traced in the stellar spectrum. The occurrence of the se
spectrum of hydrogen, ascribed to the hydrogen mole
has been suspected,[3] but not definitely established. O
of the lines has been recorded, and this should almost c
be attributed [4] to N++. The familiar Balmer series ap
emission lines in the Wolf-Rayet stars, but normally t
absorption lines in all succeeding classes.

The intensity of the hydrogen lines is at a maximum
neighborhood of Class A0. They vary greatly in widt
ever, within a given spectral class,[6] and it is difficult t
method of photometry applicable to the comparison of
very different widths. The maximum of the Balmer li
been placed by Menzel [7] at A3. The writer is inclined to
that no significant maximum can in fact be derived
Balmer lines; beyond A5, however, their intensity f
rapidly.

It is peculiar to the Balmer series to appear in every
the normal stellar sequence, and its lines at maximum e
strength the lines of every other element which appears
lar spectra, excepting those of ionized calcium.

Although hydrogen is presumably unable to give ris
"enhanced" spectrum, as the atom only possesses on
nuclear electron, the lines of the Balmer series share wit
of neutral helium the peculiarity of behaving like the lin
ionized atom.[8] They are weakened in dwarf M stars, and
strengthened in the cooler super-giants, such as α Orioni
peculiarity of the astrophysical behavior of the hydroge
also appears in the impossibly high value that is assig
ionization theory to the relative abundance of this el
An explanation, in terms of metastability, has been su
by Russell and Compton,[10] but although the hypothe

[3] Wright, Lick Pub., 13, 242, 1918.
[4] A. Fowler, M. N. R. A. S., 80, 692, 1920.
[5] H. A., 91, 7, 1918.
[6] Fairfield, H. C. 264, 19
[7] H. C. 258, 1924.
[8] *Ibid.*
[9] Payne, Proc. N. Ac. Sci., 11, 192, 1925; Chapter XIII, p. 188.
[10] Nature, 114, 86, 1924.

pears very satisfactory in the case of hydrogen, it is not applicable to the similar problem of helium. Russell [11] has remarked that "there seems to be a real tendency for lines, for which both the ionization and excitation potentials are large, to be much stronger than the elementary theory would indicate."

The hydrogen lines are often conspicuously winged. Measures of the width and intensity distribution of the wings are discussed elsewhere.[12] Wings are probably not peculiar to the hydrogen lines, but the hydrogen wings can be studied because of their strength. The feature is also seen in helium, calcium and iron lines, and wings of greater or less strength are probably universal.

The width of the hydrogen lines in A stars has been correlated with absolute magnitude, and used for the estimation of luminosities.[13] It appears, however, that the line width may not furnish an accurate measure of absolute magnitude, although it serves to discriminate stars having the c-character from those of smaller luminosity.[14] The occurrence of wings seems, moreover, to be independent of line width and of absolute magnitude.[15] These questions are connected with the problem of classifying the A stars, and are discussed in a later chapter.[16]

The continuous spectrum of hydrogen, beyond the limit of the Balmer series, corresponding to the continuous radiation observed in the laboratory for sodium by Wood,[17] and for helium by Lyman,[18] was first noted in stellar spectra by Sir William Huggins.[19] The beginning of the band appears just to the red of the last Balmer line observed.[20] It appears, from work in progress at the Harvard Observatory,[21] that the limit is nearer to the violet, the higher the luminosity, and in a nebular spectrum quoted by Hubble,[22] it almost coincides with the theoretical limit of the series.

[11] Personal letter.
[12] Chapter IV, p. 51.
[13] Mt. W. Contr. 262, 1922.
[14] Fairfield, H. C. 264, 1924.
[15] Lindblad, Ap. J., 59, 305, 1924.
[16] Chapter XII, p. 168.
[17] Ap. J., 29, 100, 1909.
[18] Ap. J., 60, 1, 1924.
[19] Atlas, p. 85, 1892.
[20] Wright, Nature, 109, 810, 1920.
[21] Chapter III, p. 43.
[22] Pub. A. S. P., 32, 155, 1920.

also in order of abundance, are silicon, sodium, magnesium, aluminum, carbon, calcium, iron, zinc, titanium, manganese, chromium, potassium, vanadium, strontium, barium, (hydrogen, and helium). All the atoms for which quantitative estimates have been made are included in this list. Although hydrogen and helium are manifestly very abundant in stellar atmospheres, the actual values derived from the estimates of marginal appearance are regarded as spurious.

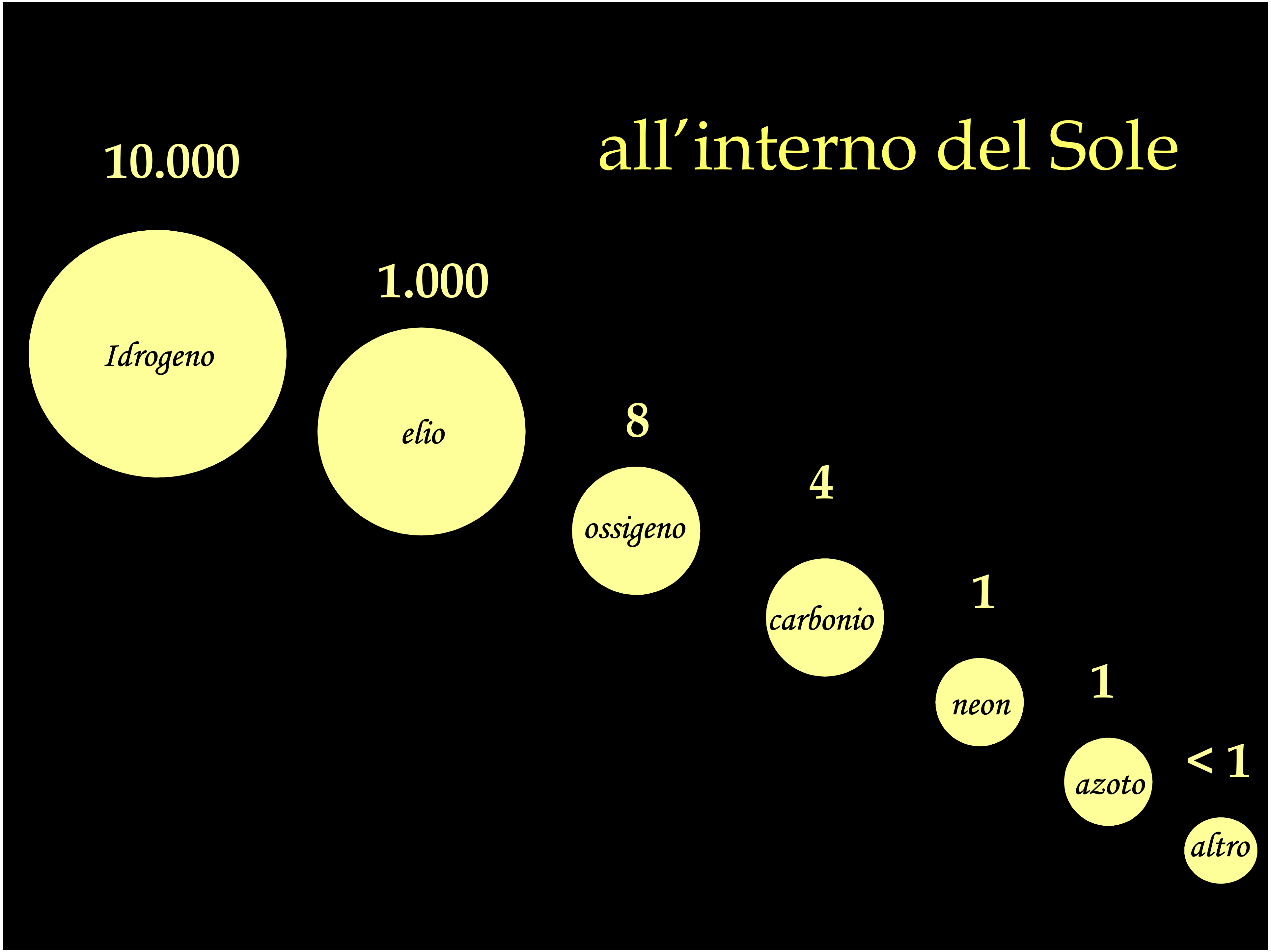
The absence from the stellar list of eight terrestrially abundant elements can be fully accounted for. The substances in question are oxygen, chlorine, phosphorus, sulphur, nitrogen, fluorine, zirconium, and nickel, and none of these elements gives lines of known series relations in the region ordinarily photographed.

The $1^5S - m^5P$ " triplets " of neutral oxygen, in the red, should prove accessible in the near future; the point of disappearance of these lines would not be difficult to estimate, and they would furnish a value for the stellar abundance of oxygen. The lines of ionized oxygen, which have not yet been analyzed into series, are conspicuous in the B stars,[14] and the element is probably present in large quantities.

Sulphur and nitrogen both lack suitable lines in the region usually studied; the analyzed spectrum of neutral sulphur is in the green and red,[15] or in the far ultra-violet,[16] and the neutral nitrogen spectrum has not as yet been arranged in series. Both sulphur and nitrogen appear, in hotter stars, in the once and twice ionized conditions,[17] and are probably abundant elements in stellar atmospheres.

For the remaining elements, phosphorus, chlorine, fluorine, zirconium and nickel, series relations are not, as yet, available. No lines of phosphorus or the halogens have been detected in stellar spectra, but these elements have not been satisfactorily analyzed spectroscopically, and their apparent absence from the stars is probably a result of a deficiency in suitable lines. Nickel

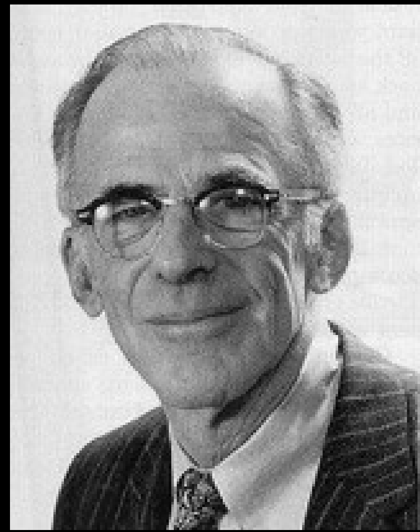
[14] H. C. 256, 1924.
[15] Fowler, Report on Series in Line Spectra, 170, 1922.
[16] Hopfield, Nature, 112, 437, 1923.
[17] H. C. 256, 1924.


all'interno del Sole
10.000
Idrogeno
1.000
elio
8
ossigeno
4
carbonio
1
neon
1
azoto
< 1
altro

Lettera di H.N. Russell a Cecilia Payne:

«Gentile Miss Payne,
ecco finalmente le note sull'abbondanze relative, che è stata così gentile da mostrarmi.
I suoi eccellenti risultati sembrano estremamente coerenti. Molte discrepanze sono risolte.
Rimane però una discrepanza piuttosto seria, quella relativa all'idrogeno, elio e ossigeno. Su questo punto credo che ci sia qualcosa di molto sbagliato nella teoria corrente.
È chiaramente impossibile che l'idrogeno sia un milione di volte più abbondante dei metalli e non ho dubbi che il numero atomi di idrogeno, nei due stati quantici, sia infinitamente superiore a quanto indicato dalle teorie di Fowler e Milne»

Tesi confermata da Russell solo nel 1929



10.000 *Idrogeno*

1.000 *elio*

8 *ossigeno*

4 *carbonio*

1 *neon*

1 *azoto*

< 1 *altro*

70 % della massa è Idrogeno

25-30 % della massa è Elio

Tracce di elementi complessi

Massa del Sole: $2 \cdot 10^{33}\ g$

Massa dell'idrogeno: $1,67 \cdot 10^{-24}\ g$

Numero di atomi di idrogeno:

10^{57}

1.000.000.000.000.000.000.000.000.000.000.000.000.000.000.000.000.000.000.000