

LETTERS TO THE EDITOR.

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Hyperfine Structure in Germanium.

THE isotopic constitution of germanium, according to Aston, is as follows:—

Mass Number	..	70	72	73	74	76
Relative Abundance	..	21.2	27.3	7.9	37.1	6.5

A study of the hyperfine structure of some significant arc lines of germanium was undertaken to investigate the presence, if any, of the even isotopic displacements in the gross multiplet levels; and it was also hoped to determine the nuclear spin of the odd isotope Ge^{73} . Using a hollow cathode discharge, the following arc lines of germanium were examined for hyperfine structure:—

λ in \AA .	Classification*
3039.07	$4p^2 \text{}^1\text{D}_2 - 4p5s \text{}^1\text{P}_1$
2754.59	$4p^2 \text{}^3\text{P}_2' - 4p5s \text{}^3\text{P}_1$
2709.63	$4p^2 \text{}^3\text{P}_1' - 4p5s \text{}^3\text{P}_0$
2691.35	$4p^2 \text{}^3\text{P}_1' - 4p5s \text{}^3\text{P}_1$
2651.57	$4p^2 \text{}^3\text{P}_0' - 4p5s \text{}^3\text{P}_1$
2651.19	$4p^2 \text{}^3\text{P}_2' - 4p5s \text{}^3\text{P}_2$
2592.54	$4p^2 \text{}^3\text{P}_1' - 4p5s \text{}^3\text{P}_2$

All the arc lines listed above were found to be single. The known relative abundance of the even isotopes of germanium renders

it certain that none of the levels here examined shows any isotope displacement. The absence of hyperfine components arising from the nuclear spin moment of the odd isotope Ge^{73} leads to the conclusion that the magnetic moment of the nucleus is very small. The possibility of the appearance of the faint hyperfine components due to Ge^{73} on longer exposures (*i.e.*, longer than two hours which I have tried) is very little, though it is not definitely ruled out.

I wish to thank Prof. A. Venkata Rao Telang for his helpful guidance.

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* Gartlein, *Phys. Rev.*, 1928, **31**, 782-92.

A Possible Origin of the Shift of Spectral Lines in Nebulae.

SPECTROSCOPIC examination of the extragalactic nebulae by Slipher and Humason has revealed the fact that the absorption lines, especially the H and K lines, are displaced towards the red in most cases. Assuming this effect as arising from a Doppler shift, Hubble has concluded that the speeds of recession of the nebulae are proportional to their distances; the claim that this conclusion is accurate to 20% is not conceded by many astronomers. There are, besides, a few galaxies which, on the

Doppler hypothesis, should be interpreted as moving towards us. Zwicky's theory, that the photon parts with some of its energy to the cosmic matter thinly strewn in the intergalactic space through which it passes, is now considered untenable.

The shift of the principal series lines of the alkalis in their absorption spectra in the presence of foreign gases affords a new clue for the explanation of the spectral shift in nebulae. Many investigators have shown that, at a few atmospheres pressure of gases such as hydrogen, helium, neon or argon, the absorption spectra of alkalis exhibit displaced lines.* This displacement takes place towards the violet in the cases of hydrogen, helium and neon; while a red shift occurs with argon and probably also with krypton and xenon. According to Fermi's theory, the spectral shift in wave-numbers is

$$\Delta\nu = -2.8 \times 10^7 (D - 1)n^{\frac{1}{2}} \pm 0.33\sigma^{\frac{1}{2}}n,$$

where D is the dielectric constant of the perturbing gas, n the number of molecules per c.c. and σ the collision cross-section. The agreement in the values of the effective cross-sections of the various gases for electrons of very slow velocity irrespective of the absorbing vapour confirms that the shift is independent of the kind of absorbing alkali atoms and depends only on the nature of the perturbing foreign gas. The nebular spectra are 'torpedo-shaped' continuous patches, containing practically as their only recognisable feature the H and K lines in absorption. A significant fact which should be remembered in connection with these lines is that they arise from absorption by ionised atoms of calcium ($4\ ^2S_{\frac{1}{2}} \rightarrow 4\ ^2P_{\frac{1}{2}, \frac{3}{2}}$) which are isoelectronic with normal potassium atoms. Considering the observed displacements of H and K lines in nebulae along with the laboratory results of the pressure shift of lines, it is possible to estimate the type and pressure of the foreign gas containing the alkali-like CaII atoms in the 'reversing layer' of the nebulae. From the experimental data it follows that the displacement increases with the increase in pressure of the foreign gas at first linearly (up to 10 atms.) and later more rapidly. N.G.C. 221 with a violet shift should possibly

contain in the reversing layer one of the lighter gases—hydrogen, helium or neon—at a pressure of about 80 atms. On the other hand, M 101 in Ursa Major, N.G.C. 385, N.G.C. 4,884 and the nebulae in Leo exhibit a red shift arising from a possible presence of argon (or even krypton or xenon) at pressures ranging from 10 to 400 atms. At these pressures the existence of ionised calcium indicates a very high temperature which from Saha's theory is of the order of 10^6 degrees. This temperature refers to the reversing layers which lie next to the cores that give rise to the continuous spectra. The surface temperature can, however, be expected to conform to the stellar class to which the nebula belongs. The red shift of lines observed in a majority of cases finds an explanation in the fact that in those cases the heavy gases have gravitated to the reversing layer next to the luminous core; the few nebulae which display a violet shift contain either mainly or exclusively the lighter gases.

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Dielectric Polarisation and Form of the Carbon Dioxide Molecule.

IBBS AND WAKEMANN¹ from the results on thermal diffusion of mixtures of carbon dioxide and hydrogen and on the temperature variation of viscosity of carbon dioxide, have concluded that "the molecules of carbon dioxide are of two definite kinds depending upon the temperature", and that "the *soft* low temperature molecule corresponds to a straight model while the *harder* high temperature molecule corresponds to a bent model". They deduced from their curves the temperatures of transition as 140° and 145° C. from viscosity and thermal diffusion data respectively. If the molecule does undergo such a change into a bent structure, the new form should be polar and would have a higher electrical polarisation. One should observe also a change in the molar refraction, though of a very small magnitude. Goldschmidt and Hølemann² have measured the refractivity of carbon dioxide over a large range of temperatures and find that the value is constant right up to 400° C.

* E. Amaldi and E. Segre, *Nature*, 1934, **133**, 141; *Nuovo Cimento*, 1934, **11**, 145; C. Fuchtbauer, P. Schulz and A. F. Brandt, *Zeits. f. Physik*, 1934, **90**, 403; Ny Tsi-Ze and Ch'en Shang-Yi, *Phys. Rev.*, 1937, **51**, 567.