ADVANTAGES AND LIMITATIONS OF QUANTITATIVE SPECTRAL CLASSIFICATION

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Abstract. The measurements of spectral lines of moderate dispersion slit spectrograms for F, G and K type stars give a large quantity of information. The measurements are time-consuming in comparison with visual classification, but the use of digitized microphotometers reduces the task, and the method is now promising. The interpretation of the measurements raises some problems, which are briefly discussed.

The great success achieved by the spectral classification has not to be emphasized here. The one-dimensional classification is an easy and quick procedure. A two-dimensional classification, such as the MK system, requires considerably more care. Deciding for a type and a class is not always easy, even for Population I stars. Population II stars do not fit in the MK system, defined by a set of standards of Population I; a special classification, such as that proposed by Landi-Dessy (1964), should be used, supposing that a complete set of Population II standards could be found. A three-dimensional classification by visual inspection seems very hard to achieve and, except for the case of more or less extreme Population II stars, the attempts for such a visual classification have not proved to be entirely successful. A precise and detailed three-dimensional classification falls in the field of quantitative classification.

The simplest idea is to measure the intensity of lines in the spectra, instead of evaluating intensities (or intensity ratios) by visual inspection. This means a heavy task, calibrating the plates with scaled photometric sources, registering spectra and calibrations through a microphotometer, determining the characteristic curve of the emulsion, measuring the tracings and reducing the measurements. This has been done in the past by several astronomers and the use of digitized microphotometers and computers reduces now considerably this task.

Let us suppose that the astronomer has a set of measures of lines. Multivariate analysis seems to be an adequate tool for using this set of data. However, under careful examination, a number of problems arises.

For example, as the temperature decreases, the intensities of most of the easily measurable lines grow more or less at the same rate, so that these lines carry essentially the same information. A rather great accuracy is necessary to measure the small differential variations which display a variation of luminosity or abundance. Such an accuracy can only be obtained by exercising great care in every step: observation, measurements, reduction. The observations have to be homogeneous, and a rather *rigid* technique has to be used.

Another difficulty arises with the meaning of the measured intensities of lines.

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On the empirical side, the measurements do not usually fit exactly the visual estimates. On the theoretical side, they are not necessarily simply related to equivalent widths, since only small dispersion spectra are used; a theoretical interpretation is not always straightforward. For instance, let us consider the ratio of the lines λ4077 Sr II / λ4071 Fe I (a classical luminosity criterion); from the statistical analysis of a sample of 129 stars, the measures of these two lines do not lead to a good luminosity criterion (Spite, 1968).

Finally, when measurements are made, it is generally expected more from these measurements than from visual inspection; quantitative estimation of T_{eff}, g or M_v and [Fe/H] are expected instead of a mere qualitative (even three-dimensional) classification; a fit with theory is required.

The best way to relate measurements of lines and theory, is to compute a synthetic spectrogram from a model (Cayrel, 1968). Good models are now found in the literature. The main difficulty is the lack of suitable physical constants (or more generally: physical knowledge) of atomic and molecular processes, so that the calculation of the synthetic spectra of late-type stars is now quite uncertain. Some progress has to be made in this field. The theory of heavy lines (chromospheric lines) has to be improved. Then, a three dimensional quantitative classification could be built on sound basis from measurements of spectrograms. This would be very valuable, especially for the study of parts of the Galaxy consisting of a mixing of Population I and II.

References

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