LETTERS TO THE EDITOR

DIRECT DERIVATION OF BALMER SPECTRA

BOHR'S attractive planetary model, and the simplicity of his derivation of the Balmer series still hold a place in theoretical physics, in spite of the palpable contradictions of the model, differences from fine-structure experimental work, and later theoretical discoveries. It would seem worth while to attempt a direct approach to the problem.

The mechanism by which the electron absorbs the energy of a photon or emits a photon of energy is not satisfactorily explained. But it is generally taken for granted that electromagnetic phenomena are governed by the Lorentz group, so that energy has to be measured by the relativistic formula

$$E=\mu/\sqrt{(1-v^2/c^2)}.$$

On the other hand, electrons in thermionic or in photo-electric emission are assigned the usual Newtonian mass-energy $mv^2/2$, m being the mass, and v the same velocity as in the other formula. This is considered necessary in view of the fact that the emitted electrons seem to follow the Maxwellian (normal) velocity distribution. In what follows, I work out the consequences of this double interpretation of energy and show that the Balmer series formula is an immediate consequence.

The basic formula used will have to be

$$E=h\nu-P=\frac{h\,[n-p]}{2\pi},\ (n \text{ an integer}), \quad (1)$$

where ν is the frequency in *sec.*$^{-1}$, of the exciter wave which has the formula, say, $A \sin nt$, h being Planck's constant as usual and P the *Austrittsarbeit* term supplied by Einstein; instead of restricting it to a metallic surface, however, we shall have to assume that the term accounts for a certain amount of energy which disappears at the surface of any system, even an atomic one, in photo-electric interaction.

The next step is to assume that this is absorbed according to the Lorentz-Einstein law, *i.e.*,

$$\frac{h\,[n-p]}{2\pi}=\frac{\mu}{\sqrt{1-v^2/c^2}}, \quad (2)$$

where μ is an unspecified constant of the absorbing system. This gives at once,

$$v^2=c^2-\frac{4\pi^2\mu^2c^2}{h^2\,(n-p)^2} \text{ whence}$$

$$\frac{mv^2}{2}=\frac{mc^2}{2}-\frac{2\pi^2m\mu^2c^2}{h^2\,(n-p)^2} \quad (3)$$

This $mv^2/2$ term, with m the mass of the electron, will now be assumed to account for the energy between levels, so that if a wave is emitted with the frequency ν, then $h\nu$ will be the energy difference; that is,

$$h\nu=\frac{2\pi^2m\mu^2c^2}{h^2c}\left\{\frac{1}{(n_1-p_1)^2}-\frac{1}{(n_2-p_2)^2}\right\};$$

$$\nu=\frac{2\pi^2m\mu^2c}{h^3}\left\{\frac{1}{(n_1-p_1)^2}-\frac{1}{(n_2-p_2)^2}\right\}, \quad (4)$$

where the extra divisor c (= velocity of light) has appeared on the right because we assume this frequency ν to be measured, as usual in spectrometry, in *cm.*$^{-1}$, and not *sec.*$^{-1}$. It remains only to note that we get the usual Rydberg constant on the right if we identify the coefficient μ with ze^2/c, where e is the charge of the electron, and z the factor for nuclear charge. Thus, the Balmer formula is derivable as a property of Planck's law, and the ambivalent measurement of energy, without any assumption as to the planetary structure of the atom. In addition, we get the fine-structure terms without further trouble. On the other hand, an assumption of some sort will have to be made about atomic structure or its field of probabilities, in order to derive the intensities.

Fergusson College,
Poona 4, D. D. Kosambi.
March 3, 1944.

STRUCTURE OF THE SECOND SPARK SPECTRUM OF BROMINE—BR III

Quartet and Doublet terms of Br III were reported in a previous communication.[1] A further investigation of the spectrum has led to the identification of many intercombination lines in the ordinary optical and vacuum grating region. The interval between the deep terms $4p\ {}^4S_{3/2}$ and $4p\ {}^2D_{3/2}$ is found to be 15042 units and that between $4p\ {}^2D_{5/2}$ and $4p\ {}^2P_{1/2}$ is 10613. The ratio between the intervals is in agreement with the theoretical value. A full report of the extension of the scheme of terms will be published elsewhere.

Andhra University,
Guntur, K. R. Rao.
February 18, 1944.

1. Rao and Krishnamurty, *Proc. Roy. Soc.* (Lond.), 1937, **161**, 38.

THERMAL REPULSION

During the last few years numerous contributions,[1,2,3,4,5] have been made to this subject from the laboratories of the Meteorological Office at Poona. It was shown[4,5] that, under the ideal conditions when convective movements are eliminated in an air-cell by bringing the plane hot surface sufficiently close to the plane cold surface, the thermal repulsion of objects like dust particles, oil droplets or a mica vane (suspended vertically by quartz fibre and at right angles to the temperature gradient) may be observed as a simple force acting in the direction of the thermal gradient towards the cold surface. Under the above circumstances, the thermal force is not affected by the disturbing influence of convection. A reference to the figures in Plate XI of Paranjape's paper[4] will show the simplicity of the phenomenon when convection is eliminated.

Fig. 1 shows the apparatus devised by Ramdas and Joglekar[5] for measuring the force due to thermal repulsion. A temperature gradient is maintained between the faces GH and KL of the vessels A and B which are kept at the desired temperature by circulating hot and cold water respectively through the tubes C_1, C_2 and C_3, C_4. T_1 and T_2 are thermometers. The vessels A and B slide in the outer piece CEFD so that the distance between GH and KL may be adjusted as desired. The joints at C, D, E and F can be made air-tight by means of a mixture of bees-wax and rosin. The mica piece M is suspended by means of a fine

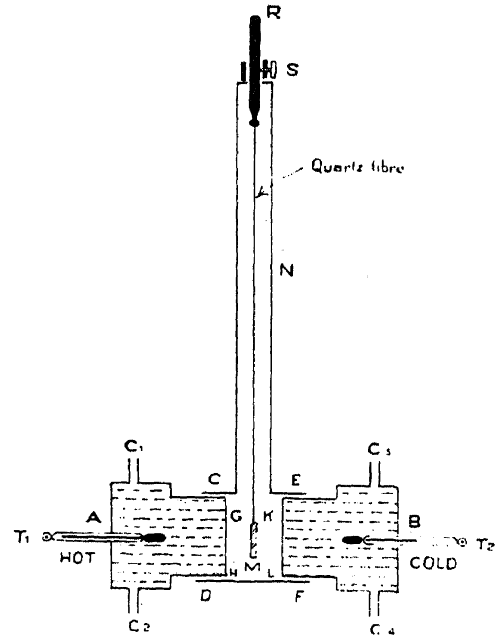

Fig. 1.

quartz fibre as shown. As soon as the face GH becomes warmer than KL, M is deflected to the right, the deflection being proportional to the thermal gradient. The deflections are measured by means of a microscope focussed on the lower end of the quartz fibre and having a suitable graticule in the eye-piece.

At the suggestion of Dr. Ramdas, the present writer undertook the investigation of the effect of the pressure of the gas on thermal repulsion. The range of pressure was from 1 atmosphere down to the lowest pressure which it was possible to obtain with a high-vac pump in series with a pair of Waran's mercury diffusion pumps, with the necessary traps to eliminate water vapour. The low pressures were measured by a Mac-Leod gauge and the higher pressures directly with the aid of a travelling microscope and a mercury manometer.

It is found that the thermal repulsion pressure F ($F = mg\theta$ where m is the mass per unit area of M the mica-piece, θ is the angular displacement from the vertical in radian measure and g is the acceleration due to gravity) is found to increase only slightly on reducing the pressure in the apparatus from 71 cm. to 1 cm. of Hg. The most interesting variations occur as the pressure is reduced below 1 cm. There is at first a gradual and later a very rapid increase in the thermal force. For an air gap of 2·5 mm. and a temperature difference of 2·5° C. between the walls (under the ideal conditions referred to at the beginning of this note, relatively small temperature gradients are indeed sufficient to produce sensible effects) the thermal force for a temperature difference of 1° C. attains a maximum value of the order of 0·027 dyne per sq. cm., when the pressure is about 10^{-2} cm. of Hg. As the pressure is reduced further the thermal force decreases rapidly. Fig. 2 shows the general nature of the results obtained. It may be pointed out that the portion BC of the curve