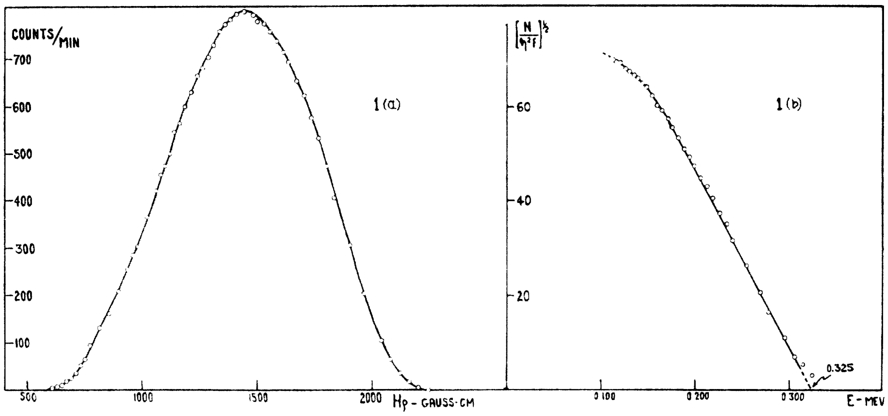

FIG. 1. (a) Positron spectrum and (b) Fermi plot of positrons from Zn^{65}.

current adjusted to transmit only negatrons. The strong conversion line corresponds to a 1.120±0.005-Mev transition. The continuous background can be attributed to Compton recoil electrons generated in the thick source. A Fermi plot failed to reveal any negatron group. It is therefore probable that orbital electron capture and positron emission are the only modes of decay of Zn^{65}. By extrapolating the continuous distribution to intercept the momentum axis, we obtain for the maximum energy of the Compton recoils the value of 0.92^{8} Mev from which the energy of the responsible gamma-ray may be calculated to be 1.14±0.02 Mev. Therefore, we may assume with reasonable assurance that the transition giving rise to the conversion line also ejects the gamma-ray responsible for the Compton distribution.

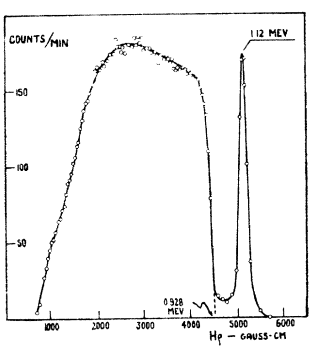

FIG. 2. Negatron spectrum of Zn^{65}.

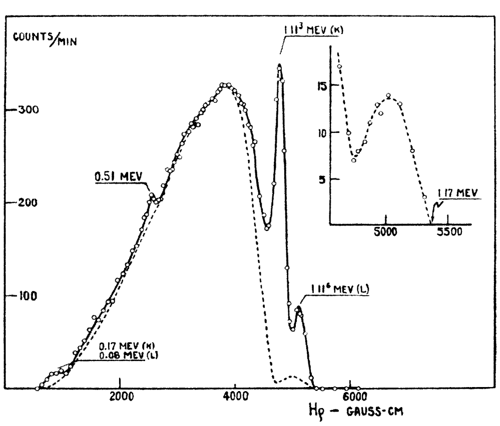

FIG. 3. Gamma-ray spectrum of Zn^{65}.

Figure 3 shows the gamma-ray spectrum taken with the uranium radiator. The solid curve is a composite curve of photo-electrons and Compton electrons combined. The broken curve is the Compton background alone, taken with the radiator removed. The measured energies of the photo-electrons plus the shell-binding energies of uranium (0.114 Mev and 0.020 Mev for K and L shells, respectively) lead to energies of $1.11^{4}\pm0.005$ Mev (a weighted average of 1.11^{3} Mev for K shell and 1.11^{6} Mev for L shell), 0.510±0.003 Mev which can be identified as annihilation radiation, and a somewhat weak peak at about 0.17±0.02 Mev or 0.08±0.02 Mev depending upon whether we assume their origin to be in the K or the L shell. The 1.11^{4}-Mev gamma-ray can be identified with the conversion electron line of 1.12 Mev and is in good agreement with the work of Jensen, Laslett, and Pratt whose revised value for this transition has been reported as 1.11^{8} Mev.[4] It id definitely lower than the value 1.14 Mev proposed by Deutsch, Roberts, and Elliott,[5] although the values are probably consistent within the error limits. The lowest energy gamma-ray has not been reported previously, and it is certainly near the limit of detection.

Examination of the Compton background curve in Fig. 3 shows a distinct distribution at the high energy end. This has been plotted on an expanded scale in the inset. It would appear to be caused by a gamma-ray of too low an intensity to produce a detectable photo-electron line. The maximum energy of the Comptons is at 1.17 Mev. The gamma-ray then has an energy of 1.38±0.03 Mev.

Further experiments are proceeding to make reasonably certain that these gamma-rays of low intensity are really those of Zn^{65} since the possibility of minute amounts of radioactive impurities cannot yet be discounted. We hope to be able to make a more detailed report in the near future.

We wish to acknowledge the generous support of the National Research Council of Canada. The work was made possible through a Grant-in-Aid of Research, and through the award of N.R.C. Studentships to two of us (D.R. and P.N.D.).

[1] Jensen, Laslett, and Pratt, Phys. Rev. **75**, 458 (1949).
[2] Hornyak, Lauritsen, and Rasmussen, Phys. Rev. **76**, 731 (1949).
[3] W. C. Peacock, Plut. Proj. Rep. Mon. N-432, **56** (December, 1947).
[4] Jensen, Laslett, and Pratt, Phys. Rev. **76**, 430 (1949).
[5] Deutsch, Roberts, and Elliott, Phys. Rev. **71**, 389(A) (1942).

Neutron-Proton Scattering

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October 7, 1949

IN order to account for the coherent scattering of slow neutrons by para- and orthohydrogen molecules, as well as the observed binding energy of the deuteron, assuming a square well interaction, different ranges need to be assumed for the central and the tensor part of the interaction in triplet states. Assuming such different ranges, however, Castillejo and Richardson[1] have been unable to account for the observed total cross section for neutrons of energy about 90 Mev.

To investigate whether better agreement could be obtained with a different well shape, similar calculations have been made employing a two-range Yukawa-well with ranges 0.80×10^{-13} cm and 1.60^{-13} cm for the central and tensor forces respectively for the triplet interaction. The appropriate constants were determined by the iteration method for these ranges to fit the data on the binding energy and the electrical quadrupole moment of the deuteron, and the proportion of D-wave thus obtained is 3.8 percent—in good agreement with that needed to explain the observed magnetic moment of the deuteron. For the interaction in singlet states a range of 1.18×10^{-13} cm was used to fit the data on p-p scattering.

The low energy scattering total cross sections have been obtained for incident neutrons of energy 0–3 Mev in agreement with the experimental results. But the high energy (83 Mev) total cross sections are large as usual, *viz.*, 14.6×10^{-26} cm^2 and 12.1 $\times10^{-26}$ cm^2 for the symmetrical and Serber (interaction in even states only) types of interaction respectively. The following table gives the angular distribution in the two cases, in 10^{-26} cm^2:

$\theta°$	0	15	30	60	90	120	150	165	180
Sym. $\sigma(\theta)$	1.49	1.43	1.30	0.97	0.81	1.06	2.08	2.65	2.97
Serber $\sigma(\theta)$	1.30	1.30	1.27	0.89	0.73	0.89	1.27	1.30	1.30

The validity of Born's approximation for high energy scattering in the triplet states has also been examined and it is found that in the present case it gives much smaller value for the cross section than that obtained by the exact method. The detailed account will be published elsewhere.

I wish to express my indebtedness to Professor H. S. W. Massey, F.R.S. for his keen interest in the calculation. I also wish to thank Dr. T. M. Hu and Mr. K. N. Hsu for many valuable discussions. Finally I express my thanks to the Government of Bihar (India) for extension of the scholarship enabling me to complete this work.

[1] L. Castillejo and H. T. Richardson, Phys. Rev. **76**, 1732 (1949).

Structure of the Line λ4686 of He II

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In order to test the theory of level shift in hydrogen-like atoms,[1,2] the structure of the line λ4686 of He II was studied. The light source was a cool aluminum hollow cathode discharge tube, which was filled with helium of about 1 mm Hg pressure. The fine structure was examined by the use of a silvered Fabry-Pérot etalon and a glass Lummer plate of thickness 4.7 mm.

The structure of the line λ4686 calculated according to the recent theory,[2] together with the observed structure, is shown in Fig. 1. Figure 2 is a reproduction of a photograph taken with a 2-mm etalon.

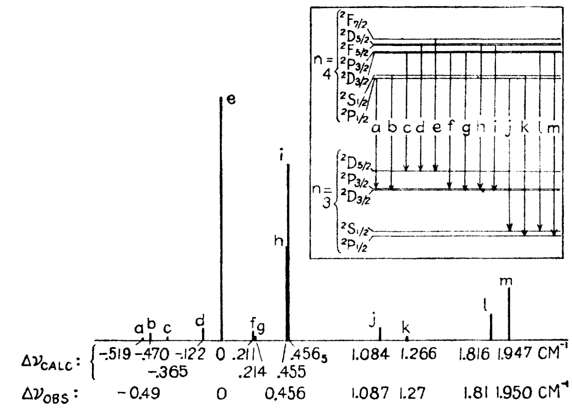

Fig. 1. Transition scheme and calculated and observed structure of He II λ4686.

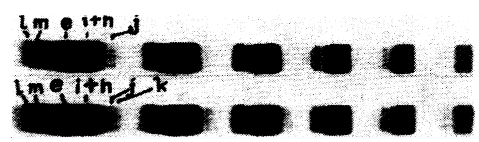

Fig. 2. Inference pattern of He II λ4686 taken with a 2-mm etalon.

Mack and Austern[3] had previously resolved the components j and k, and obtained the value 0.16 ± 0.02 cm^{-1} as the mutual distance. The value obtained by us is 0.18 ± 0.006 cm^{-1}, and is nearer the one required by the theory (0.182 cm^{-1}). In addition to the resolution of the components j and k, the components l and m were also resolved in the present work, and the mutual distance was observed to be 0.14 ± 0.01 cm^{-1}, which is to be compared with the theoretical value 0.130_5 cm^{-1}. The observed structure is therefore in harmony with the theory,[1,2] but the accuracy of measurement is still insufficient for testing the level shift of the terms other than S terms.

One weak component not required by the theory was observed at -0.87 cm^{-1}. This was also observed by Paschen[4] in his former work, but rejected as doubtful in his later work. The line breadth of the component seems to be due to a light element, but the possibility of attributing it to the aluminum spectrum is not so definitely excluded.

In conclusion we wish to thank Professor M. Kiuchi who took deep interest in our work and kindly loaned us the helium gas.

[1] H. A. Bethe, Phys. Rev. **72**, 33 (1947). F. J. Dyson, Phys. Rev. **73**, 617 (1948).
[2] N. M. Kroll and W. E. Lamb, Phys. Rev. **75**, 388 (1949). J. B. French and V. F. Weisskopf, Phys. Rev. **75**, 1240 (1949).
[3] J. E. Mack and N. Austern, Phys. Rev. **72**, 972 (1947). See also G. R. Fowles, Phys. Rev. **73**, 639 (1948); **74**, 219 (1948).
[4] F. Paschen, Ann. d. Physik **50**, 901 (1916); **82**, 689 (1927).

Note on Wave Amplification by Interaction with a Stream of Electrons

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In a recent paper, J. A. Roberts,[1] extending the work of V. A. Bailey[2] on the propagation of plane electromagnetic waves in an ionized gas, purports to show that plane waves with gain exist in infinite space filled with a uniform density of heavy positive ions and an equal density of electrons which move with uniform velocity in a given direction. The paper appears to be open to criticism, some of which extends to Bailey's original work.

Roberts' Eq. (1), a special case of one derived by Bailey, is said to be non-relativistic, but contains terms of order V^2/C^2, where V is the velocity of the electron stream. When the equation is derived again using the relativistic equations of motion for the electrons, further terms of order V^2/C^2 appear. The equation thus found may be readily factored and the resultant plane wave solutions show no gain. A similar conclusion may be reached by making a Lorentz transformation to a system in which the electrons are at rest. In this case the permissible plane wave solutions are found very simply and they may then be transformed back into the rest system. It would appear that an inconsistent neglect

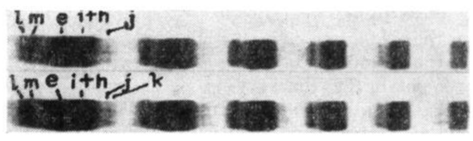

FIG. 2. Inference pattern of He II λ4686 taken with a 2-mm etalon.