

THURSDAY, AUGUST 29, 1872

## SCHELLEN'S SPECTRUM ANALYSIS

*Spectrum Analysis in its Application to Terrestrial Substances, and the Physical Constitution of the Heavenly Bodies.* By Dr. H. Schellen, Director der Realschule, I.O. Cologne. Translated from the second enlarged and revised German edition by Jane and Caroline Lassell, edited, with notes, by W. Huggins, LL.D., D.C.L., F.R.S. (Longman and Co., 1872.)

IT is not difficult to deliver interesting lectures or to write an instructive book on spectrum analysis. The rapid succession of brilliant discoveries in this new branch of science, the amount of fundamental facts added by it to human knowledge, especially in the field of the cosmical world, assure the lecturer or writer appealing to the intelligent but not scientific public of useful and legitimate success. But what is not so easy to do is to interest at the same time the *gens du monde* and scientific men, by offering a selection of the most recent discoveries in a bright and literary form attractive to the former, and yet keeping for the latter the appearance of precision, and exactness of the numerical results.

All these conditions are very happily filled in "Schellen's Spectrum Analysis," edited by Mr. W. Huggins from the second German edition. I shall commence by giving a brief account of the chief points of the book.

The first part, introductory, is occupied by a description of the artificial sources of high degrees of heat and light, of which the study is so intimately connected with the chemical and astronomical phenomena embraced in the field of spectrum analysis; various apparatus, for instance, the gas-burner, the magnesium lamp, the Drummond lime-light, the electric spark of the induction coil, the Geissler's tube, and the electric light produced by voltaic batteries are described, and the practical adjustments are briefly but sufficiently referred to for a good understanding of the subject.

The second part is devoted to an elementary abstract of the geometrical and mechanical properties of light. The fundamental analogy between light and sound is developed, in order to explain to a reader unlearned in optics how the colour of a ray is the corresponding element of the pitch of a musical sound, and how it is possible to define a coloured ray by the time of its luminous vibrations. The description of refraction phenomena, especially the paths of rays through a prism, leads naturally to the separating process of the different colours on which spectrum analysis is founded.

Some examples of such an analysis of light by means of a prism are given, amongst which we may mention the screen-projections of the spectra of the electric, sun, or magnesium light; a sufficient number of illustrations enables every one easily to repeat the experiments.

A considerable number of chapters is devoted to the construction of the simple and compound spectroscopes. The chief points of this construction, especially the contrivances for the simultaneous comparison of two spectra, the determination of the position of lines in the spectrum

are carefully described. Afterwards a practical account of the methods for exhibiting spectra of terrestrial substances, for instance, metallic salts volatilised in a gas-burner, &c., will certainly interest chemists.

The beautiful appearance in the spectroscopy of heated gases in Geissler's tubes, their bright lines, and also the important question concerning the change of spectra with temperature and pressure, all these subjects are sketched in general outlines; it is nevertheless to be regretted that an account of the beautiful experiments of MM. Frankland and Lockyer have not a place amongst these descriptions; the difficult problems raised by these experiments are not completely solved, and we by no means can accept every assertion developed in this interesting chapter.

The curious absorption phenomena to be observed in the spectrum analysis of light which has passed through certain liquids, especially of organic origin, deserved a peculiar notice; the author has not neglected to describe one of the most remarkable spectra—the absorption-bands of the blood, and to indicate what advantage natural history is able to derive from such observations even on microscopical objects.

An interesting chapter contains the theoretical and experimental explanation of the reversal of the spectra of gaseous substances. This phenomenon, studied independently by Foucault and Angström, and definitely generalised by Kirchhoff, is perhaps the chief point of the history of spectrum analysis, and certainly the beginning of its utilisation as a powerful method of investigation.

The only practical example of reversal given in the book is that of sodium vapour; but recent experiments have proved that nearly all metallic vapours heated conveniently in the voltaic arc show the reversal of a great number of bright lines into black ones.

The third part of the book, the most important in extent and results, is devoted to the application of the spectrum analysis to the heavenly bodies.

The sunlight, according to its brightness and to the peculiarities of its spectrum, is the best and easiest example to study. The dark lines in infinite number which it shows, called "Frauenhofer lines," from the discoverer, deserve special attention; therefore the author has illustrated the description of the sun-spectrum with two sets of maps. The first is a reduction of Kirchhoff's maps engraved on wood, representing in several tints the lines from *A* to *G*; the second series is a reduction to about half size of the admirable *normal solar spectrum* of Angström, in which the Frauenhofer lines from *a* to *H<sub>1</sub>H<sub>2</sub>* are co-ordinated according to their wave-lengths. The accuracy of these lithographic plates is really wonderful; they will have the great merit of introducing amongst physicists and astronomers the wave-length scale for the designation of lines instead of Kirchhoff's scale, which is an arbitrary one; and in any case they will facilitate the transformation of the data from one to another. I must add that Angström's maps have been introduced into the present edition by the English editor, and that such an addition is certainly one of the greatest attractions of this book for scientific men.

A good abstract of Kirchhoff's and Angström's memoirs on the coincidence of the dark solar lines with the bright lines of metallic vapours leads to the hypothetical con-

stitution of the sun; this problem is so difficult, that it is necessary to leave to every one the responsibility of his own ideas on this subject. I ask, then, for permission to decline any critical notice of this part of the book.

I must mention also a useful description, illustrated with maps, of the telluric and atmospheric lines from the works of Brewster, Gladstone, Angström, and Janssen.

The remaining part of the book is entirely devoted to the most delicate applications of spectrum analysis to astronomy. A preliminary description of the sun-spots, faculae, and other peculiarities of the surface of the sun, of the prominences round the disc, and so on, is given before the spectroscopic process for analysing these appearances is introduced, and enables the reader to understand very well the difficulties of the problem and the interest of its solution. I must mention especially the interesting account of the three total solar eclipses of 1868, 1869, 1870. A large series of drawings and photographic *fac similes* give the best idea of the phenomena, and show the improvements due to photography and spectroscopy; the relatively great extent devoted to this account is justified by the importance of the subject; the spectrum analysis of the prominences is in fact one of the most considerable results obtained for a long time in the sciences of cosmogony.

Now from this discovery of Janssen's it is easy to observe every day the solar prominences by utilising the bright lines of their spectrum. Janssen's method, discovered in India soon after the eclipse of 1868, was independently discovered again some weeks after by Lockyer, who has the real merit of announcing two years before the possibility of such an important observation, and would very likely have had the honour of priority if he had had beforehand the material means of carrying out his designs.

Schellen's book contains a complete account of the improved telespectroscopes of Lockyer, Respighi, Secchi, Huggins, Janssen, Young and Zöllner, and a beautiful series of coloured sketches, representing some daily observations of prominences all varying, but truly characteristic of their form. I must confess, however, that some of those beautiful pictures seem to me rather too much embellished by the imaginative fancy of one of the observers. The sun-spots and faculae observed with a telespectroscope give a good number of new facts which have led Lockyer and Secchi to the most important inductions upon the constitution of the sun.

The spectroscope, as it is known, is able to give an exact measurement of the proper velocity of the luminous bodies. A German physicist, Doppler, deserves to be mentioned as the first who called the attention of astronomers to this subject, though a good number of his assertions may be incorrect. After him, Fizeau, a French physicist, to whom we are indebted for the first determinations of the velocity of light on the surface of the earth, showed the errors of Doppler in a little paper not very well known, published in 1849 ("Bulletin de la Société Philomatique de Paris"), and calculated the apparent change of refrangibility which would be produced by the proper motion of some heavenly bodies; but no direct experiment was made before the complete application of spectrum analysis to the sidereal phenomena. In this

way Schellen's book gives a good abstract of the works of Huggins and Secchi. In these researches the velocity of rotation of the sun was to be tested as a verification of the general law of the phenomenon. I ought to say, that, the rather discordant results want a theoretical analysis, because the problem seems to me, in the case of the sun, more complicated than it appears at first sight. However, the influence of the velocity of the gas streams, especially of hydrogen, which constitute the greater part of the prominences, is unquestionably verified by Lockyer's observations. In the same way Huggins has proved and determined the proper motion of Sirius by the apparent change of refrangibility of the F line.

The remaining part of the book is devoted to stellar and meteoric spectrum analysis. It is impossible to give a superficial notice of the beautiful researches of Huggins and Secchi, researches which are always going on; the reader will find with interest various important results of these studies—for instance the existence in many stars of a good number of terrestrial substances—hydrogen, nitrogen, magnesium, sodium, &c.

One of the most interesting facts is the observation of the temporary star which appeared in May 1856; the great brightness of the star was due, as indicated by the spectroscope, to an immense mass of incandescent hydrogen.

At the end of the work the author gives some very important observations of Huggins and others on the spectrum of nebulae; the chief result is the possibility, with the aid of the spectroscope, of distinguishing by the composition of their light the true nebulae from the clusters of stars.

Finally, a description of the spectrum of the aurora borealis, the identification of its bright lines with some bright lines of the solar corona, a description of various meteors, lightnings, and their spectra, show into what difficult objects this new branch of science has pushed its investigations.

On the whole, this book must be considered as a good type of a "popular work;" it deserves the attention of the public, and the esteem of scientific men; and finally, it recommends itself by a gracious side. It was translated into English by two ladies, who have had the double merit of giving a proof of their good scientific taste, and of showing an example of the help which their sex is able to afford to science.

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#### OUR BOOK SHELF

*Health and Comfort in House-building.* By J. Drysdale, M.D., and J. W. Hayward, M.D. (London: E. and F. Spon, 1872.)

*Sewer-gas, and how to keep it out of Houses.* By Osborne Reynolds, M.A. (London: Macmillan and Co., 1872.)

THE first of these works supplies a want long felt by that section of the public who are desirous of obtaining a good supply of fresh air in their houses, without being subjected to the cold draughts usually associated with almost every system of ventilation. The book is most carefully written, and is evidently the result of much thought, time, and intelligent labour. After reviewing very fairly the systems of ventilation which have been proved to be ineffectual for supplying fresh warm air to the whole of a house, although perhaps very appropriate for single rooms, we are told that the key-note of this new