HISTORY OF X17 PARTICLE*

*HYPOTHETICAL

M. CIEMAŁA
IFJ PAN
19/09/2024

OUTLINE

- Introduction – what is X17?
- Experiments from the XX century
- XXI century
- Summary

WHAT IS X17 PARTICLE? – „ATOMKI ANOMALY”

Year 2015

Anomaly observed in the angular correlation of e^+e^- pairs emitted

in nuclear transition in the $^8Be^*(18.15\ MeV)$

PRL 116, 042501 (2016) PHYSICAL REVIEW LETTERS week ending 29 JANUARY 2016

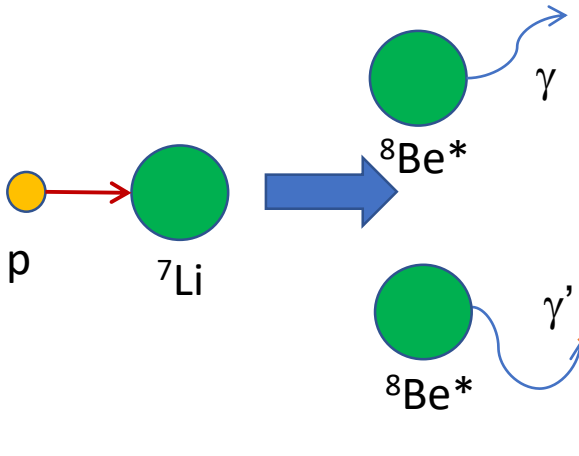
Open Access

Observation of Anomalous Internal Pair Creation in ^8Be: A Indication of a Light, Neutral Boson

A. J. Krasznahorkay, M. Csatlós, L. Csige, Z. Gácsi, J. Gulyás, M. Hunyadi, I. Kuti, B. M. Nyakó, L. G. Tornyi, Zs. Vajta, T. J. Ketel, and A. Krasznahorkay

Phys. Rev. Lett. **116**, 042501 – Published 26 January 2016

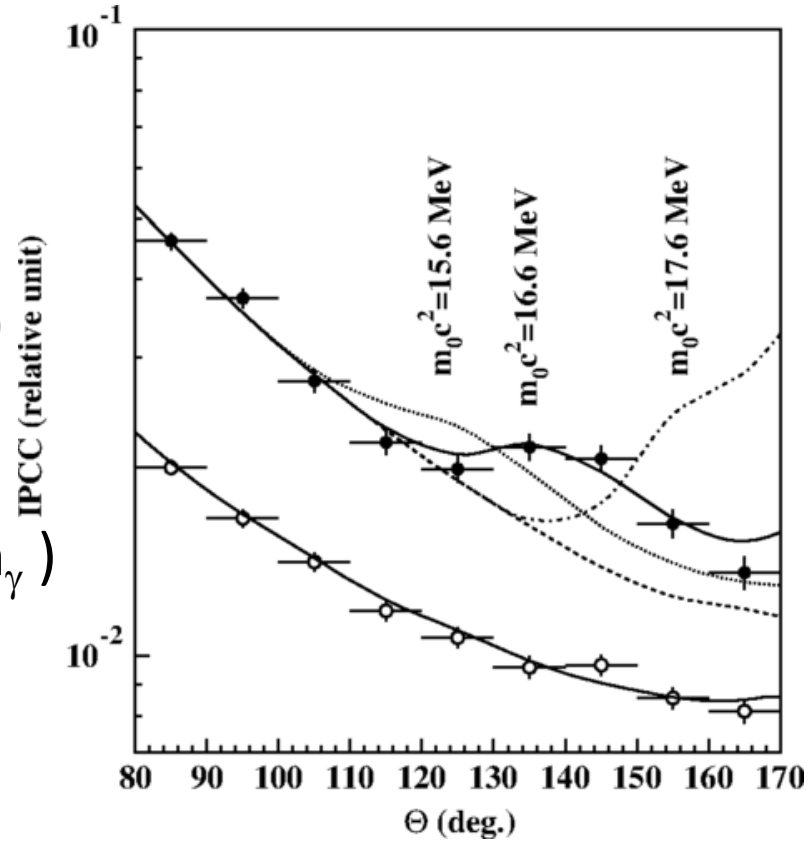
WHAT IS X17 PARTICLE? – „ATOMKI ANOMALY"



$^{8}Be^{*} \rightarrow {}^{8}Be + \gamma$ ($branch_{\gamma} = 1.4 \times 10^{-5}$)

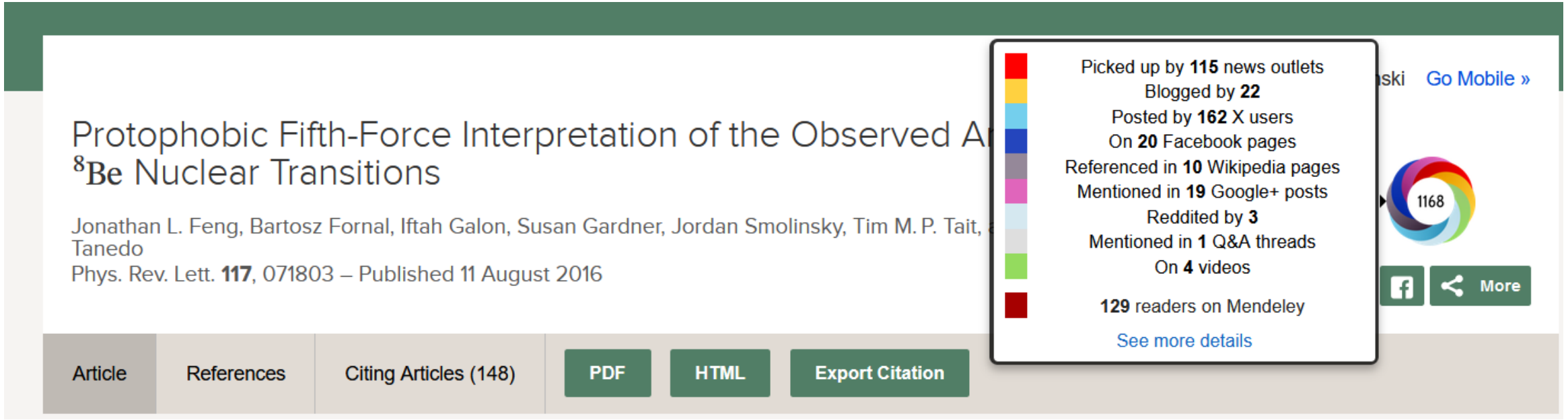
$^{8}Be^{*} \rightarrow {}^{8}Be + e^{+}e^{-}$ ($branch_{e} = 3.9 \times 10^{-3}\ branch_{\gamma}$)

$^{8}Be^{*} \rightarrow {}^{8}Be + (X17 \rightarrow e^{+}e^{-})$ ($branch_{X} = 5.8 \times 10^{-6}\ branch_{\gamma}$)



A. J. Krasznahorkay et al., Phys. Rev. Lett. 116, 042501 (2016)

WHAT IS X17 PARTICLE – „ATOMKI ANOMALY”



„The data are explained by a 17 MeV vector gauge boson X that is produced in the decay of an excited state to the ground state, $^8Be^* \rightarrow {}^8Be\,X$, and then decays through $X \rightarrow e^+e^-$. The X boson mediates a fifth force with a characteristic range of 12 fm and has millicharged couplings to up and down quarks and electrons, and a proton coupling that is suppressed relative to neutrons.”

EXPERIMENTS FROM THE XX CENTURY

Volume 74B, number 4, 5 PHYSICS LETTERS 17 April 1978

AXION EMISSION IN DECAY OF EXCITED NU

S.B. TREIMAN
Joseph Henry Laboratories, Princeton University, Prince
and
F. WILCZEK [1]
The Institute for Advanced Studies, Princeton, NJ 0854(

Received 28 February 1978

Decay of an excited nuclear state by axion emission can be related, under certain circumstances, to an isotopically analogous β decay process. All strong interaction and nuclear complications for the former reaction are therefore fixed by data on the latter, so that the axion rate can be reliably predicted up to open parameters of the underlying weak interaction model. This is illustrated, in the framework of a simple axion model, with the example of decay of $^{12}C^*$ (15.1 MeV). For plausible values of the parameters, the ratio of axion to gamma decay widths is of order 10^{-5}. Some aspects of decay of the axion itself are commented on; and we also briefly discuss possible alternative models of axion interactions.

PHYSICAL REVIEW D VOLUME 18, NUMBER 5 1 SEPTEMBER 1978

Do axions exist?

T. W. Donnelly, S. J. Freedman, R. S. Lytel, R. D. Peccei, and M. Schwartz
Institute of Theoretical Physics, Department of Physics, Stanford University, Stanford, California 94305
(Received 21 March 1978)

We critically examine various existing experiments which could provide evidence for the axion. Although our conclusions regarding the existence of this particle are somewhat pessimistic, we discuss other possible experiments which could throw additional light on this question.

In 1978 two papers appear: Treiman and Wilczek and Donnelly et al., which proposed that axions could be discovered through the study of nuclear decays (the best cases are ~10-20 MeV excited levels in light nuclei)

EXPERIMENTS FROM THE XX CENTURY

VOLUME 57, NUMBER 2 PHYSICAL REVIEW LETTERS 14 JULY 1986

Search for a Short-Lived Neutral Particle Produced in Nuclear Decay

M. J. Savage, R. D. McKeown, and B. W. Filippone
W.K. Kellogg Radiation Laboratory, California Institute of Technology, Pasadena, California 91125

and

L. W. Mitchell
Normal Bridge Laboratory of Physics, California Institute of Technology, Pasadena, California 91125
(Received 28 February 1986)

We report on a search for a short-lived neutral particle ϕ produced in the decay of the 9.17-MeV $J^\pi = 2^+$ state in ^{14}N. The experiment is sensitive to decays into an e^+e^- pair with $\tau_\phi \lesssim 10^{-11}$ s. For $m_\phi = 1.7$ MeV we place a limit on the branching ratio of $\Gamma_\phi/\Gamma_\gamma \leqslant 4\times10^{-4}$ at the 90% confidence level.

9.17 MeV excited state in ^{14}N from ^{13}C(p,γ)^{14}N at E_p = 1.75 MeV

EXPERIMENTS FROM THE XX CENTURY

ELSEVIER

14 November 1996

PHYSICS LETTERS B

Physics Letters B 388 (1996) 235–240

A deviation in internal pair conversion

F.W.N. de Boer [a,1], O. Fröhlich [a], K.E. Stiebing [a], K. Bethge [a], H. Bokemeyer [b], A. Balanda [c], A. Buda [d,e], R. van Dantzig [f], Th.W. Elze [a], H. Folger [b], J. van Klinken [d], K.A. Müller [a], K. Stelzer [a], P. Thee [a], M. Waldschmidt [a]

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[b] *Gesellschaft für Schwerionenforschung (GSI), D-64220 Darmstadt, Germany*
[c] *Institut of Physics, Jagellonian University, Pl-30-055 Cracow, Poland*
[d] *Kernfysisch Versneller Instituut (KVI), Nl-9747 AA Groningen, The Netherlands*
[e] *Department of Physics, SUNY at Stony Brook, Stony Brook, NY 11794, USA*
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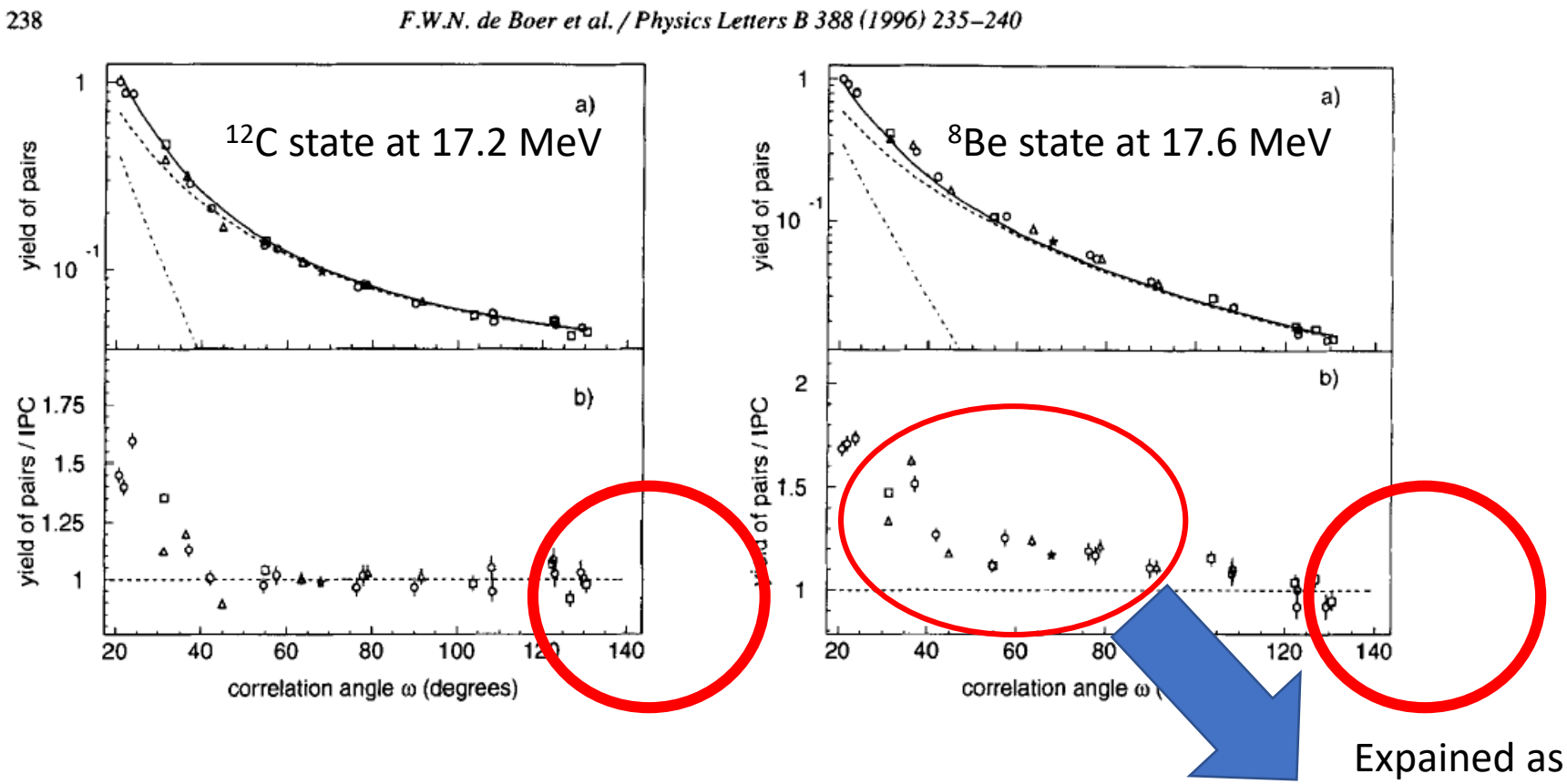
Received 6 May 1996; revised manuscript received 26 September 1996
Editor: J.P. Schiffer

Measured e^+e^- decay of the 17.2 MeV level in ^{12}C and e^+e^- decay of the 17.6 MeV level in ^{8}Be.

EXPERIMENTS FROM THE XX CENTURY



Expained as decay of short lived boson with mass ~9 MeV/c^2

EXPERIMENTS FROM THE XX CENTURY

J. Phys. G: Nucl. Part. Phys. **23** (1997) L85–L96. Printed in the UK PII: S0954-3899(97)87438-5

LETTER TO THE EDITOR

Excess in nuclear e^+e^- pairs near 9 MeV/c^2 invariant mass

F W N de Boer†+, R van Dantzig‡, J van Klinken§, K Bethge†,
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† Insititut für Kernphysik, Universität Frankfurt (IKF), D-60486 Frankfurt am Main, Germany
‡ Nationaal Instituut voor Kernfysica en Hoge-Energie Fysica (NIKHEF), 1009 DB Amsterdam, The Netherlands
§ Kernfysisch Versneller Instituut (KVI), 9747 AA Groningen, The Netherlands
¶ Gesellschaft für Schwerionenforschung (GSI), D-64291 Darmstadt, Germany
* State University of New York at Stony Brook (SUNY), Stony Brook, NY 11794, USA

Received 5 September 1997

Abstract. Data on internal pair conversion in widely different nuclear transitions with energies above 12 MeV have an apparent excess in e^+e^- pairs around 9 MeV/c^2 invariant mass. While the deviations individually may be circumstantial, in combination they appear to point to an overall anomaly.

EXPERIMENTS FROM THE XX CENTURY

^{A}Z	I^{π}	T	E MeV	B_X	Γ_X meV	α_X 1.7×10^{-6}	m_X MeV/c^2	
^{20}Ne	1^-	1	17.8 E1 16.2 E1	$\leqslant 1.3 \times 10^{-4}$	$\leqslant 3$	$\leqslant 1.8$		C.P. Montoya, et al., 1993, Nucl. Instrum. Meth. A 334 437
^{12}C	1^-	1	17.2 E1	$\leqslant 2.3 \times 10^{-5}$	$\leqslant 1$	$\leqslant 0.3$		F.W.N. de Boer et al., 1996 Phys. Lett. 388B 235
	2^-	1	12.3 E1					
^{12}C	1^+	0	12.7 M1	$(1.6 \pm 0.7) \times 10^{-3}$	0.55 ± 0.24	38 ± 17	9.2 ± 1.0	A. Buda, et al., 1993 Nucl. Instrum. Meth. A 335 479
^{12}C	1^+	1	15.1 M1	$\leqslant 4.6 \times 10^{-5}$	$\leqslant 1.7$	$\leqslant 0.9$		
^{12}C			114 M1	$\leqslant 9.8 \times 10^{-5}$	$\leqslant 8$	$\leqslant 0.8$		B. Hoistad, et al., 1993 Nucl. Phys. A 553 543c
^{8}Be	1^+	1, 0	17.6 M1 14.6 M1	$(11.4 \pm 3.4) \times 10^{-5}$	1.9 ± 0.4	1.5 ± 0.4	9 ± 1	F.W.N. de Boer et al., 1996 Phys. Lett. 388B 235

From F.W.N. de Boer, et al. J. Phys. G: Nucl. Part. Phys. 23 (1997) L85–L96.

XXI CENTURY

Vol. 37 (2006) *ACTA PHYSICA POLONICA B* No 1

LEPTON PAIRS FROM A FORBIDDEN M0 TRANSITION: SIGNALING AN ELUSIVE LIGHT NEUTRAL BOSON?*

A. Krasznahorkay[a], F.W.N. de Boer[b], M. Csatlós[a], L. Csige[a]
Z. Gácsi[a], J. Gulyás[a], M. Hunyadi[a], T.J. Ketel[c], J. van Klinken[d]
A. Krasznahorkay Jr[a], A. Vitéz[a]

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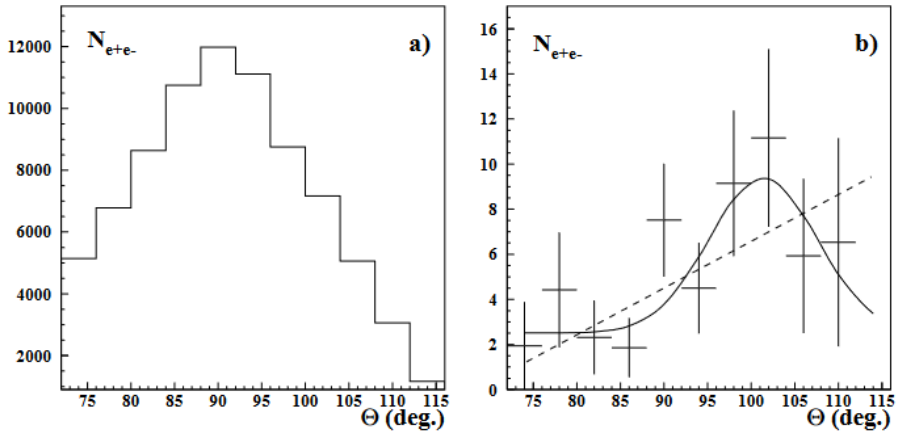

Fig. 2. The angular correlation of the e^+e^- pairs obtained from the decay of the 6.05 MeV (a) and from the 10.95 MeV (b) transitions in ^{16}O.

XXI CENTURY

ANOMALOUS INTERNAL PAIR CREATION IN ^{8}Be AS A SIGNATURE OF THE DECAY OF A NEW PARTICLE*

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Z. Gácsi, A. Krasznahorkay Jr., B.M. Nyakó

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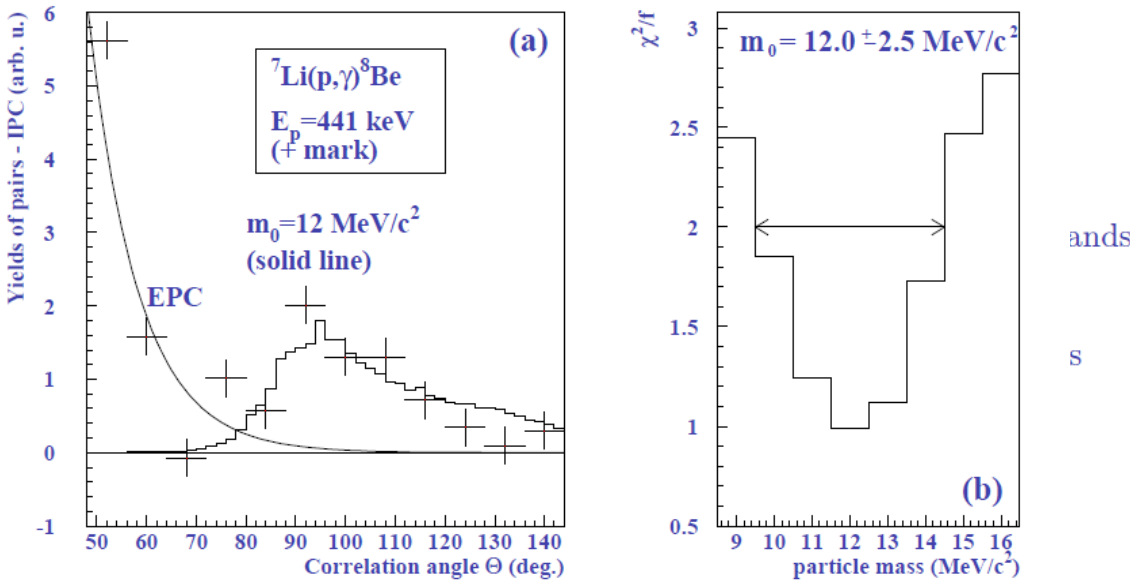
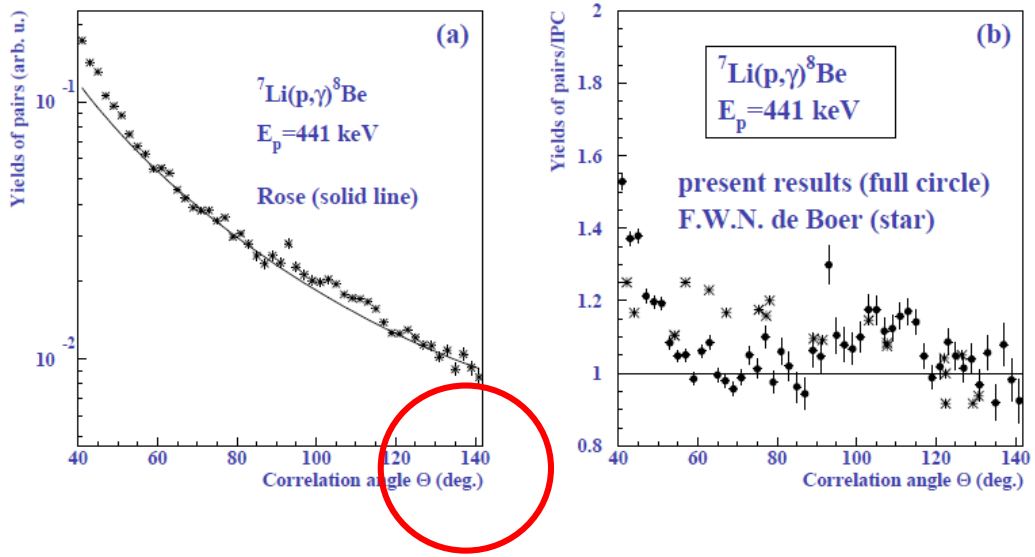


Proceedings after XXX Mazurian Lakes Conference on Physics, Piaski, Poland, September 2–9, 2007.



XXI CENTURY

- A.J. Krasznahorkay et al. , Observation of Anomalous Internal Pair Creation in 8Be: A Possible Indication of a Light, Neutral Boson, Phys. Rev. Lett. 116, 042501 – Published 26 January 2016
- A.J. Krasznahorkay et al. , On the creation of the 17 MeV X boson in the 17.6 MeV M1 transition of ^{8}Be, EPJ Web of Conferences 142, 01019 (2017), Published, 2 April 2017
- A. J. Krasznahorkay et al. , New anomaly observed in 4He supports the existence of the hypothetical X17 particle, Phys. Rev. C 104, 044003, Received 27 October 2019
- A. J. Krasznahorkay et al., New anomaly observed in 12C supports the existence and the vector character of the hypothetical X17 boson, Phys. Rev. C 106, L061601, Received 5 November 2022, Accepted 5 December 2022
- **Tran The Anh, Tran Dinh Trong, Attila J. Krasznahorkay, Attila Krasznahorkay, József Molnár, Zoltán Pintye, Nguyen Ai Viet, Nguyen The Nghia, Do Thi Khanh Linh, Bui Thi Hoa, Le Xuan Chung and Nguyen Tuan Anh, Checking the ^{8}Be Anomaly with a Two-Arm Electron Positron Pair Spectrometer, *Universe* 2024, *10*(4), received: 29 January 2024**

MANY PAPERS WITH EXPLANATIONS (FEW EXAMPLES)

- Péter Kálmán, Tamás Keszthelyi, Anomalous internal pair creation, Eur. Phys. J. A (2020) 56:205

(It is found that nuclear transitions, the transition energy of which is significantly lower than the whole transition energy, can cause peak lation.)

9 Summary

It was raised that e^-e^+ anomalies to the usual IPC decay of an excited nuclear state can be ascribed to reactions of higher order of standard perturbation calculation. Our standard explanation results in possible peaks at about $\Theta_{2,m} = 146.2°$ and $\Theta_{3,m} = 144.2°$, that seem to fit well with the observed anomalous peak at about $\Theta \approx 140°$ [14,16] in the case of decay of resonantly excited state of ^8Be. Our mechanism may qualitatively explain recent anomalous e^-e^+ observations [15,16] made in the case of the decay of resonantly excited states of ^4He too. Consequently, the assumption of the hypothetical X17 particle is not the sole possible explanation of the observed e^-e^+ anomalies.

MANY PAPERS WITH EXPLANATIONS (FEW EXAMPLES)

- A. C. Hayes, J. Friar, G. M. Hale, and G. T. Garvey, Angular correlations in the *e*+e- decay of excited states in 8Be, Phys. Rev. C 105, 055502

Motivated by the recent observation of anomalous electron-positron angular correlations in the decay of the 18.15-MeV 1^+ excited states in ^{8}Be, we reexamine in detail the standard model expectations for these angular correlations. The 18.15-MeV state is above particle threshold, and several multipoles can contribute to its e^+e^- decay. We present the general theoretical expressions for e^+e^- angular distributions for nuclear decay by $C0, C1, C2, M1, E1$, and $E2$ multipoles, and we examine their relative contribution to the e^+e^- decay of ^{8}Be at 18.15 MeV. We find that this resonance is dominated by $M1$ and $E1$ decay, and that the ratio of $M1$ to $E1$ strength is a strong function of energy. This is in contrast to the original analysis of the e^+e^- angular distributions, where the $M1/E1$ ratio was assumed to be a constant over the energy region $E_p = 0.8$–1.2 MeV. We find that the existence of a "bump" in the measured angular distribution is strongly dependent on the assumed $M1/E1$ ratio, with the present analysis finding the measured large-angle contributions to the e^+e^- angular distribution to be lower than expectation. Thus, in the current analysis we find no evidence for axion decay in the 18.15-MeV resonance region of ^{8}Be.

MANY PAPERS WITH EXPLANATIONS (FEW EXAMPLES)

Can nuclear physics explain the anomaly observed in the internal pair production in the Beryllium-8 nucleus?

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ARTICLE INFO

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ABSTRACT

Recently the experimentalists in Krasznahorkay (2016) [1] announced observing an unexpected enhancement of the e^+–e^- pair production signal in one of the ^{8}Be nuclear transitions. The subsequent studies have been focused on possible explanations based on introducing new types of particle. In this work, we improve the nuclear physics modeling of the reaction by studying the pair emission anisotropy and the interferences between different multipoles in an effective field theory inspired framework, and examine their possible relevance to the anomaly. The connection between the previously measured on-shell photon production and the pair production in the same nuclear transitions is established. These improvements, absent in the original experimental analysis, should be included in extracting new particle's properties from the experiment of this type. However, the improvements can not explain the anomaly. We then explore the nuclear transition form factor as a possible origin of the anomaly, and find the required form factor to be unrealistic for the ^{8}Be nucleus. The reduction of the anomaly's significance by simply rescaling our predicted event count is also investigated.

CONC

- Anom … s in ^{8}Be, ^{4}He and ^{12}
- Still w … in the nuclea
- Real v … oof of X17 exista

10:00	**Probing light dark particles with η and $\eta^{\prime}$ decays** — *Sergi Gonzalez-Solis* *A-1-13, Faculty of Physics, Astronomy and Computer Science, Jagiellonian Univeristy* 09:35 - 10:20
	An update of the X17 particle — *Attila Krasznahorkay* 10:20 - 11:00
11:00	**Coffee Break** *A-1-13, Faculty of Physics, Astronomy and Computer Science, Jagiellonian Univeristy* 11:00 - 11:30
	TBA — *Tommaso Marchi* *A-1-13, Faculty of Physics, Astronomy and Computer Science, Jagiellonian Univeristy* 11:30 - 12:00
12:00	**New light particle searches with PADME** — *Kalina Dimitrova* *A-1-13, Faculty of Physics, Astronomy and Computer Science, Jagiellonian Univeristy* 12:00 - 12:30
	Lunch break *A-1-13, Faculty of Physics, Astronomy and Computer Science, Jagiellonian Univeristy* 12:30 - 14:00
13:00	
14:00	**Search for X17 in the η->e+e-π+π- decay at pp@4.5 GeV with HADES** — *Krzysztof Prościński* *A-1-13, Faculty of Physics, Astronomy and Computer Science, Jagiellonian Univeristy* 14:00 - 14:30
	Search for Hidden Sector New Particles in the 3-60 MeV Mass Range: Focusing on the Hypothetical X17 Particle *William Briscoe* *A-1-13, Faculty of Physics, Astronomy and Computer Science, Jagiellonian Univeristy* 14:30 - 15:00

Thank you for your attention!

XXI CENTURY

Frascati Physics Series Vol. LVI (2012)
DARK FORCES AT ACCELERATORS
October 16-19, 2012

SEARCHING FOR A LIGHT NEUTRAL AXIAL-VECTOR BOSON IN ISOSCALAR NUCLEAR TRANSITIONS

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Abstract

The electron-positron angular correlations within the pairs created in the decay of the 17.6-MeV ($J^\pi = 1^+$, $T = 1$) and the 18.12-MeV ($J^\pi = 1^+$, $T = 0$) *isovector and isoscalar magnetic dipole* transitions in ^{8}Be were measured. A sharp maximum was found at large angles in the isoscalar transition(s), which indicates that, in an intermediate step, a neutral isoscalar particle with a mass of 13.45(30) MeV/c^2 and $J^\pi = 1^+$ was created with a confidence level of 3σ. This particle may be identified with U, the supersymmetrical gauge boson, and may be related to dark-matter particles in the universe.

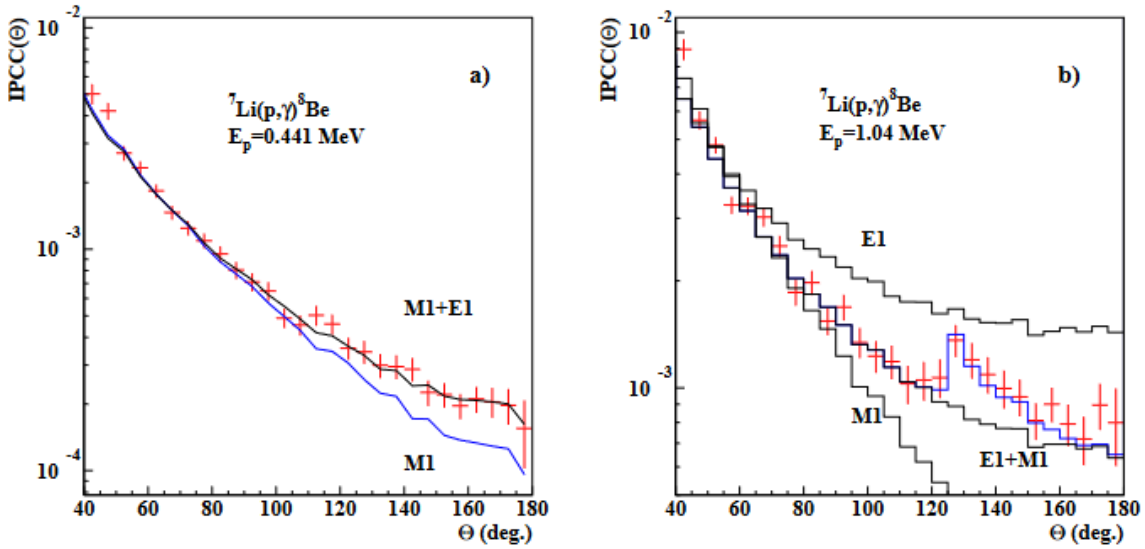

Figure 5: *Measured angular correlation of the e^+e^- pairs originated from the decay of the 17.6 MeV resonance (a) and from the 18.15 MeV resonance (b) (red dots with error bars) compared with the simulated ones assuming pure M1 and E1 transitions and M1+E1 mixed transitions. The contribution of a 13.5 MeV boson is shown in blue.*