29. COMMISSION DES SPECTRES STELLAIRES

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Investigation of stellar spectra has been active during the last four years. Without attempting to make a complete survey, some important researches may be mentioned.

The theory of the intensities and contours of absorption lines has been discussed by Eddington, Milne, Pannekoek, Woolley, H. H. Plaskett, and others, and has proved to be difficult. For example, no quantitative theory has yet been developed for the residual intensity which remains in even the strongest lines, although the physical causes underlying the formation of residual intensities are rather obvious. Study of solar lines with light which has left the surface at different angles shows that the processes which produce the wings and the centre are probably different. The most promising line of attack on this intricate problem appears to be in studies of the solar spectrum, where different regions of the disc may be separately investigated, rather than of integrated starlight. The highest dispersion available, even in solar work, will be none too great.

The intensities of spectral lines have almost always been recorded on arbitrary scales, varying with the observer, the type of plate, and many other circumstances. These should be replaced by a rational scale. The best practical parameter appears to be the "total intensity"—proportional to the amount of light which the line removes from the spectrum, in terms of that lost in a perfectly black, sharp-edged band of standard width. This has the great advantage that its measurement is unaffected by the resolving power of the spectroscope (within reasonable limits). Milne remarks, "Even to define this strictly is hard; we should have to say 'the continuous spectrum which would result if the atoms in question were removed from the stellar atmosphere and replaced by fictitious atoms devoid of selective properties near this frequency and endowed with scattering and absorption coefficients equal to the mean value of the scattering and absorption coefficients of all the other (un-selective) atoms present, at this frequency.' Again, what is to be done with blends? If the atoms of different elements had exactly the same line-frequency ν_0, they would produce a single observable depression. Is this to be referred to each atom in the presence or in the absence of the other? The difficulty occurs acutely when wings overlap."

In addition to these difficulties in the theoretical definition of the "continuous background" from which the loss is to be measured there are great practical difficulties even in estimating it in the case of widely winged lines, blends, etc. Nevertheless, any reasonably good measures are much preferable to the very crude scales now in use. Such measures should be made on plates which have been adequately standardized—preferably by impressing upon them suitable photometric standards before development. The width of the standard line is sometimes taken as an Angstrom. A unit proportional to the wave-length might be preferable, since theoretically $d\lambda/\lambda$ is a function of the number of atoms effective in producing the line.

To determine this number is a hard problem. Theoretical contours may perhaps be applied to the wings of broad lines. For the rest, recourse may be had to an empirical calibration with the aid of multiplets. The published discussion of Rowland's scale is provisional, and may need considerable correction for the weakest and strongest lines. Further work is needed to determine whether it is affected by "interlocking" of lines in multiplets, and to what extent the data derived from the Sun are applicable to spectra of other classes. Direct calibration of stellar spectra should be practicable, but only with very high dispersion.

A complete empirical specification of a line must involve at least one parameter in addition to the total intensity—for example, the central intensity, or "depth." Determination of this is much complicated by lack of resolving power. A third parameter is required to take account of widening of the type associated with rotation of the star. Lines subject to the Stark effect may require a fourth parameter. The presence of "forbidden" lines of *He* I, discovered by Struve, is important in this connection.

Bright lines would require an independent and probably very complicated classification.

The attack on general problems of the constitution of stellar atmospheres, suggested in the last report of this Commission, must await the discussion of these matters. It is already evident, however, that the great strength of the lines of ionized metals in the red super-giants, such as Alpha Orionis, presents a serious puzzle.

One important conclusion appears to be well established; that the atmospheres of the Sun and stars are composed mainly of hydrogen, which is probably much more abundant than all other elements together. This has important consequences in many branches of astrophysics.

With regard to individual spectra, we may note:

Wolf-Rayet Stars. Beals has suggested that the wide emission bands arise from atoms ejected with high velocity in all directions. Many observers consider that the degree of excitation indicated by the relative intensities of the emission bands is not the same as that derived similarly from the absorption lines, nor are the two closely correlated. B. Edlen (*Observatory*, **55**, 115, 1932) reports the presence in Wolf-Rayet spectra of bright lines of *N* IV, *N* V, *O* IV, *O* V and *O* VI, indicating a much higher degree of ionization than has previously been detected in stellar spectra.

Classes O and B. Struve has given a comprehensive list of the absorption lines. All but a small fraction of these are identified. Ionized oxygen and nitrogen furnish the greater number.

The presence of bright lines in these spectra has been attributed by Struve to a rotating envelope of gas, well above the star's surface.

Class A. Peculiar spectra, in which the lines of certain elements (Si^+, Mn^+, Eu^+, etc.) are abnormal, appear in considerable numbers; but no explanation of this has yet been suggested.

Classes K and M. Bright H and K lines are frequently, and perhaps normally, present in the spectra of giants, and also in a good many dwarfs. The reason is still obscure.

Peculiar spectra have been extensively studied. Some are very strange, e.g. class M, with emission lines of He^+ and nebular lines. Others vary enormously, such as the "iron star" XX *Ophiuchi*. These changes are sometimes recurrent, but are wholly unexplained. The systematic classification of spectra of the fainter stars, and the accepted system, continue actively. Miss Cannon, in the Henry Draper Extension, has added more than 100,000 stars to the 225,000 of the Henry Draper Catalogue.

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Work is also being done by Schwassmann at Bergedorf, Lindblad and Schalen at Upsala, and by Becker, on plates obtained at La Paz. Detailed studies of high-dispersion spectra have been made at the Mount Wilson Victoria and Yerkes observatories.

The general consensus of opinion in the Committee is to the effect that no formal recommendations regarding notation need be made at the present time.

Beals's tentative classification of Wolf-Rayet spectra was made before Edlen's recent discoveries, which may aid in the establishment of a definitive arrangement in order of atomic excitation.

The peculiar type of wide lines shown, for example in α *Aquilae*, is probably due to rapid rotation; but most members of the Commission doubt whether a specific letter to denote this peculiarity is now required. The same statement may be made regarding the forbidden lines of *He* I (arising doubtless from the Stark effect). Bright H and K lines are found in many late-type stars, but it would be premature to adopt a special symbol for this until it is settled whether it may not be a normal characteristic (for spectra observed with adequate dispersion).

Your Commission therefore beg to report substantial progress in its field, without presenting specific recommendations.

HENRY NORRIS RUSSELL
President of the Commission

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