of the improbability that such a very marked group should not have been recognized by the above-mentioned observers if it was actually present, on the one hand, and that the element should have been represented by a single member only of this group, on the other. The confident way in which this metal has been accepted as recognized, by more than one speculator, seems to challenge question on the evidence.

And I would take the present opportunity to remark that, after the studied avoidance (on my part) of such hasty conclusions, I have felt it rather hard to be set right where I had not erred, as in the case of the orange line. I never said that a line, apparently identical though it was with D, represented sodium. One writer, if I recollect right, made *me* responsible, not only for sodium and hydrogen, but for magnesium as well!

Neither word even *occurs* in my report, except incidentally in the words "a sodium-flame." The exceeding care which I observe in your own writings in this respect will, I hope, make it unnecessary for me to apologize for this protest.

To return: I do not question the presence of an element giving a green line; the testimony of three observers must be taken as conclusive; but I am slow to believe that either E or *b* is connected with it.

This afternoon I made a slight advance towards seeing the actual forms with greater comfort. Taking a hint from your figure (p. 216 of the above article), I introduced one of the compound prisms of the hand-spectroscopes into the eye-tube, thus increasing the dispersion by about one-fourth, which enabled me to open the slit a little wider. Finding a suitable prominence, I was able to examine it with an aperture of about 20″ to 25″. As it was not much more than 1′ in height, I could, by a slight pressure one way or the other, view the whole. It is of course wholly unimportant what the actual form was, but, for the sake of illustration, I attempt a drawing. It is not easy to convey the impression of a fleecy cloud such as I saw. I looked at one or two others in the same way, and left off eventually quite satisfied that with a suitable battery the whole of any prominence or eruption might be seen with comfort (either the red, or the orange, or the blue, or any other principal image being examined at will) by limiting the field of view, and with it the unnecessary diffuse light, to the actual dimensions of the object. The portion of a cloud-shape which is due to one element will thus be artificially separated from the form which is due to another, and the regions or strata to which the various elements are confined will become known with certainty *.



It is unfortunately impossible for me to prosecute these researches any further. I have neither the leisure nor the opportunity to devise and use suitable instruments except at rare intervals, for which such discoveries will not wait.

Yours very truly,

J. Herschel, Lt. R.E.

* As an instance of this kind, I may point to Captain Haig's observations with the hand-spectroscope. As this instrument *has no slit*, his "bands" mean the coloured repetitions of the line of sierra or low clouds fringing the moon's limb at the point, only that with so low a power, and amid the confusion of images, he did not recognize (apparently) the similarity of general outline of the differently coloured images. Hence the term "bands," which has misled at least one reviewer into inferring a slit, and thereby immensely overrating the scope of these instruments.

J. H.