latitude effect as measured with electroscopes is about 10 percent.[1] However, the above results indicate that for the shower radiation the latitude effect is even less than this value, and if this is indeed true, then it follows that a part of the showers at sea level must be caused by an incoming photon radiation.

The above experimental result is in substantial agreement with that of Johnson in the Atlantic Ocean.[2]

The pleasant cooperation of the Union Steamship Company and especially the officers of the steamships *Makura* and *Niagara*, made this experiment possible.

W. H. Pickering

California Institute of Technology,
Pasadena, California,
May 21, 1936.

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[1] Millikan and Neher, Phys. Rev. **47**, 205 (1935).

[2] T. H. Johnson and D. N. Read, Phys. Rev. **49**, 639 (1936).

Possibility of Selective Phenomena for Fast Neutrons

In the experiments on nuclear transformations produced by collisions with fast neutrons no resonance phenomena have yet been observed. Therefore it may be of interest to indicate here that such phenomena can be expected in the region of semi-light nuclei and that, with the evidence at present available on nuclear reactions, one can even in certain cases predict the energy of fast neutrons for which resonance disintegration should be observed.

It is usually accepted that the phenomena of resonance take place when the "intermediate compound" of the reaction (i.e., original nucleus+incident particle with its total energy) possesses the excess of energy corresponding to one of its discrete quantum states. For example from the existence of resonance phenomena in the reaction:

$$ {}_{13}\mathrm{Al}^{27} + {}_{2}\mathrm{He}^{4} \rightarrow {}_{15}\overline{\mathrm{P}}^{31} \rightarrow {}_{14}\mathrm{Si}^{30} + {}_{1}\mathrm{H}^{1}, \qquad (1) $$

where, for six different resonance velocities of incident α-particles, the discrete groups of protons with the energy ranging from *6.0 MEV* up to *8.6 MEV* are emitted,[1] we can conclude that the nucleus ${}_{15}P^{31}$ possesses well-defined energy levels for the excitation up to *8.6 MEV* above its "ionization potential" for proton (i.e., binding energy of proton in this nucleus). Accepting for this binding energy the value about *10 MEV* we come to the conclusion that the nucleus in question has discrete and widely separated levels for the total excitation as high as *18 MEV* and that, consequently, *Bohr's* picture of very close and practically overlapping levels,[2] introduced for the understanding of neutron capture by heavy nuclei, cannot yet be applied in this region of atomic weights.

An analogous case is represented by the reaction:

$$ {}_{12}\mathrm{Mg}^{25} + {}_{2}\mathrm{He}^{4} \rightarrow {}_{14}\overline{\mathrm{Si}}^{29} \rightarrow {}_{13}\mathrm{Al}^{28} + {}_{1}\mathrm{H}^{1}, \qquad (2) $$

which, according to *Ellis and Henderson*[3] shows a strong resonance for the energy of α-particles somewhat below *5.4 MEV*. As far as in this case the energy balance is negative and, according to Duncanson and Miller,[1] has the value *−1.16 MEV*, the protons emitted in resonance case must have the energy around *4.2 MEV*. The same intermediate compound as in (2) can be obtained if one bombards silicon (most abundant isotope ${}_{14}\mathrm{Si}^{28}$ present in amount 96 percent) by fast neutrons:

$$ {}_{14}\mathrm{Si}^{28} + {}_{0}n^{1} \rightarrow {}_{14}\overline{\mathrm{Si}}^{29} \rightarrow {}_{13}\mathrm{Al}^{28} + {}_{1}\mathrm{H}^{1}, \qquad (3) $$

so that choosing the energy of incident neutrons so that ${}_{14}\overline{\mathrm{Si}}^{29}$ would have the same total energy as in the resonance case of the reaction (2) one should expect to observe the resonance.

To calculate the necessary energy of neutrons we must know the difference of binding energies of a neutron and a proton in our nucleus. This can be easily estimated from the circular process:

$$ \begin{aligned} {}_{14}\mathrm{Si}^{28} + {}_{0}n^{1} &= {}_{14}\mathrm{Si}^{29} + Q_n, \\ {}_{14}\mathrm{Si}^{28} - {}_{1}\mathrm{H}^{1} &= {}_{13}\mathrm{Al}^{28} - Q_p, \\ {}_{13}\mathrm{Al}^{28} &= {}_{14}\mathrm{Si}^{28} + e + E_{\mathrm{max}}, \end{aligned} \qquad (4) $$

giving us: $Q_n - Q_p = [m_r - (m_p + m_e)]c^2 - E_{\mathrm{max}} = 1\ MEV - 3\ MEV = -2\ MEV$, which means that in this case the proton is bound 2 *MEV* stronger than the neutron. Thus the intermediate compound of the reaction (3) will have the total energy corresponding to resonance if the energy of incident neutrons will be around $4.2\ MEV - (Q_n - Q_p) = 6.2\ MEV$.

It should be interesting to find experimentally such selective phenomena in silicon for the neutrons of this or lower energy.

G. Gamow

George Washington University,
Washington, D. C.,
May 28, 1936.

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[1] W. E. Duncanson and H. Miller, Proc. Roy. Soc. **A146**, 396 (1934).

[2] N. Bohr, Nature **137**, 344 (1936).

[3] C. D. Ellis and W. J. Henderson, Nature **136**, 755 (1935).

Comments on Robertson's Interpretation

In recent papers in the *Physical Review* Engstrom and Zorn[1] and H. P. Robertson[2] have shown that the only transformations which preserve a Euclidean three-dimensional reference system with constant light velocity are the Lorentz transformation and the constant acceleration transformation discussed in my paper,[3] or a combination of the two. This disposes of my expectation that other such reference systems might exist.

Lest any one should infer from Robertson's paper that my theory is merely a special case of Einstein's general theory, I should like to emphasize the fact that Einstein's theory (both special and general) makes the *measured* interval between two nearby events as determined by ideal scales and clocks the same for all reference systems, whereas mine does not. Therefore the two theories are quite different in their physical content.

In connection with Robertson's expectation that my procedure must lead to the usual classical expression for the ponderomotive force, I would point out that Adams and I have shown[4] that it may lead to a very different equation of motion.

Leigh Page

Yale University,
May 26, 1936.

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[1] Engstrom and Zorn, Phys. Rev. **49**, 701 (1936).

[2] H. P. Robertson, Phys. Rev. **49**, 755 (1936).

[3] L. Page, Phys. Rev. **49**, 254 (1936).

[4] Page and Adams, Phys. Rev. **49**, 469 (1936).