OCLC #: 162580877
SOURCE: ILLiad
DUE DATE:
SPCL MES:

STATUS: PENDING 20100617 **NEED BEFORE:** 20100717
REQUEST DATE: 20100617 **RECEIVE DATE:**
BORROWER: AZU **NEW DUE DATE:**
RENEWAL REQ:
LENDERS: *GEBAY, GEBAY, GEBAY

66629589

TITLE: Commentarii : Pontificia Academia scientiarum 3
IMPRINT: Civitas Vaticana Ca. 1973 - 1979
ARTICLE: P.A.M. Dirac: 006.... James Chadwick
VOLUME: 3
ISSUE DATE: 1973
PAGES: pp. 5ff
VERIFIED: <TN:817742><ODYSSEY:150.135.238.6/ILL> OCLC
SHIP TO: ILL/UNIVERSITY ARIZONA LIBRARIES/1510 E UNIVERSITY/TUCSON AZ 85721-0055

BILL TO: same//FEIN 86-6004791//BLLD acct#51-105
SHIP VIA: Ariel or Library Mail
MAXCOST: IFM - $50
COPYRIGHT COMPLIANCE: CCL
ODYSSEY: 150.135.238.6/ILL
FAX: (520) 621-4619 //ODYSSEY PREFERRED/IL...
EMAIL: askddt@u.library.arizona.edu
AFFILIATION: AZNET ; GIF ; GWLA ; SHRS
BORROWING NOTES: For Book Chapter requests, scan the chapter only, do not lend book. If ov
your
page limit, please CONDITIONAL request. Thank you.

PATRON: Aversa, Alan G

PONTIFICIA ACADEMIA SCIENTIARVM

COMMENTARII
Vol. III - N. 6
pag. 1-8

JAMES CHADWICK

P. A. M. DIRAC
Pontifical Academician

James Chadwick was born in 1891 in Manchester. He studied in the Physics Department of Manchester University, where he came under the influence of Ernest Rutherford. He very early started on research work, in collaboration with A. S. Russell. They were the first to detect and investigate the γ-radiation that accompanies the α-emission of certain atoms, ionium, radium and polonium.

In the autumn of 1913 Chadwick went to Berlin to work with Geiger, who had also been previously working in Rutherford's laboratory in Manchester. Chadwick soon obtained important results about the emission of β-rays from radioactive deposit sources. Previous investigators had found, by photographic methods, that the β-rays involved a line spectrum. Chadwick used a Geiger counter and found that the line spectrum was superposed on a continuous spectrum. He inferred, correctly, that the primary emission from the source was the continuous spectrum.

Paper presented on April 17th, 1975, during the Plenary Session of the Pontifical Academy of Sciences.

In the summer of 1914 Chadwick and three other young Englishmen took a walking holiday in the Black Forest. They had a care-free time, with no newspapers, and knew nothing of the tense international situation, until suddenly all four were arrested and interned. They were confined in the prisoner-of-war camp at Ruhleben until the end of the war.

Chadwick did not entirely waste his time during this period. Another one of the four was C. D. Ellis, whom Chadwick taught physics, and together they did some simple experiments with apparatus that they constructed themselves, supplemented by some equipment that was kindly supplied to them by Planck, Nernst and Lise Meitner.

At the end of the war Chadwick rejoined Rutherford in Manchester. Within a year Rutherford became the director of the Cavendish Laboratory at Cambridge and took Chadwick there with him. Rutherford and Chadwick then carried out an important series of experiments involving the bombardment of various targets by α-particles.

The epoch-making discovery occurred in 1932. When beryllium is bombarded with the high-energy α-particles from polonium, a peculiar penetrating radiation is found to come off. This radiation was first observed by Bothe and Becker in Germany and by Irène and Frédéric Joliot-Curie in Paris. The latter had noticed that when this radiation falls on paraffin, large numbers of protons are ejected. However, all these research workers misinterpreted the radiation. They all thought it was a form of γ-rays.

Chadwick recognized this rather mysterious phenomenon as something important, worthy of a closer investigation. He measured the ranges of the ejected protons carefully and determined the relative numbers with different ranges. He found that the numbers were much greater than would be expected if the protons were just recoil protons that had been hit by γ-rays. Also, the energies of the γ-rays needed to produce such recoils would have to be up to 55 MeV, which could not be understood, as the original α-rays had energies of only about 5 MeV.

Chadwick did similar experiments with the beryllium radiation falling on a target containing nitrogen nuclei, much heavier than the protons in the paraffin, and obtained even more paradoxical results. The nitrogen nuclei were found to recoil with energies up to 1.2 MeV, which would require γ-rays of about 90 MeV.

Chadwick then took a decisive step. He realized that the beryllium radiation could not be γ-rays. But still it had to be uncharged, as it was so penetrating. It had to be a new kind of particle, the neutron. In order to have enough momentum to knock out the protons and nitrogen nuclei, it would have to have a mass about equal to that of the proton. The laws of conservation of energy and momentum could then be satisfied in the collision processes.

It needed great boldness to postulate a new particle in those days. People had been brought up to believe that there are only two kinds of elementary particle, protons and electrons, corresponding to the two kinds of electricity, positive and negative. Just a short time previous to Chadwick's discovery a new particle, the positron, had been discovered, but still people were loath to postulate new particles and would only do so with compelling evidence.

In some work that he did soon afterwards, Chadwick was able to obtain a fairly accurate value for the mass of the neutron. He studied the nuclear reaction

$$B^{11} + He^{4} \rightarrow N^{14} + n \, .$$

The masses of the nuclei involved here were fairly well known, so, by observing the energies and using Einstein's connection between energy and mass, he was able to find the mass of the neutron. His result was 1.0067 times the mass of the proton, which is not so far from the presently accepted value 1.00898.

Since the mass of the neutron is greater than that of the proton, Chadwick inferred, correctly, that the neutron is an unstable particle, and decays into a proton and an electron.

Chadwick's discovery of the neutron led to enormous developments of nuclear physics. The neutron provides the ideal projectile to use for bombarding atomic nuclei. If one uses a charged particle as projectile, before it can reach the nucleus it has to pass by the electrons which are circling the nucleus and form a shield. It then has to climb the potential barrier provided by the charge of the nucleus. It must have a large initial energy, or it cannot do this, and in any case it will reach the nucleus only with a greatly reduced energy.

The neutron, on the other hand, does not interact at all with the electrons and passes freely through the shield. It then has no potential barrier to climb, so it hits the nucleus with its full energy.

Thus the neutron opened up a wide new field for experimentation. In many cases it may be captured by the nucleus, and with very heavy nuclei it can lead to an entirely new process — fission. This leads to the possibility of the release of nuclear energy on a large scale.

The neutron is also a concept of great theoretical importance for describing the structure of nuclei. Previous to the discovery of the neutron one had to picture a nucleus as composed of protons and electrons, because these were the only particles one had to put into it. There was then a great difficulty in undestanding how an electron could be retained in the nucleus because, with its very small mass, the laws of quantum mechanics would require it to have a considerable motion, and it just could not be confined in such a small volume as an atomic nucleus without an excessive energy.

The difficulty was now resolved. There are no electrons in the nucleus. The nucleus is composed entirely of protons and neutrons, both of them heavy particles which can easily be confined to a small volume.

In 1935 Chadwick moved to Liverpool and built up a laboratory which did valuable work on nuclear disintegration. It was this laboratory which observed the fission cross-section for U^{235} and thereby showed the possibility of a chain reaction to release atomic energy.

Chadwick received many honours for his outstanding contribution to physics. He died in July 1974.