Proposal for creating a new code for a new nuclear reaction channel with bound dineutron escape

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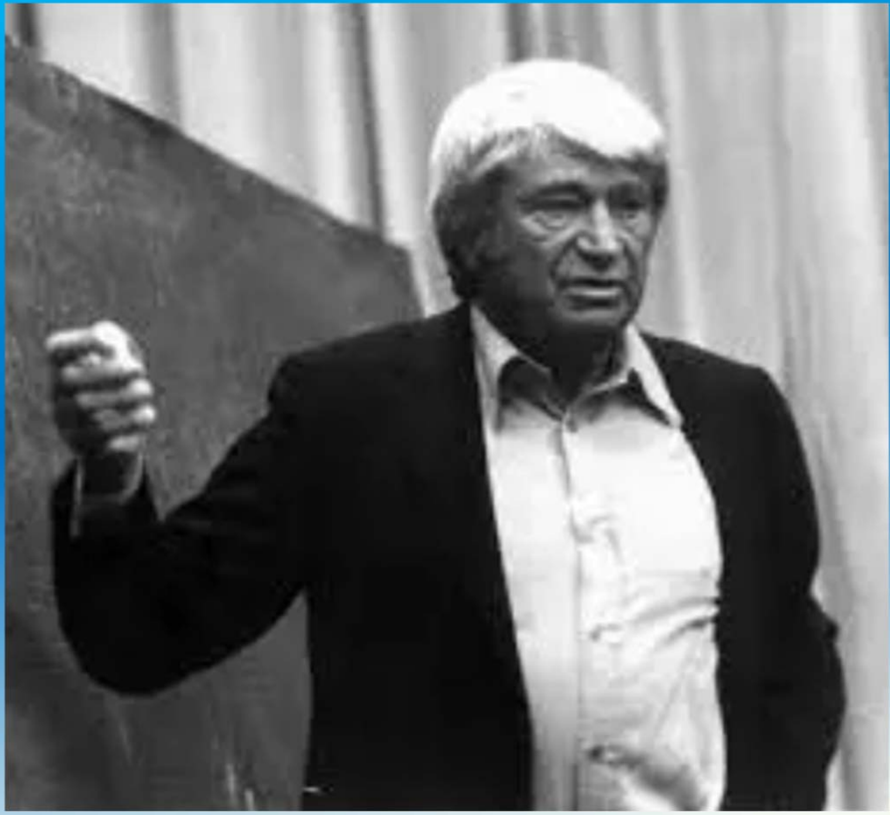
NRDC-2025 Technical Meeting (17-20 June, 2025, Madrid, Spain)

Search for a two nucleon system or the dineutron (n2) as a bound particle or the two nucleon nuclei without protons was raised for a first time in 1946 [1].

However, over decades such two neutron bound nuclei have been considered as non-existing due to the Pauli Exclusion Principle, which forbids the two neutrons to bind together as the dineutron in any space spot due to missing at least 66 keV, necessary for forming the potential well of interaction between them slightly deeper to establish a bound state. [2].

[1] M.Y.Colby, R.N.Little, Phys. Rev. 70, 437 (1946).
[2] N.Dzysiuk, I.M.Kadenko, O.O.Prykhodko, Nucl. Phys. A 1041 (2024) 122767

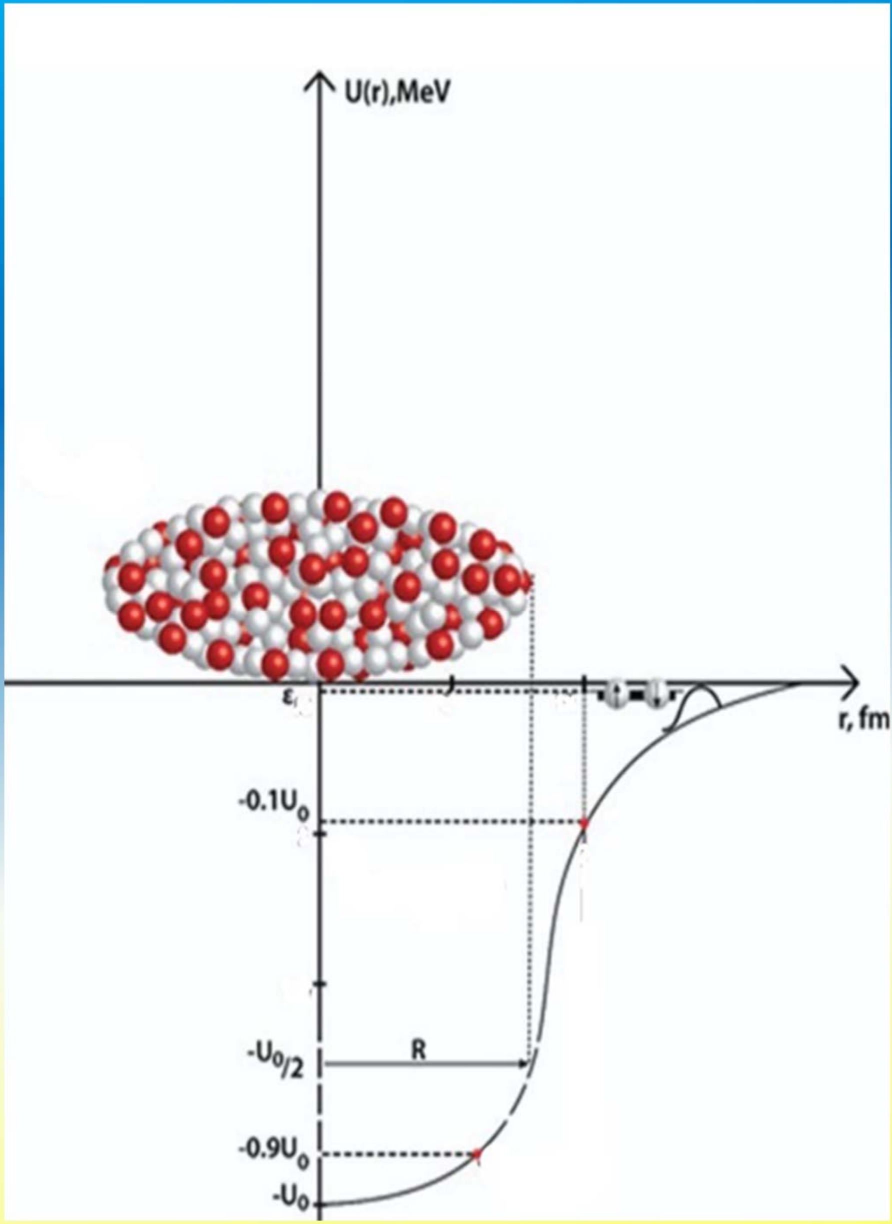


In 1972 Arkadiy Migdal published a paper [3],

where the formation of the dineutron in a bound state was predicted

following to escape of the two paired up neutrons from compound nucleus.

[3] A.B. Migdal, Yad. Fiz. 16, 427 (1972) / Sov. J. Nucl. Phys. 16, 238 (1973).



This escape can take place for the case when the kinetic energy of the two neutrons is much less of their interaction energy and if single particle levels are formed within the potential well of the heavy nucleus but beyond its radius.

This bound state corresponds to the real level at an additional energy branch, which concludes at $\varepsilon_c \sim 0.4$ MeV. Then any single particle states are ranged within [0÷0.4] MeV. The atomic masses of the massive nuclei must be within 100 and 200 μu in order to comprise a system consisting of the heavy nucleus plus the dineutron near the surface of this nucleus [4, 5].

[4] I. Kadenko, APP/B,48, 1669, 2017
[5] I.M.Kadenko, B.Biro, A.Fenyvesi ,EUL,131,52001,2020

The experimental studies of the formation of a bound dineutron in the outgoing channel were done in the measurements of the

^{159}Tb (n, ^{2}n)^{158g}Tb [6, 7];

^{197}Au (n, ^{2}n) ^{196g}Au [5];

^{175}Lu(n,^{2}n)^{174g}Lu [8] nuclear reactions.

[6] Igor Kadenko,J,EUL,114,42001,2016
[7] I.M.Kadenko, APP/B,48,1669,2017
[8] Ihor Kadenko, Barna Biro, Mihaly Braun ett all,   PL/B,859,139100,2024

A traditional neutron activation technique was used to irradiate samples followed by measurements of the induced activity with HPGe spectrometer in order to detect gamma-peaks of the reaction product when the (n,2n) reaction channel is not open for incident neutron energies.

Debrecen

^{159}Tb (ACCEL,2FR CAD) Cadarache

^{197}Au (CYCLO,3HUNDEB) Debrecen

^{175}Lu (CYCLO,3HUNDEB) Debrecen

Target	Product	E_n (MeV)	$T_{1/2}$	$E_{th}(n,2n)$ (MeV)
^{159}Tb	^{158}Tb	6.85	180.YR	8.18
^{197}Au	^{196}Au	6.09÷6.39 6.18÷6.46	6.183D	8.11
^{175}Lu	^{174}Lu	5.51÷6.00	3.31YR	7.71

Reaction	E_n (MeV)	σ (mb)	Entry
$^{197}Au(n,^{2}n)^{196g}Au$	6.09÷6.39 6.18÷6.46	0.18±0.06 0.037±0.008	32251
$^{175}Lu(n,^{2}n)^{174g}Lu$	5.51÷6.00	$33.5^{+7.0}_{-6.7}$	32253
$^{159}Tb(n,^{2}n)^{158g}Lu$	6.85	75. ± 30.	32255

In 32251

REACTION (79-AU-197(N,X)79-AU-196,,SIG,,MSC/SPA)

X = a bound dineutron

in 32253

REACTION (71-LU-175(N,X)71-LU-174,,SIG,,SPA)

X = a bound dineutron

I propose to use in REACTION SF3=N2 for a bound dineutron. Therefore, the reactions should be written as

in 32251

REACTION (79-AU-197(N,N2)79-AU-196,,SIG,, SPA)

in 32253

REACTION (71-LU-175(N,N2)71-LU-174,,SIG,,SPA)

The data for the ^{159}Tb(n,^{2}n)^{158}Tb reaction was not compiled as in the article published in 2016 the cross section value was not determined through low statistic. Only now when I prepared this paper I find that the measurements were continued and the ^{159}Tb(n,^{2}n)^{158}Tb cross section value was determined. So if we use a new SF3=N2 for a bound dineutron the reaction in the new entry 32255 should be written as REACTION (65-TB-159 (N,N2) 65-TB-158,,SIG,, SPA) and the entry 32255 can be compiled as follows.

```
ENTRY            32255   20250604                                 32255  0    1
SUBENT        32255001   20250604                                 32255  1    1
BIB                 12         24                                 32255  1    2
TITLE      New direction in nuclear physics originated from the   32255  1    3
           neutron activation technique application               32255  1    4
AUTHOR     (I.M.Kadenko)                                          32255  1    5
INSTITUTE  (4UKRKGU)                                              32255  1    6
REFERENCE  (J,APP/B,48,1669,2017)                                 32255  1    7
           #doi:10.5506/APhysPolB.48.1669                         32255  1    8
REL-REF    (I,,Igor Kadenko,J,EUL,114,42001,2016)                 32255  1    9
           (M,23255001,N.Dzysiuk+,J,NP/A,936,6,2015)              32255  1   10
FACILITY   (ACCEL,2FR CAD) The AMANDE facility (the Institute for 32255  1   11
           Radiation Protection and Nuclear Safety, Cadarache),   32255  1   12
           which is based on a HVEE 2 MV Tandetron accelerator    32255  1   13
           system.                                                32255  1   14
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INC-SOURCE (D-D) Neutrons were generated using the nuclear      32255  1   15
           reaction between accelerated deuterons and a thin    32255  1   16
           deuterated target composed of a titanium layer       32255  1   17
           saturated by deuterium attached to 0.5 mm thick silver 32255  1   18
           backing.                                             32255  1   19
DETECTOR   (HPGE) The coaxial HPGe detector GC2020. The detector 32255  1   20
           was properly shielded with a lead housing.           32255  1   21
SAMPLE     One Tb sample used in a shape of a cylinder of 30 mm 32255  1   22
           diameter with 5 mm thickness (total mass of 28.9 g). 32255  1   23
METHOD     (ACTIV)                                              32255  1   24
STATUS     (APRVD) Approved by I.Kadenko, 4 June 2025.          32255  1   25
HISTORY    (20250604C) UkrNDC                                   32255  1   26
ENDBIB             24          0                                32255  1   27
NOCOMMON            0          0                                32255  1   28
ENDSUBENT          27          0                                32255  199999
SUBENT       32255002   20250604                                32255  2    1
BIB                 4          6                                32255  2    2
REACTION   (65-TB-159(N,N2)65-TB-158,,SIG,,SPA)                 32255  2    3
DECAY-DATA (65-TB-158-G,180.YR,DG,944.2)                        32255  2    4
ERR-ANALYS (DATA-ERR) Statistical contribution is major to the  32255  2    5
           total uncertainty.                                   32255  2    6
STATUS     (TABLE,,I.Kadenko,J,APP/B,48,1669,2017) Text on p.1673.32255  2    7
           (SUPPL,32255003) Calculated neutron spectrum         32255  2    8
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Thank You

for Your attention!

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