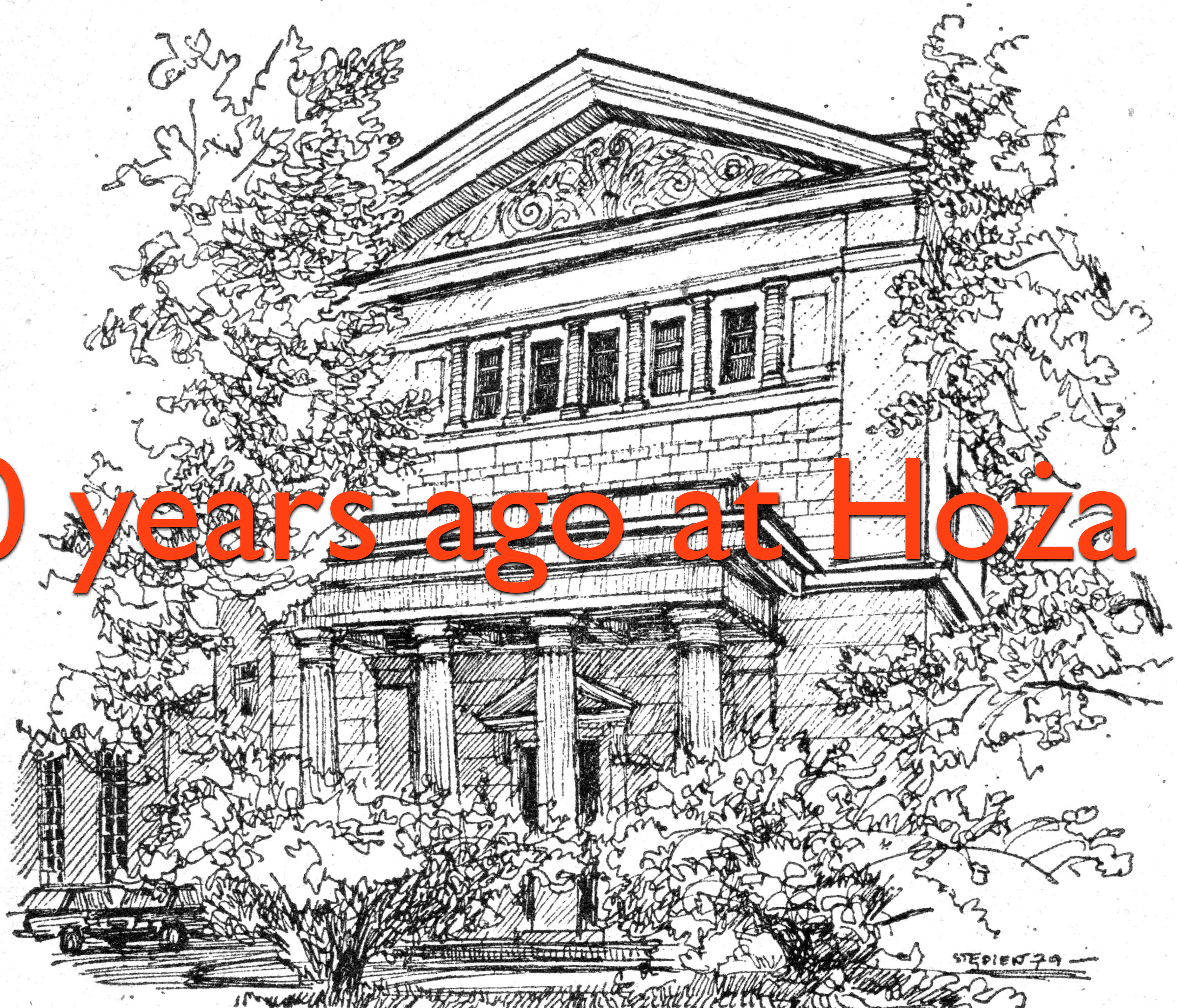
AKW

21 XI 2022

70 years ago at Hoża 69

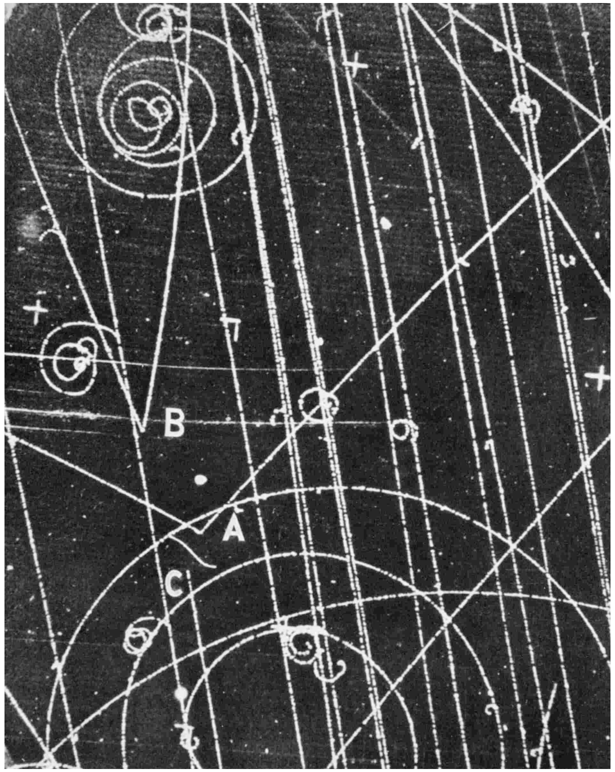


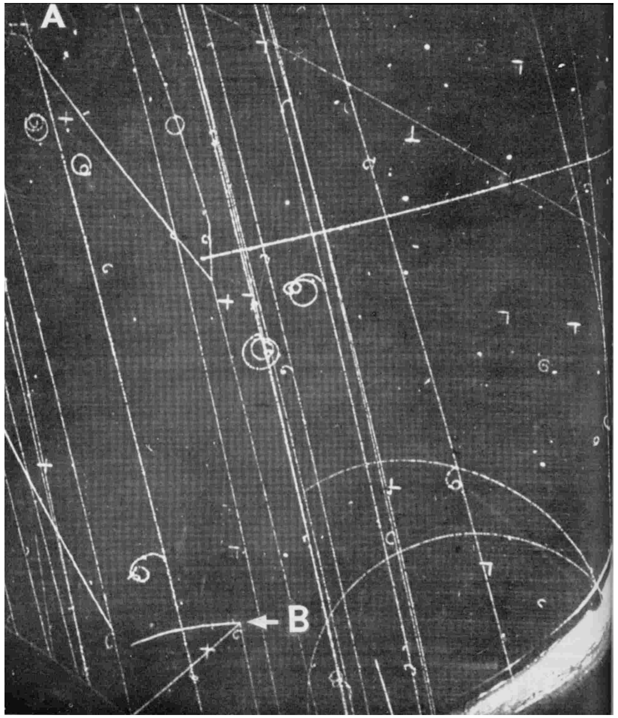
Discovery of hypernuclei: September-November 1952

The first hypernucleus
was discovered in September 1952
by Marian Danysz and Jerzy Pniewski
in the University of Warsaw
physics laboratory at Hoża 69

It happened during the time of confusion concerning the newly discovered heavy unstable particles.

The study of hypernuclei was of considerable help in understanding the properties of strange particles.





V particles discovered in 1947 had unusual properties

- They were copiously produced in high energy collisions (with cross section of a few percent of that for π production)
- Thus, if the same mechanism was responsible for their production and decay, their lifetime should be of the order of 10^{-21} s
- The observed lifetime was $\geq 10^{-10}$ s

V-particles and heavy mesons (December 1952)

Particle	lifetime (s)	Q (MeV)	Mass (m_e)	Spin
? $V_1^{\pm} \rightarrow p + \pi^-$ $\rightarrow (n + \pi^{\pm})$?				half integral
$V_1^0 \rightarrow p + \pi^-$	**$3{\cdot}10^{-10}$**	**40 ± 3**	**2190 ± 5**	half integral
? $S^{\pm}, \chi^{\pm}, V^{\pm} \rightarrow \pi^{\pm} + ?$	10^{-8} - 10^{-10}		900-1500	-
? $S^{\pm}, \kappa^{\pm}, V^{\pm} \rightarrow \mu^{\pm} + (\gamma + \nu)$?	10^{-8} - 10^{-10}		1100	integral
$\tau^{\pm} \rightarrow \pi^{\pm} + \pi^+ + \pi^-$	**$> 10^{-9}$**	**75.8**	**977 ± 6**	integral
? $V^{\pm} \rightarrow \pi^{\pm} + \pi^0 + \pi^0$				integral
$V_2^0 \rightarrow \pi^+ + \pi^-$ $\rightarrow (\pi^+ + \pi^- + ?^0)$? $\rightarrow (\pi^{\pm} + \tau^{\pm}$ or $\zeta^0)$?	**$2{\cdot}10^{-10}$**		**950**	integral
? $\zeta^0 \rightarrow \pi^+ + \pi^-$? $\zeta^{\pm}$			500? 500?	

A. Pais, Some remarks on the V-particles,
Phys. Rev. 86, 663 (1 June 1952)

The abundance of V-particles can be reconciled with their long lifetime by using only interactions of a conventional structure, provided a V-particle is produced together with another heavy unstable particle

All „old" particles have n = 0; all „new" particles have n = 1
The sums of $n_{initial}$ and n_{final} must be both even or both odd in strong and electromagnetic processes

The 'even-odd rule' of Pais allowed reaction $N + N \rightarrow \Lambda + \Lambda$

Experimental evidence was AGAINST pair production of V's

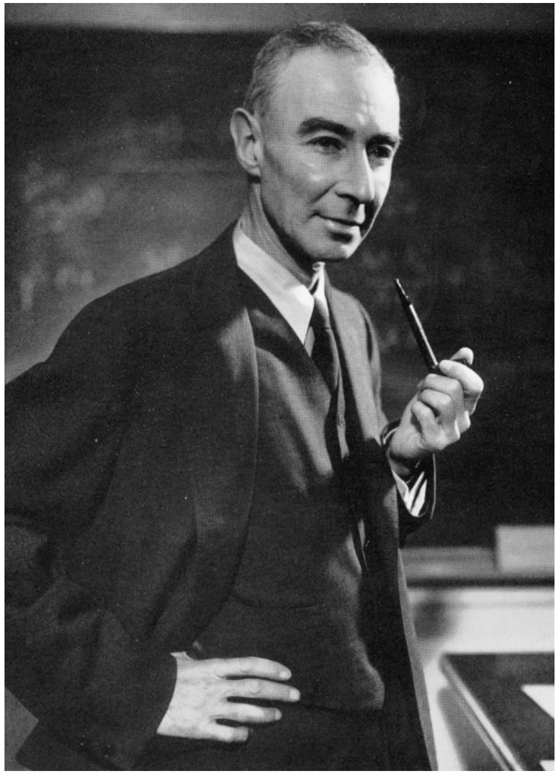
W. B. Fretter et al. (Berkeley)

"Three pairs were observed. This frequency of observation contradicts the hypothesis that V^0-s are created only in pairs, unless one V^0 usually has a value of $\beta\gamma$ from 5 to 10 times as large as the other."

R. B. Leighton et al. (CalTech)

"An analysis of the 152 examples leads to the following principal conclusions: (1) V-particles result from the impact of mesons and probably also of nucleons, upon nuclei. (2) V-particles are generally produced singly and not in pairs…"

Both papers published in *Phys. Rev.*, January 1, 1953, (subm. September 1952)



"I hope our grandchildren when they attend the 2038 conference in Rochester will take it for granted that they know these things."

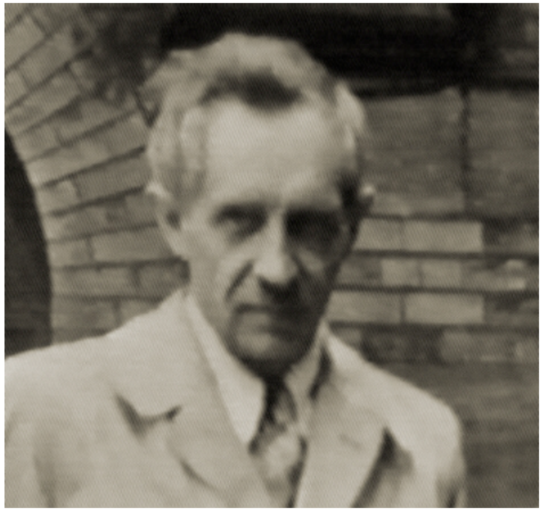
Robert Oppenheimer at the Third Annual Rochester Conference, December 18-20, 1952; Proceedings p.74

The discoverers

as seen in 1952

Marian Danysz

Mr. Danysz, little known electrical engineer
joined Hoża 69 in 1948
November 1949 – May 1952 in England

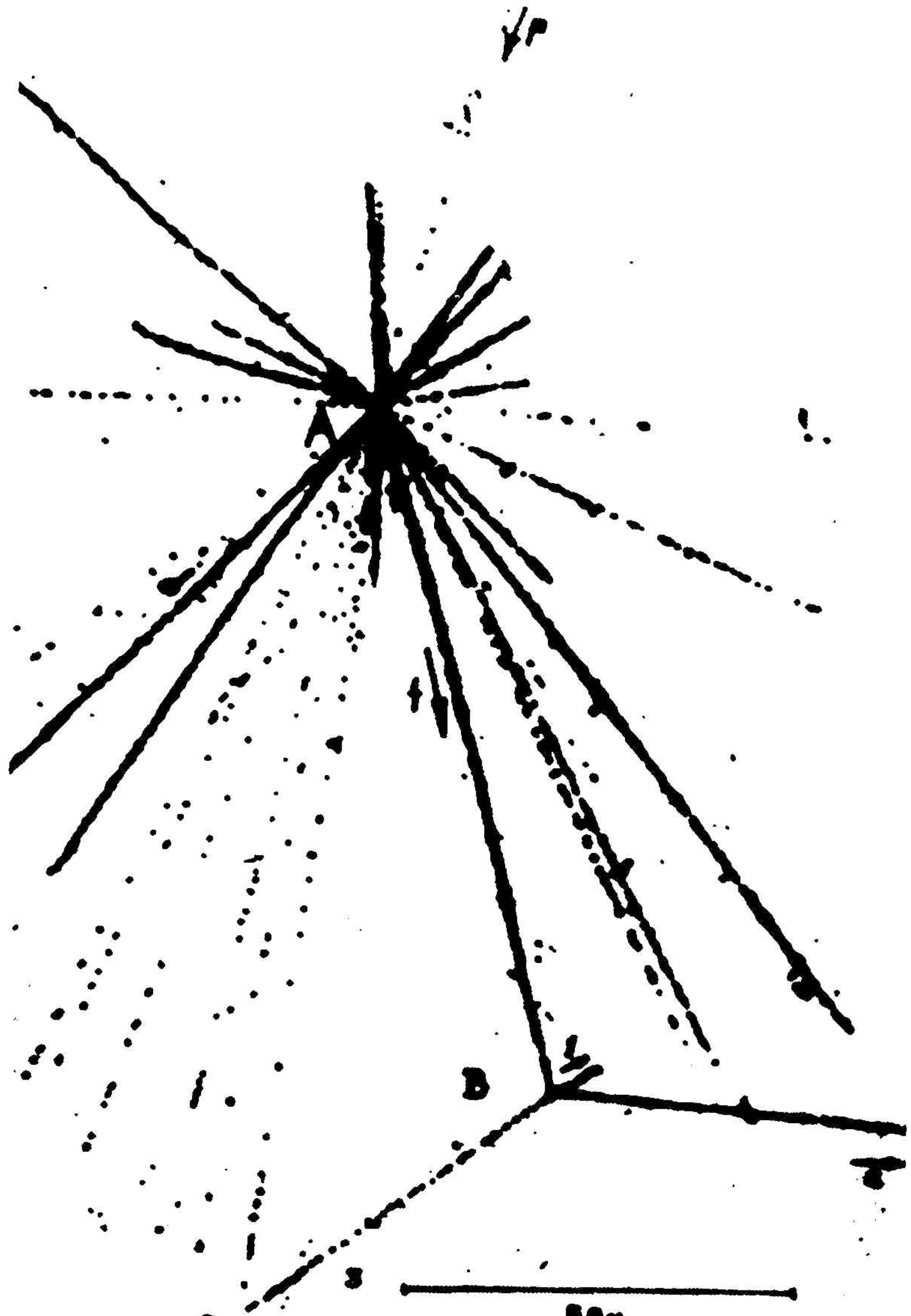


Jerzy Pniewski

Ph.D. on β spectroscopy (June 1951)
known mainly for serving as right hand
of Stefan Pieńkowski in rebuilding Hoża 69
after World War II

"Late in the evening of September 19 we began to analyse the recorded events one by one. Suddenly Marian exclaimed 'Look, what a strange animal' and showed me two stars connected by a prominent and quite thick track. It was obvious that one of the stars was due to a disintegration of a heavy emulsion nucleus, silver or bromine, by a high energy cosmic radiation proton. The nucleus was split into small fragments and only one of them, distinct by its quite long track, seemed to have mass considerably larger than the others. Its track ended with a four prong star which indicated its spontaneous decay... But then the lifetime of the fragment, estimated from the length of its track, was unbelievably large for such an excitation..."

J. Pniewski, Autobiographical reminiscences


B
50μ

"We spent nearly three weeks on endless and heated discussions during which we eliminated various explanations of the observed inconsistencies... Twice a day we went for coffee to cafe „Niespodzianka" and it was there that we suddenly began to see the light, that so large energy released in the secondary star was comparable to the energy of annihilation of the π-meson, the particle discovered five years earlier. The first hypothesis was that the fragment carried a bound π-meson, similarly to an electron bound in an atom. This very attractive hypothesis had to be rejected because it was improbable that the fragment could capture and carry away one of the mesons produced in a high energy collision. But we were only one step from the proper interpretation that the fragment contained a bound V^0_1 particle. The V^0_1 particle was discovered in 1951 by Armenteros but no one expected that it could be bound in atomic nucleus with protons and neutrons..."

J. Pniewski, Autobiographical reminiscences

...We sent letters to...

W. C. Heisenberg,

C. F. Powell,

and D. Skobeltzyn...

J. Pniewski, Autobiographical reminiscences

BULLETIN DE L'ACADÉMIE
POLONAISE DES SCIENCES
Cl. III — Vol I, Nos 1—2, 1953

EXPERIMENTAL PHYSICS

Delayed Disintegration of a Heavy Fragment Emitted in Nuclear Explosion

by

M. DANYSZ and J. PNIEWSKI

Communicated by A. SOLTAN at the meeting of October 20, 1952

Introduction. A remarkable coincidence of two events recorded in a photographic emulsion was recently observed in this laboratory. It occurred in a G 5 plate, 600 μ thick, which had been exposed at high altitude (85.000 feet)*) to cosmic radiation, and concerns two stars marked *A* and *B* (Fig. 1). The centre of the star *B* coincides with the end of the track of a heavy fragment *f*, ejected from star *A*. If this coincidence is not accidental, it must be considered as an example of delayed disintegration of a heavy fragment. The probability of such a coincidence being very small, we thought it might be of interest to analyse the case more closely. It is clear, of course, that any conclusions drawn from a single observation should be treated with due caution.

Analysis. The disintegration referred to as star *A* represents the effect of a high energy interaction, presumably between a singly charged particle and a bromine or silver nucleus. The disintegration referred to as star *B* seems to be a case of delayed decay of a heavy fragment ejected from the star *A*.

Following the nomenclature of Brown et al. [1], star *A* may be des-

Dear Professor Powell

It is more than four months as I am back in Warsaw. The summer time - time of holiday - was a dead time for me. Nothing hapends. But it is already over. From September the work has begun, and I hope we have some prospects for the future. I have easily found people who are interested in emulsion work, three scanners are active since the end of September, problem of microscopes seems to find a satisfactory solution.

At present the only base of our work are Bristol plates, they will be good as material for starting work, for teaching people the technique and may serve for some research -unfortunatly, they are rather distorted. Were it possible to have a few plates for us flown in future baloon flights from Bristol? I will manage of course to cover the cost of the plates and she 11 do the processing myself.

With this letter I enclose a short note concerning a star of a rather exeptional character. We have worked on it with my friend J.Pniewski who will - I hope- continue to work with me in plate technique. If you find the whole problem not unreasonable we might send later a fuller account to Phil.Mag.

We would be very grateful for all suggestion and criticisms.

Yours most sincerely,

M. D.

Danysz to Powell on October 26, 1952

Dear Professor Powell,

It is more than four months as I am back in Warsaw...
From September the work has begun, and I hope we have some prospects for the future. I have easily found people who are interested in emulsion work, three scanners are active since the end of September, problem of microscopes seems to find a satisfactory solution...
With this letter I enclose a short note concerning a star of a rather exceptional character. We have worked on it with my friend J. Pniewski who will – I hope – continue to work with me in plate technique. If you find the whole problem not unreasonable we might send later a fuller account to Phil.Mag.
We would be very grateful for all suggestion and criticisms.
Yours most sincerely
M. Danysz

MAX PLANCK-INSTITUT FÜR PHYSIK
GÖTTINGEN BÖTTINGERSTRASSE 4

GÖTTINGEN, 10th November, 1952
Tel.: 3653

Dr. M. Danysz

Instytut Fizyki
Uniwersytetu Warszawskiego
Fizyka Doświadczalna

Warszawa / Polen
ul. Hoża 69

Dear Danysz,

Thank you very much for your letter of October 26th and the preprint of your paper which, I think, is very interesting. Prof. Heisenberg has also read it with great interest. He agrees that the event cannot be explained as the delayed disintegration of an excited nucleus since the time 10^{-11} sec is much too long. On the other hand, the probability for the event being a "delayed σ-star" is extremely small, too: The binding-energy of a π^--meson in the K-shell is of the order of 1 MeV whereas the average energies of the mesons ejected in the disintegration at A are apparently much greater. So it is unlikely that a π^--meson would have been captured by the fragment. But even if it had been captured, it would have to be expected to interact with the nucleus within a time much shorter than 10^{-11} sec.

Your suggestion that the event might be explained in connection with the V_1^0 or a similar particle seems to be very reasonable, however. The V_0^1 particles appear to be different from the nuclear force mesons in that they may be created and annihilated only in conjunction with their anti-particles. In your event the V_1^0 may have been separated from its anti-particle, which flew off in a different direction, and was left within the fragment where it decayed after its life-time had elapsed.

I wonder what the future will teach us about all these funny particles.

With best wishes,
Yours sincerely,

K. Gottstein.

Klaus Gottstein to Danysz

Göttingen, 10^{th} November, 1952.

Dear Danysz,

Thank you very much for your letter of October 26^{th} and the preprint of your paper which, I think, is very interesting. Prof. Heisenberg has also read it with great interest. He agrees that the event cannot be explained as the delayed disintegration of an excited nucleus since the time 10^{-11} sec is much too long. On the other hand, the probability for the event being a "delayed σ-star" is extremely small, too. The binding energy of a π^--meson in the K-shell is of the order of 1 MeV whereas the average energies of the mesons ejected in the disintegration at A are apparently much greater. So it is unlikely that a π^-- meson would have been captured by the fragment. But even if it had been captured, it would have to be expected to interact with the nucleus within a time much shorter than 10^{-11} sec.

Klaus Gottstein to Danysz (cont.)

Your suggestion that the event might be explained in connection with the V_1^0 or a similar particle seems to be very reasonable, however. The V_1^0 particles appear to be different from the nuclear force mesons in that they may be created and annihilated only in conjunction with their anti-particles. In your event the V_1^0 may have been separated from its anti-particle, which flew off in a different direction, and was left within the fragment where it decayed after its life-time had elapsed.
I wonder what the future will teach us about all these funny particles.
With best wishes,
Yours sincerely,
K. Gottstein

UNIVERSITY OF BRISTOL

C. F. POWELL, M.A., F.R.S.
Melville Wills Professor of Physics.
Tel. No: Bristol 24161 Ext. 110.
Night Service 25027.

H. H. WILLS PHYSICAL LABORATORY,
ROYAL FORT,
BRISTOL 8.

November 19th, 1952.

Dear Danysz,

Thank you very much for your letter of the 26th October. The event is certainly most striking, but I feel that you would be well advised not to publish it at this stage. Inspite of the most remarkable precision with which the heavy particle ends its range at the point of origin of the second star, you still have to meet ~~to~~ the objection that you are dealing with a chance juxtaposition of unrelated events. Because of this, I think it would be best, either to wait until a second example of the same phenomenon is found, or, to publish a photograph of it with a minimum of descriptive material. There seems to be no point, for example, in giving a detailed description of the big star from which the heavy particle was emitted.

We are still working on the heavy mesons and several important questions are not yet solved. Perkins has shown that heavy mesons of mass about 1,200 ± 200 m_e are emitted from stars produced by protons with an energy as low as 5 BeV, and possibly considerably lower. These heavy mesons absorb as much, or nearly as much, of the available energy as do the π-mesons. It is not yet decided whether they are kappas or chi's.

Menon and O'Ceallaigh now have 17 examples of kappa or chi-mesons at the end of their range. The recent measurements of the masses of chi's have been giving values between 900 and 1,000 m_e, and we wonder

Powell to Danysz, November 19, 1952

Dear Danysz,
Thank you very much for your letter of the 26th October. The event is certainly most striking, but I feel that you would be well advised not to publish it at this stage. Inspite of the most remarkable precision with which the heavy particle ends its range at the point of origin of the second star, you still have to meet the objection that you are dealing with a chance juxtaposition of unrelated events. Because of this, I think that it would be best, either to wait until a second example of the same phenomenon is found, or, to publish a photograph of it with a minimum of descriptive material. There seems to be no point, for example, in giving a detailed description of the big star from which the heavy particle was emitted....

The second event

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF PHYSICS
IMPERIAL INSTITUTE ROAD
Telephone - - KENSINGTON 4861
~~PROF. SIR GEORGE P. THOMSON, M.A., F.R.S.~~

ROYAL COLLEGE OF SCIENCE
SOUTH KENSINGTON
LONDON - - S.W.7

19 November 1952.

Dr. M. Danysz,
Hoza 69,
WARSAW. POLAND.

Dear Danysz,

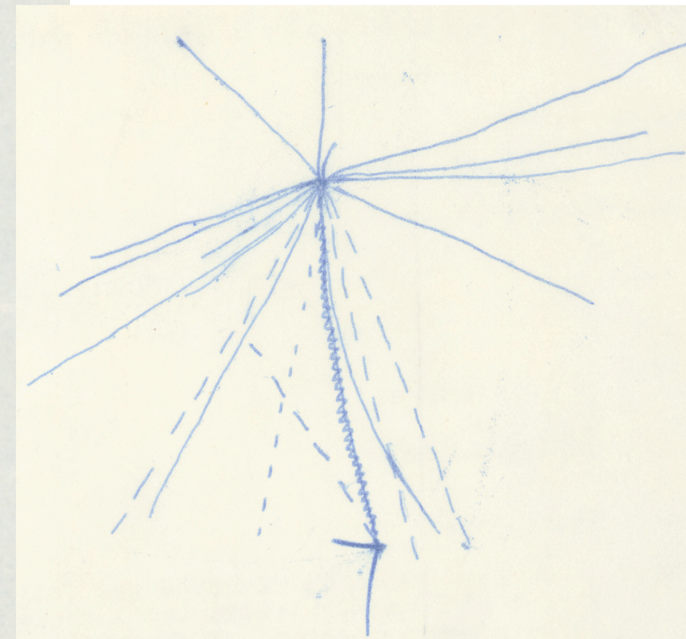
We have recently observed the following event. A star of 19 heavy tracks and 1 shower particle emits a heavy fragment of charge about 12 units. This particle comes to rest in the emulsion as shown by its taper down. At the point where it comes to rest there is a small 3-prong star. I enclose a rough sketch of the event. Menon tells me that you have recently observed a very similar event and mentioned the possible explanation in terms of trapped π-mesons.

He suggested that we might publish a short note on this jointly. I would be glad to do this, if you think it is a good idea, two events being better than one. I would imagine a note or a letter in Phil. Mag. would be the thing. Would you let me know what you think. In any case, I would be glad to receive further details of your event.

With best wishes,

Yours sincerely,

E.P. George.



Two papers or one?

Danysz to E. P. George (28 November 1952)

Dear George,

Thank you for your letter of the 19th November and the news concerning your case of a delayed disintegration of a heavy fragment. Obviously two events of such a kind are much better than one, and I quite agree that it is a good idea to publish this jointly in a note or letter in Phil. Mag...

Not to lose time we suggest that you would write a rough draft of the letter or note in question and send us a copy before publication as we may have some suggestions or remarks to make...

Two papers or one?

Danysz to A. J. Herz (9 February 1953)

Dear Herz,
...After receiving a letter from Menon, concerning Powell's proposition, we have sent the material related to our case to Bristol, and left all the decision concerning the publication to Powell.
So I hope all is O.K.
Of course we are pleased to have another note in the same issue of the Phil. Mag. supporting our observation...

The first event published

Delayed Disintegration of a Heavy Nuclear Fragment: I *

By M. Danysz and J. Pniewski
Institute of Experimental Physics, University of Warsaw †

[Received December 1, 1952]

A remarkable coincidence of two events recorded in a photographic emulsion has recently been observed in this laboratory. It occurred in a G5 emulsion, 600 μ thick, which had been exposed to cosmic radiation at an altitude of 85 000 feet,‡ and consists of two stars marked A and B in the photo-micrograph reproduced in Plate 13. The centre of the star B coincides with the end of the track of a heavy fragment ejected from the star A. If this coincidence is not accidental, it must be considered as an example of the delayed disintegration of a heavy fragment. The probability of a fortuitous coincidence is very small, and it therefore seemed appropriate to analyse the events more closely. It is clear, of course, that any novel conclusions drawn from a single observation should be treated with proper reserve.

The disintegration referred to as star A represents the result of a high-energy interaction, presumably between a singly-charged particle and a silver or bromine nucleus. In the nomenclature of Brown *et al.* (1949), the star A may be described as of type 21+18p. The track p—see Plate 13—is the only track in the upper hemisphere with minimum grain density, of which the direction coincides approximately with the 'axis' of the cone of the emitted shower particles. It therefore probably represents the incident particle which produced the disintegration A. Scattering measurements do not allow an accurate evaluation of its energy, but they are not inconsistent with the above assumption. Using statistical data of Camerini *et al.* (1951), and of Daniel *et al.* (1952), we estimate the energy of the primary particle to be about 30 Bev. Energy measurements on some of the longer tracks produced by the shower particles are also in agreement with this estimate.

From the analysis of the 'black' and 'grey' tracks of star A, we could identify nine α-particles, one heavy fragment and eleven singly-charged particles. As no slow mesons were detected, the latter were probably due to protons, deuterons or tritons. The comparison of the shape of the track 'f' with those of other multiply-charged particles stopping in the emulsion allows a rough estimate of the charge of fragment f; the most probable value is about 5.

The initial kinetic energy of the fragment 'f', estimated from its range (90 μ) and charge (Perkins 1950), is of the order of 60 Mev. The fragment appears to stop in the emulsion exactly in the centre of star B.

* A preliminary report of this observation was given by Professor A. Soltan at the meeting of the Polish Academy of Science held on 20th October 1952.

† Communicated by Professor C. F. Powell, F.R.S.

‡ We are indebted to Professor C. F. Powell for the opportunity of exposing the plates in a balloon flight and processing them at Bristol.

The second event

Delayed Disintegration of a Heavy Nuclear Fragment: II

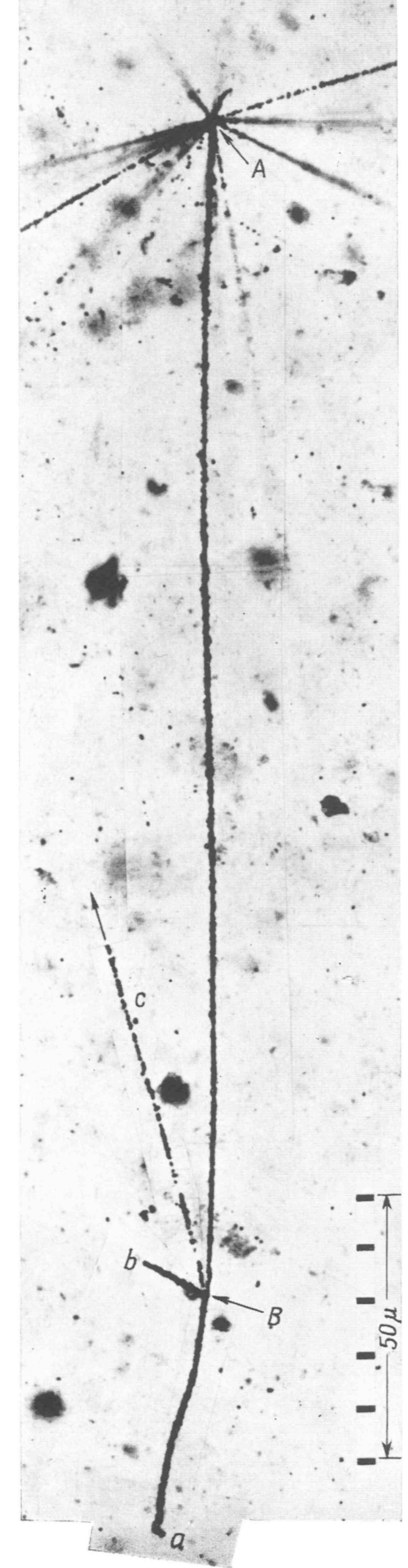
By D. A. TIDMAN, G. DAVIS, A. J. HERZ and R. M. TENNENT
Imperial College, London, S.W.7 *

[Received December 15, 1952]

SOON after Dr. Menon of Bristol University had informed us about the event found by Danysz and Pniewski (see the preceding note), a similar observation was made in this laboratory. Photo-micrographs of the event are shown in Plate 14.

The event occurred in a G5 emulsion, 400 μ thick, exposed in a balloon flight at geomagnetic latitude 40° N. The balloon floated for eight hours at about 96 000 feet. The parent disintegration (star A) is of type 16+0p, excluding the heavy fragment f. The track of the

* Communicated by Dr. E. P. George.



Phil. Mag. 44, 350 (March 1953)

The third event

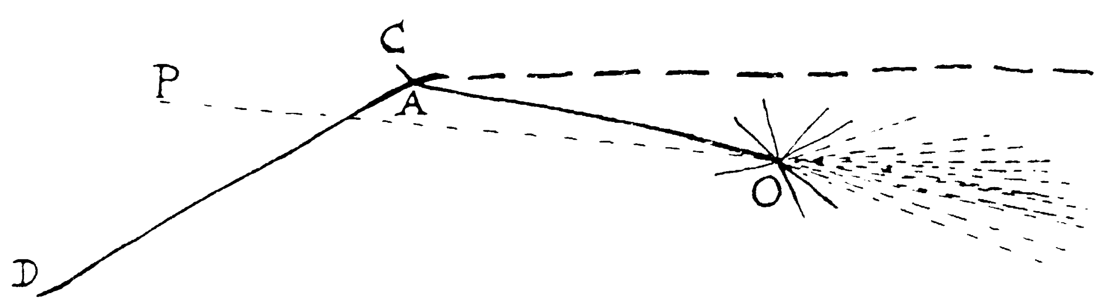
PHYSIQUE NUCLÉAIRE. — *Émission probable d'un fragment nucléaire contenant une particule* V°. Note de MM. **Jean Crussard** et **Daniel Morellet**, présentée par M. Louis Leprince-Ringuet.

Le phénomène décrit ci-après a été observé dans une plaque photographique Ilford G_5 de 600 μ d'épaisseur, qui a été exposée au rayonnement cosmique en haute altitude sous 3 cm de cuivre, au moyen de ballons-sondes.

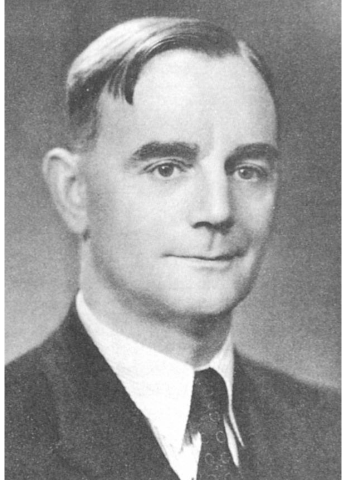
Il se trouve dans une grande étoile de 60 branches, dont environ 30 au minimum d'ionisation, produite par une particule de $Z = 1$ très énergique. Le schéma ci-contre montre son aspect.

O est le centre de l'étoile, PO la particule incidente. La particule OA, qui paraît lente, produit une petite étoile secondaire ABCD.

Trace OA (longueur : 68 μ). — L'aspect et la mesure photométrique [1] sont compatibles avec une particule α en fin de parcours, ou également un noyau de lithium. Un proton est possible à la rigueur, mais beaucoup moins



Comptes Rendus Acad. Sci. 236, 64 (Séance du 5 Janvier 1953)



Powell remained sceptical for several months

"Further examples have now been observed of the process, first observed by Danysz, in which a heavy nuclear fragment ejected from a nuclear explosion reaches the end of its range and disintegrates. It appears that π-mesons are frequently emitted as one of the products of the secondary disintegration. It is possible that these events are due to the presence, in the nuclear fragment, of a nucleon in an excited state; but alternative explanations cannot at present be excluded."

Nature, September 12, 1953, p.477

"The original discovery suggesting that Λ^0 hyperons can exist not only as free particles but also bound within nuclei was due to Danysz and Pniewski... An excited hydrogen atom, to use the simplest example, consists of a proton and an electron in a state of higher energy than in the normal atom. The analogy might then suggest that the excited nucleon consists of a proton and an associated π^- - that the Λ^0 is a composite particle. Such a view could not have been finally excluded while our knowledge was confined to the decay of the free Λ^0 particle...
These considerations suggest that the Λ^0 particle is an excited nucleon in a different sense from that suggested by familiar analogies. We are entering a new field where basically new concepts remain to be established."

C. F. Powell, Excited nucleons, Nature 173, 469 (14 March 1954)

Padova Conference, April 1954

Summary of 17 known events by M. Grilli and R. Levi Setti

"In none of the cases the total energy release in the disintegration of the fragments is inconsistent with the hypothesis first suggested by M. Danysz and J. Pniewski, that a neutron in the fragment is simply replaced by a Λ^0."

The first systematic review of experimental data

Vol. XVI (1957) ACTA PHYSICA POLONICA Fasc. 1—2

SURVEY OF THE HYPERFRAGMENT EXPERIMENTAL DATA*

By A. Filipkowski, J. Gierula, P. Zieliński

Cosmic Ray Department, Institute of Nuclear Research, Warszawa

(*Received December 5, 1956*)

All the available cases (about 120) interpreted as hyperfragment decays underwent a selection in effect of which 72 cases were considered to be hyperfragment decays, whereas in the remaining ones there is a possibility of the existence of other interpretations. On the basis of such a "pure sample" of hyperfragments certain statistical conclusions in reagard to the production, decay, binding energy, structure, and life-time of light hyperfragments was reached.

Tables facilitating the estimation of the binding energy of the Λ° hyperon in light hyperfragments have been drawn.

Introduction

During the last 4 years since the discovery of hyperfragments more than 120 events interpreted as possible examples of hyperfragment decay have been already published. On the basis of such material one may try to reach some conclusions of statistical

Hypernuclear physics came of age

Saint-Cergue, 28-30 March, 1963

International Conference on Hyperfragments

by **E. H. S. BURHOP** and **W. O. LOCK**

Background to the Conference

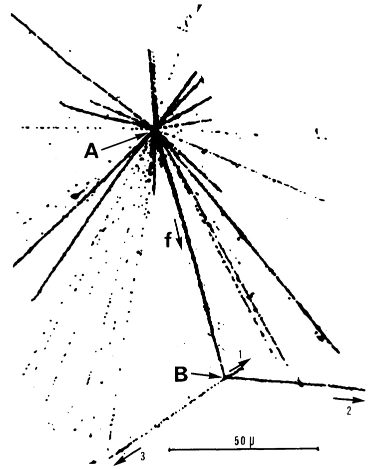
In the early fifties, soon after the discovery of the so-called 'strange particles', two Polish physicists, M. Danysz and J. Pniewski, observed that nuclei could be formed in which a lambda hyperon was trapped. These **'hypernuclei'** were unstable and, of course, broke up when the trapped hyperon decayed into a pi meson and a nucleon after a time of the order 10^{-10} second. Such hypernuclei may be produced as a result of the break-up of a nucleus after an interaction, and their life-time is still long enough to enable them to produce a track of length from a few microns (thousandths of a millimetre) up to several millimetres in a nuclear photographic emulsion. Because they are usually produced as a result of the breaking up or 'fragmentation' of a larger nucleus, hypernuclei produced in this way are commonly referred to as **'hyperfragments'.**

The fact that hyperfragments can be formed at all shows that the interaction between a lambda hyperon and a nucleus must be one of attraction, at least under some conditions. From an estimate of the binding energy of the hyperon (that is, the amount of energy needed just to remove the lambda hyperon from the rest of the nucleus), some information about the force between the lambda and a nucleon can be obtained. This is very important information for elementary-particle physics and very hard to obtain in other ways. For example, the most direct way of obtaining such data is to study the scattering of lambda hyperons by nucleons. These studies are very difficult, however, because of the short life of the hyperon, which means that there is usually a path length of only a few millimetres before the decay, and an enormous number of hyperons need to be studied in order to obtain just a few examples of scattering.

On the other hand, many hundreds of examples of hyperfragments have now been identified and their binding energies measured. This is possible if all the products resulting from the break-up of the hyperfragment are charged, so that their individual kinetic energies can be measured. From the sum of these, the energy available from the break-up of the hypernucleus is obtained, and this is equal to the energy released in the decay of the trapped hyperon (the Q-value, known quite accurately as 37.57 MeV) less the binding energy of the hyperon in the hypernucleus. In practice, accurate values of the binding energy can be estimated only if the pi meson resulting from the lambda decay escapes from the fragment (mesonic decay). In many cases the pi meson is absorbed before leaving the fragment (non-mesonic decay).

A whole new branch of nuclear physics is in process of being built up around the properties of hypernuclei. A start has been made in the determination of the spins and isospins of their ground states, and methods are being considered for the study of their excited states.

In these circumstances it seemed timely to organize a conference to review the present state of knowledge in this field. Further, since most hyperfragments have short ranges, the technique that is best suited to study them is usually that of nuclear emulsions. It was therefore very appropriate that the conference should have been organized on behalf of the CERN Emulsion Experiments Committee. Other techniques are beginning to show their value in the field, however, and some



From the original in 'Philosophical Magazine'

The first hyperfragment, discovered by Danysz and Pniewski in 1953. A cosmic-ray particle (p) causes a nuclear disintegration at A ; one of the particles (f) emitted in the 'star' comes to rest at B and disintegrates with the emission of three charged particles. This particle (f) is the hyperfragment.

Recent exposures of emulsions to beams of 1.5-GeV/c negative kaons at CERN have already produced several possible examples of 'stars' in which two hyperfragments are produced.

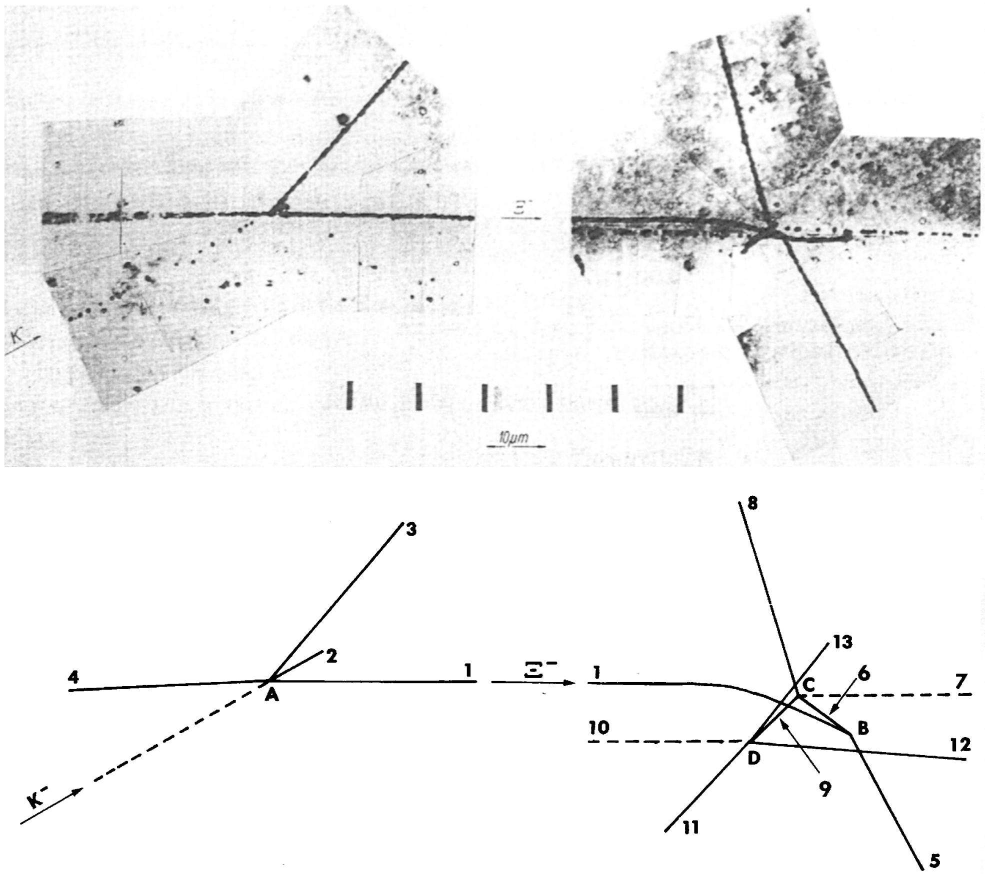
From time to time in CERN COURIER, reference has been made to 'hypernuclei' and 'hyperfragments' and, although some kind of explanation was usually appended, many readers no doubt remained with only a vague idea of their real significance. In the present article, the authors have first described in general terms the nature and properties of these special kinds of nuclei, and then reviewed the major topics discussed at the recent international conference on this subject.

Prof. E.H.S. Burhop, of University College, London University, has been particularly interested in this field for some time, and for the last two years has been responsible for the 'European K^- Collaboration' which co-ordinated the efforts of eight different laboratories for the analysis of nuclear emulsions exposed at the CERN proton synchrotron to beams of K^- mesons. He is at present at CERN for a year, as a CERN Visiting Scientist, concerned chiefly with the study group on new accelerators. W.O. Lock has worked with nuclear emulsions for many years, and is joint Leader of the Nuclear Emulsion Group in the Nuclear Physics Division at CERN. He is also at present secretary of the Nuclear Physics Research Committee.

68 participants from 14 countries

17 talks published in the Proceedings

The first double hypernucleus



$$ {}^{10}_{\Lambda\Lambda}\mathrm{Be} \rightarrow {}^{9}_{\Lambda}\mathrm{Be} + \mathrm{p} + \pi^- $$
$$ \searrow \mathrm{p} + {}^{4}\mathrm{He} + {}^{4}\mathrm{He} + \pi^- $$

8.A

Nuclear Physics 49 (1963) 121—132;

THE IDENTIFICATION OF A DOUBLE HYPERFRAGMENT

M. DANYSZ, K. GARBOWSKA, J. PNIEWSKI, T. PNIEWSKI and J. ZAKRZEWSKI
Institute of Experimental Physics, University of Warsaw and Institute for Nuclear Research, Warsaw

E. R. FLETCHER
H. H. Wills Physics Laboratory, University of Bristol

J. LEMONNE, P. RENARD † and J. SACTON
Université Libre de Bruxelles

W. T. TONER ††
CERN, Geneva

D. O'SULLIVAN, T. P. SHAH and A. THOMPSON
Institute for Advanced Studies, Dublin

P. ALLEN ‡, Sr. M. HEERAN and A. MONTWILL
University College, Dublin

J. E. ALLEN, M. J. BENISTON ‡‡, D. H. DAVIS and D. A. GARBUTT
University College, London

V. A. BULL, R. C. KUMAR and P. V. MARCH
Westfield College, London

Received 17 June 1963

Abstract: The detailed analysis is presented of an event which is interpreted as the mesonic cascade decay of a double hyperfragment produced by the capture of a Ξ^- hyperon on a light emulsion nucleus. The most likely interpretations of the double hyperfragment are those in terms of either ${}_{\Lambda\Lambda}\mathrm{Be}^{10}$ or ${}_{\Lambda\Lambda}\mathrm{Be}^{11}$.

1. Introduction

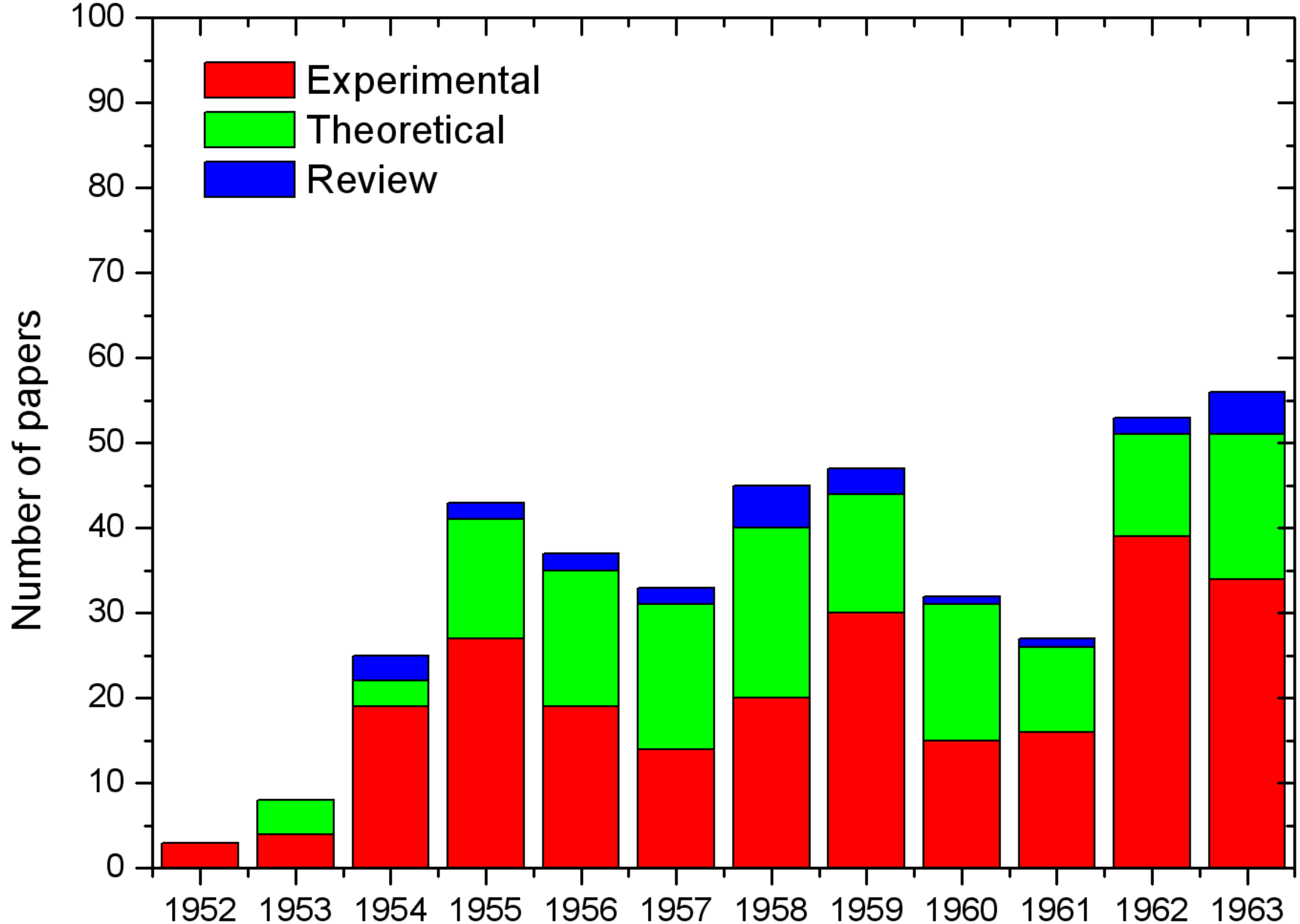
In the interactions of K^- mesons of sufficiently high energy with nuclei, Ξ^- hyperons may sometimes be produced. When a Ξ^- hyperon is brought to rest, it will interact with a nucleus to produce two Λ^0 hyperons according to the reaction

$$ \Xi^- + \mathrm{p} \rightarrow \Lambda^0 + \Lambda^0 + 28.5 \text{ MeV}. \qquad (1) $$

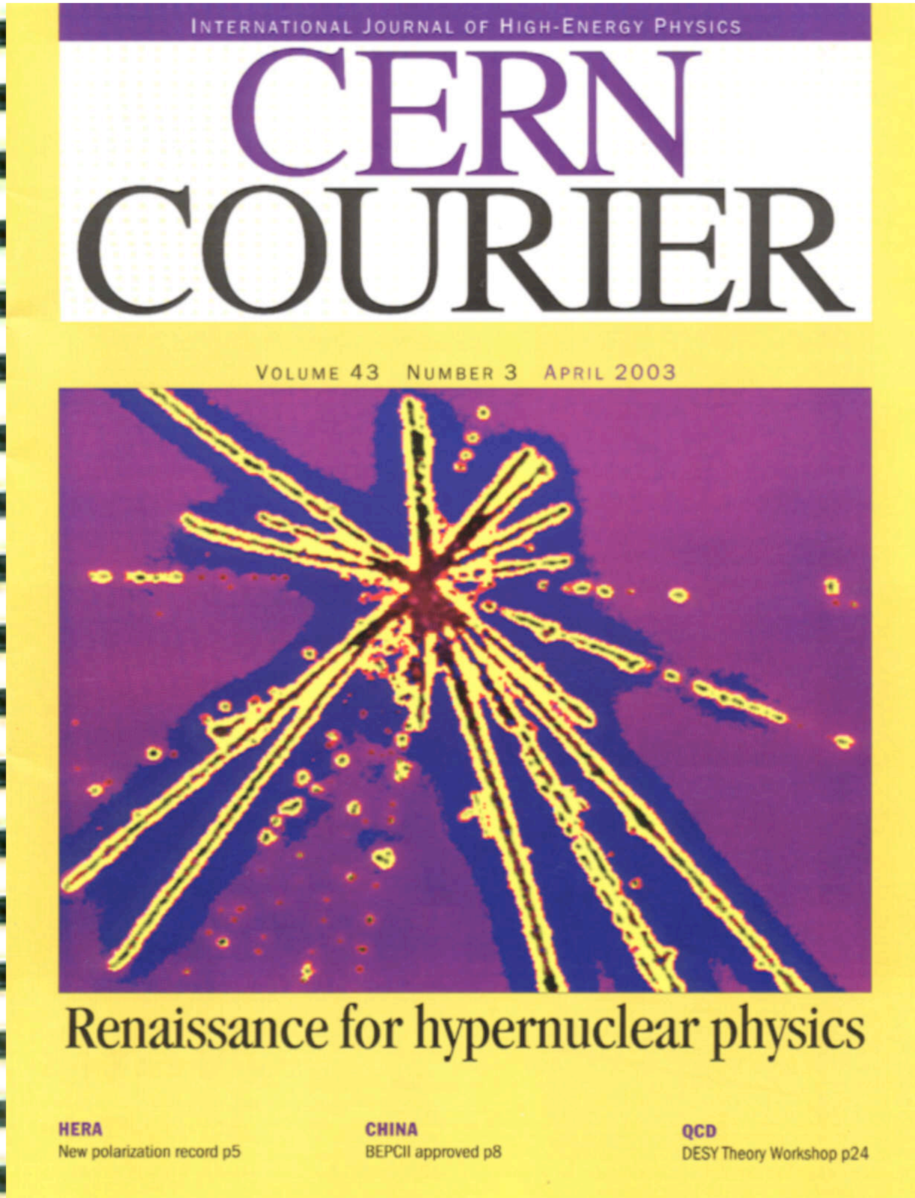
Since the energy release in such an interaction is small, the two Λ^0 hyperons may easily become bound to form two ordinary hyperfragments or a double hyperfragment, i.e., a nuclear structure containing two bound Λ^0 hyperons [1]). The study of double hy-

† Chercheur agréé à l'Institut Interuniversitaire des Sciences Nucléaires, Belgique.
†† Supported by the British Emulsion Committee.
‡ Now at University College, London.
‡‡ Now at the Enrico Fermi Institute for Nuclear Studies, Chicago.

Papers on hypernuclear physics



Renaissance for hypernuclear physics



Hypernuclear physics program in Jülich in Germany (COSY), Newport News in USA (TJNAF), BNL in USA, Dubna in Russia (Nuclotron), KEK in Japan, Frascati in Italy (FINUDA at DAΦNE)

PHYSICAL REVIEW C **106**, 044306 (2022)

Deformation and hyperon halo in hypernuclei

Huai-Tong Xue (薛怀通), Q. B. Chen (陈启博), Xian-Rong Zhou (周先荣),* and Y. Y. Cheng (程奕源)
Department of Physics, East China Normal University, Shanghai 200241, China

H.-J. Schulze
INFN Sezione di Catania, Dipartimento di Fisica, Universitá di Catania, Via Santa Sofia 64, 95123 Catania, Italy

(Received 6 April 2022; accepted 13 September 2022; published 10 October 2022)

The effects of deformation and the change of the nuclear core on the hyperon binding and halo structure in single-Λ p-shell hypernuclei are studied for the C hyperisotopes and $N = 6$ hyperisotones in the framework of the deformed Skyrme-Hartree-Fock approach with combinations of the NN interactions SIII, SGII, SkI4 and the ΛN interactions LY1 and SLL4, respectively. Deformation causes more deeply bound states with smaller extension of the density distributions and radii. The possibility of deformed halo structures of Λ $1p$ states in hypernuclei up to a mass number $A = 15$ is found.

DOI: 10.1103/PhysRevC.106.044306

I. INTRODUCTION

Since the observation of the neutron halo structure in ^{11}Li in 1985 [1], the halo phenomenon has been intensively studied from both experimental and theoretical sides [2–4] in very neutron-rich nuclei, which are far away from the valley of stability, close to or at the neutron drip line. Compared to their isobars, the neutron density distribution of halo nuclei can extend far beyond the nuclear surface area and they have an abnormally large matter radius. In addition, halo nuclei can have strong soft electric dipole transition strengths [5]. Necessary conditions for forming a halo are that one or two valence neutrons have (a) weak binding with typical separation energies $S_n \lesssim 1$ MeV [3,6], which are significantly smaller than the canonical value of 8 MeV and (b) low orbital angular momenta $l = 0$ or 1 [3]. The binding of one or two

Λ, provides a unique laboratory to study the ΛN interactions. Because unrestricted by the Pauli exclusion principle, the Λ hyperon can enter deeply into the nucleus and is a good probe to study the nuclear structure and interaction that would be more obscured in ordinary nuclei.

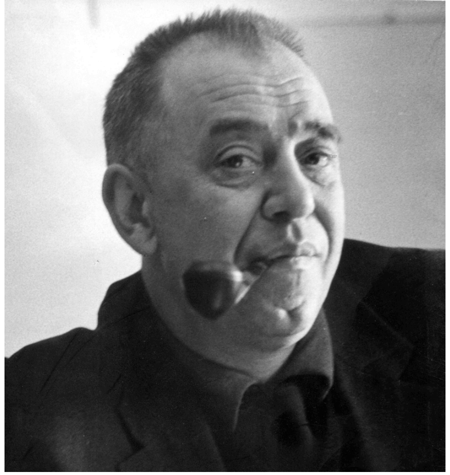
So far, numerous studies have been conducted on the influence of the hyperon in neutron-rich hypernuclei [14–19], the exploration of the hyperon drip line [20,21], as well as the feasibility of halo states in very light systems [22,23].

It is hence very interesting to investigate whether one or few Λ hyperons could also form halo structures in heavier Λ hypernuclei. In boron and carbon isotopes, the possibility of forming a halo structure has recently been investigated in the framework of the spherical Skyrme-Hartree-Fock (SHF) model [24]. Halo structures with wave functions extending beyond the nuclear surface were found in the Λ $1p$ states of

The discoverers

as seen today

Marian Danysz



- born 1909 in Paris
- son of Polish-French physicist Jan (Jean) Kazimierz Danysz, who made the first β-spectrometer (1911)
- studied electrical engineering at Warsaw Polytechnic
- while still a student, worked in Warsaw Radiological Laboratory and co-discovered (1934) radioactive isotope of fluorine, co-authored 2 papers
- 1937-1939 worked as an electrical engineer
- 1945-1948 taught electricity in a Technical School
- 1949-1952 in Liverpool and Bristol, mastered nuclear emulsion technique in Powell's laboratory
- 1951 with Owen Lock and Gideon Yekutieli claimed discovery of a new particle (ζ^0)

Jerzy Pniewski

- born 1913 in Płock, son of a high-school teacher
- studied mathematics, and later physics, at the University of Warsaw
- started career in molecular optics; two papers (1938)
- 1948-1950 in Liverpool to study β-spectroscopy
- June 1951 Ph.D. in nuclear spectroscopy
- persuaded by Danysz to join him (1952) in cosmic ray studies using nuclear emulsions
- head of the Institute of Experimental Physics since November 21,1953

Marian Danysz

- little formal physics background
- fantastic intuition
- unusual imagination
- hated administration,
  formalities and lecturing
- loved fast driving and hunting
- chain-smoker of cigars,
  cigarettes and pipe
- loved good food

Jerzy Pniewski

- solid background in physics and mathematics
- well organized and systematic
- good lecturer
- competent and efficient administrator
- loved to entertain friends with magic tricks and puzzles
- never smoked but loved good cognac

"I am reminded of a famous remark of Napoleon. Whenever he was presented with a young man for military advancement, he invariably asked the question: 'Is he lucky?' This was by no means a casual inquiry. The important quality for which he was seeking was – does this man put himself in a situation where he <u>can</u> be lucky? If you fail to put yourself in a situation where it is possible to have good fortune then you cannot have any success; if you do, you may."

Powell in the after-dinner talk at St. Cergue

Louis Pasteur

"In the field
of observation,
chance only favours
those minds which
have been prepared"

Lucky and well prepared

- The first hypernucleus found just after the start of scanning of new emulsion plates in a new laboratory of little experience – incredible piece of luck or a miracle

- The first double hypernucleus again found in Warsaw (one of the eight collaborating labs) – incredible piece of luck or another miracle

Danysz and Pniewski were lucky and well prepared (later they first discussed hypernuclear isomerism and Pniewski initiated hypernuclear spectroscopy)

Two lucky physicists

The end