its diameter would have been overwhelming, and feeling that here was a crucial test to apply to a question which has so long been debated, but never with such interest among the workers as recently, it was with some excitement that I found myself before these two photographs some little time ago with two American astronomers of eminence, for the purpose of endeavouring to settle the question. Suffice it to say that we came to the conclusion that the rifts were not identical, that the two cameras had *not* photographed the same phenomenon, although at first there appeared to be sufficient similarity to make the matter appear doubtful, and, unfortunately, the photographs vary so much in size, and the margin of the American one is so limited, that it will be scarcely possible to make a final comparison until they are brought to a common scale, and superposed the one on the other. I do not think it is surprising that rifts should appear in both photographs, supposing a non-solar cause were at work, for the Corona between the rifts on Mr. Brothers' photograph looks like a very wide ray.

Assuming then for the present that the photographic evidence goes the way of all the other evidence—that in short, the solar corona, including all its fantastic boundaries, has been probably reduced from one, two, or three solar diameters, to six, eight, or ten minutes,—I care not which,*—let us examine some of the details of the various observations.

In Professor Watson's drawing, the intimate connection between the higher and lower levels of the chromosphere (including the portions not at present observed by the new method), comes out in a very striking way. Mr. Seabroke at my request, made careful maps of the positions of the prominences before the totality commenced, and Professor Watson made his drawing of the Corona, independently of the positions of the prominences. On the homeward journey the map was compared with the sketch, and to use Professor Roscoe's words, "On comparing the two drawings thus independently made, a most interesting series of coincidences presented themselves. Wherever on the solar disc a large group of prominences was seen in Mr. Seabroke's map, there a corresponding bulging out

of the Corona was chronicled on Professor Watson's drawing, and at the positions where no prominences presented themselves, there the bright portions of the corona extended to the smallest distances from the sun's limb." We may remark that these coincidences show the excessive fidelity of the drawing, and make it one of the most valuable of the products of the Expedition.

On former occasions the Corona has been stated to assume a roughly four-cornered form. This was also observed in Spain last December, and seems at last explained by three drawings made by one of the American party there.

At the commencement and end of totality, when the moon unequally covered the sun, the photographs have recorded an excess of light on the Corona on the side where the limbs occur nearest in contact. I am told that this effect in one of Lord Lindsay's photographs is very striking; it is certainly so in one of Mr. Brothers'. In the drawings we have a slightly different effect. At the commencement of totality, when the western or right hand limbs were in contact, we get Fig. 1, at the end of totality the appearance recorded was Fig. 2; the picture at the middle

of totality compounding both these appearances, and being roughly represented by Fig. 3, in which the rectangular appearance comes out in its full strength.

A word now about the polariscopic observations. I may remark on this that it is much more easy for us to explain slight polarisation which might be atmospheric, than it is to explain, if we content ourselves with laboratory experiments, strong *radial* polarisation which must take place at the sun. If we assume that gas or vapour of considerable tenuity does not reflect light (although I think this is to assume very much for the gas or vapour *at the sun*, at all events), what is it that reflects light to us at the sun, and reflects it apparently only *above* the level of the intensely incandescent hydrogen? Certainly not solar spray. If we deny reflection to gases altogether, may it not be the continuous portion of the spectrum of the gas itself to which the light is due. But this question of polarisation is certainly one in which very much remains to be done, and it is *consoling* to know that the results obtained now will much facilitate the planning of the next polariscopic campaign, which, we may add, should not be deferred beyond the end of this year.

J. NORMAN LOCKYER

PHYSICAL LABORATORIES

IN an excellent article in a late number of NATURE, Prof. Fickering has drawn attention to the importance of the practical teaching of Physics, and has shown how this is being done on an extensive scale in America. It may be interesting to trace the similarity between the methods employed by different teachers, and to show what opportunities are and have for some time past been open to students in London for the practical study of every branch of Physics.

* I beg here to give the actual words employed by Dr. Frankland and myself in the communication to the Royal Society on the subject. Speaking of the chromosphere, it was remarked "the tenuity of this incandescent atmosphere is such that it is extremely improbable that any *extensive atmosphere*, such as the corona has been imagined to indicate, lies outside it."—Proc. R.S., Feb. 11, 1869. I never imagined that all the Corona was non-solar. Again, Proc. R.S., No. 116, 1870, discussing the American Eclipse, I state that the chromosphere includes the "radiance" observed in the American Eclipse, of which radiance Dr. Gould wrote as follows:—

"An examination of the beautiful photographs made at Burlington and Ottumwa . . . and a comparison of them with my sketches of the corona, have led me to the conviction that the radiance around the moon in the pictures made during totality is not the corona at all, but is actually the image of what Lockyer has called the chromosphere. This interesting fact is indicated by many different considerations. The directions of maximum radiance do not coincide with those of the great beams of the corona; they remain constant, while the latter were variable. There is a diameter approximately corresponding to the solar axis, near the extremities of which the radiance upon the photographs is a minimum, whereas the coronal beams in these directions were especially marked during a great part of the total obscuration. The coronal beams stood in no apparent relation to the protuberances, whereas the aureole seen upon the photographs is most marked in their immediate vicinity. . . . Whatever of this aureole is shown upon the photographs was occulted or displayed by the lunar motion, precisely as the protuberances were. The variations in the form of the corona, on the other hand, did not seem to be dependent in any degree upon the moon's motion. The singular and elegant structural indication in the special aggregations of light on the eastern side may be of high value in guiding to a further knowledge of the chromosphere. They are manifest in all the photographs by your parties which I have seen, but are especially marked in those of shortest exposure, such as the first one at Ottumwa. In some of the later views they may be detected on the other side of the sun, though less distinct; but the very irregular and jagged outline of the chromosphere, as described by Janssen and Lockyer, is exhibited in perfection."

Professors of Physics at different Universities have usually selected their best students to assist them in their private laboratories, to the mutual advantage of professor and student, but I believe that Prof. Clifton was the first to propose, more than three years ago, that a course of training in a physical laboratory should form a part of the regular work of every student of Physics.

This system was adopted and at once put in action at King's College, on a very considerable scale for a college with no endowment whatever, and has been working for now nearly three years. Two large rooms adjoining the Museum of Physical Apparatus were fitted up for a Physical Laboratory, and a third room was built for a store and battery room. Fixed tables in both large rooms are supplied with water and gas, and with pipes passing to gasholders containing oxygen and hydrogen, also with thick copper wires insulated from one another passing to the battery room, so that in electrical work the fumes from batteries are entirely got rid of.

The principal instruments have their fixed places on the tables, and a description of the measurement to be made is given to each student, and while in progress his work is examined by the professor or demonstrator. The course of study includes the subjects of pneumatics, heat, light, electricity, and magnetism, and with the regular class, a definite order in each subject is kept to as nearly as possible. When, as has sometimes been the case, there are twelve or more students beginning their laboratory course at the same time, it is necessary to deviate from the regular course, and to set some to begin with heat, some with light, and others with electricity. For some experiments, such as the determination of the relation between the pressure and volume of a gas, or the measurement of the expansion of a gas for given changes of temperature, requiring the use of the manometer and calorimeter, it is found better to have two students working together, each student making in his turn and so checking every part of the measurement or determination.

The accuracy of the results obtained has been very great, and is an evidence of the interest taken in the work by the student, and of the value of such a course of study as a mental training, to say nothing of the actual knowledge gained. Every student is required to produce fair results, and to give an account of the methods which he has employed, before he is allowed to proceed to another part of the subject. Besides the students pursuing the regular course there are several who wish to devote their attention to some one branch, such as Electricity. In this subject, after making determinations of Resistance, Strength of current, and Electromotive force with simple galvanometers, they pass to more delicate measurements with Thomson's Galvanometers and Electrometers, such as the experimental determination of equi-potential lines on a conducting surface uniting two poles of a battery, and perform all the tests and measurements required in connection with Telegraph lines and cables.

The more advanced students carry on investigations in the Laboratory, such as the measurement of the effect of heat in altering the magnetic polarity of dia-magnetic bodies, or in altering the rotation of the plane of polarisation of a beam of polarised light as it passes through sugar solutions.

Students are encouraged to combine their work in the Physical Laboratory with their work in the Mechanical Workshop, and are enabled to design and construct apparatus, and their inventive powers are exercised often with great success. From experiments with Attwood's Machine one student has designed and made for himself a new form of governor for an engine, another has designed an Inductometer for measuring the time required to produce the maximum induced current in a wire by the action of another current.

The success of the Laboratory system of teaching may be judged from the quality of the work done by the students, who are mostly from sixteen to eighteen years of age, and are always eager for the work, as well as from the fact that in the last term there were twenty-three students in the Laboratory, and the numbers are steadily increasing.

It will be seen that to the student of Electricity or any branch of Physics, every opportunity is offered of pursuing the object which lies before him, and that the advance which may be made by him is dependent only on his own exertions.

W. G. ADAMS

MORELL'S GEOMETRY

The Essentials of Geometry, Plane and Solid, as taught in French and German Schools, with shorter Demonstrations than in Euclid; adapted for Students preparing for Examination, Cadets in Military and Naval Schools, Technical Classes, &c. By J. R. Morell, formerly one of Her Majesty's Inspectors of Schools. (London: Griffith and Farran, 1871.)

A WORK with this attractive and somewhat ambitious title cannot fail to attract attention, appearing, as it does, at a moment when very commendable efforts are being made to improve the teaching of Geometry in our schools, and to prepare the public mind for an important reform which will necessarily involve the adoption of textbooks more suited to modern habits of thought and inquiry than the Elements of Euclid. It will, no doubt, therefore be expectantly read by many, and the fact that the author is already widely known as a writer on philosophy and grammar, and was formerly one of Her Majesty's Inspectors of Schools, will tend to raise expectations, and will lend it an authority to which, as we shall presently see, it is by no means entitled. Our duty to students preparing for examination compels us, in fact, to warn them that this book can render them no essential service whatever, but, on the contrary, may do them incalculable mischief; and our sympathy with the praiseworthy efforts above alluded to—our desire to prevent undeserved discredit from being attached to those efforts—obliges us to dissociate this one from them, and to criticise it with all due severity.

The plan and general arrangement of the book are open to the severest criticism; we deem it unnecessary, however, to dwell thereon, for the work is so destitute of the most essential of all "Essentials of Geometry"—accuracy and clearness—that no possible rearrangement of its materials could redeem it. We shall consequently draw attention solely to the deplorable looseness of expression, indicative of hopeless inaccuracy of thought with which almost every page is disfigured.