atomic constants — a matter that has been discussed in detail in the preceding seven chapters.

The observed intensity can therefore be used *directly* for only a crude estimate of abundance. Roughly speaking, the lines of the lighter elements predominate in the spectra of stellar atmospheres, and probably the corresponding atoms constitute the greater part of the atmosphere of the star, as they do of the earth's crust. Beyond a general inference such as this, few direct conclusions can be drawn from line-intensities. Russell[1] made the solar spectrum the basis of a discussion in which he pointed out the apparent similarity in composition between the crust of the earth, the atmosphere of the star, and the meteorites of the stony variety. The method used by him should be expected, in the light of subsequent work, to yield only qualitative results, since it took no account of the relative probabilities of the atomic states corresponding to different lines in the spectrum.

Uniformity of Composition of the Stellar Atmosphere

The possibility of arranging the majority of stellar spectra in homogeneous classes that constitute a continuous series, is an indication that the composition of the stars is remarkably uniform — at least in regard to the portion that can be examined spectroscopically. The fact that so many stars have *identical* spectra is in itself a fact suggesting uniformity of composition; and the success of the theory of thermal ionization in predicting the spectral changes that occur from class to class is a further indication in the same direction.

If departures from uniform distribution did occur from one class to another, they might conceivably be masked by the thermal changes of intensity. But it is exceedingly improbable that a lack of uniformity in distribution would *in every case* be thus concealed. It is also unlikely, though possible, that a departure from uniformity would affect equally and solely the stars of one spectral class. Any such departure, if found, would indicate that the presence of abnormal quantities of certain elements was

[1] Russell, Science, **39**, 791, 1914.

an effect of temperature. This explanation appears, however, to be neither justified nor necessary; there is no reason to assume a sensible departure from uniform composition for members of the normal stellar sequence.

Marginal Appearance of Spectrum Lines

Fowler and Milne[2] pointed out that the "marginal appearance," when the line is at the limit of visibility, is a function of the abundance of the corresponding atom. For this reason their own theory, which dealt not with the marginal appearance but with the maximum of an absorption line, was capable of a more satisfactory observational test than Saha's. It is possible, as shown below, to extend the Fowler-Milne considerations and to use the observed marginal appearances as a measure of relative abundance.

The conditions for marginal appearance must first be formulated. When a strong absorption line is at maximum, the light received from its center comes from the deepest layer that is possible for the corresponding frequency. The actual depth depends, as was pointed out in Chapter IX, upon the number of absorbing atoms per unit volume, and upon the atomic absorption coefficient for the frequency in question. The suggestions that were put forward in the chapter just quoted indicate that different lines, at their maxima, arise from different "effective levels," the more abundant atoms appearing, other things being equal, at higher levels.

As an absorption line is traced through the classes adjacent to the one at which it attains maximum, it begins to diminish in intensity, owing to the decrease in the number of suitable atoms. If the line is very intense, the first effect of the fall in the number of suitable atoms is a reduction in the width and wings. As the number of suitable atoms per unit volume decreases further, a greater and greater thickness of atmosphere is required to produce the same amount of absorption, and accordingly the line originates deeper and deeper in the atmosphere of the star. As

[2] R. H. Fowler and Milne, M. N. R. A. S., **83**, 403, 1923.