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

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The dineutron is a bound particle, or two-nucleon nucleus, consisting of the two neutrons only without any nucleus charge and formed in the outgoing channel of neutron-induced nuclear reaction near the residual nucleus surface.

The dineutron was predicted by Migdal [1] to be formed as a bound particle under certain circumstances when an additional bound state appears, not existing in the perturbation theory. This bound state is interpreted as a single particle state for the two neutrons, or bound dineutron, located near the surface of some nucleus, beyond its volume but within its potential well. Also 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 [2, 3].

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; ^{197}Au (n, ^{2}n) ^{196g}Au; ^{175}Lu(n,^{2}n)^{174g}Lu nuclear reactions. 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.

Results of these measurements were published in

1. J,EPL,114, 42001,2016 (I. Kadenko Possible observation of the dineutron in the ^{159}Tb (n, ^{2}n) ^{158g}Tb nuclear reaction)
2. J,APP/B,48, 1669, 2017 (I. Kadenko New direction in nuclear physics originated from the neutron activation technique application)
3. J,EUL,131,52001,2020 (I.M.Kadenko, B.Biro, A.Fenyvesi Statistically significant observation of and cross-sections for a new nuclear reaction channel on 197Au with bound dineutron escape)
4. J,PL/B,859,139100,2024 (Ihor Kadenko, Barna Biro, Mihaly Braun et all Formation of bound dineutrons in the 175Lu(n,^{2}n) 174gLu nuclear reaction and its cross-section)

The last two articles were compiles as 32251 and 32253.

Reactions were written as

REACTION (79-AU-197(N,X)79-AU-196,,SIG,,MSC/SPA) in 32251
X = a bound dineutron
REACTION (71-LU-175(N,X)71-LU-174,,SIG,,SPA) in 32253
X = a bound dineutron

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

REACTION (79-AU-197(N,**N2**)79-AU-196,,SIG,, SPA) in 32251

REACTION (71-LU-175(N,**N2**)71-LU-174,,SIG,,SPA) in 32253.

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

[2] I. Kadenko, Europhys. Lett. 114, 42001 (2016).

[3] I. Kadenko, Acta Physica Polonica B 50, 55, (2019)

The data for the ^{159}Tb(n,^{2}n)^{158}Tb reaction was not compiled as in the article published in 2016 (J,EPL,114, 42001,2016) 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
ENDBIB               6          0                                 32255  2    9
NOCOMMON             0          0                                 32255  2   10
DATA                 3          1                                 32255  2   11
EN         DATA       DATA-ERR                                    32255  2   12
MEV        MB         MB                                          32255  2   13
6.85       75.        30.                                         32255  2   14
ENDDATA              3          0                                 32255  2   15
ENDSUBENT           14          0                                 32255  299999
SUBENT        32255003   20250604                                 32255  3    1
BIB                  3        254                                 32255  3    2
SUPPL-INF  (INCSP) The theoretical neutron fluence energy         32255  3    3
           distribution is calculated – for each distance – using 32255  3    4
           the TARGET code coupled to MCNP to calculate the       32255  3    5
           scattered neutrons, taking into account the solid angle32255  3    6
           to the target subtended by the 1.5 cm radius sample.   32255  3    7
           Col. 1: En (MeV)                                       32255  3    8
           Col. 2: Fluence (1/cm2)                                32255  3    9
           ------------------------------                         32255  3   10
```

0.021	1.723E+05	32255	3	11
0.025	1.385E+05	32255	3	12
0.046	2.143E+05	32255	3	13
0.063	2.626E+05	32255	3	14
0.080	2.993E+05	32255	3	15
0.096	3.564E+05	32255	3	16
0.113	4.630E+05	32255	3	17
0.143	4.305E+05	32255	3	18
0.172	5.125E+05	32255	3	19
0.214	5.674E+05	32255	3	20
0.257	7.056E+05	32255	3	21
0.269	6.013E+05	32255	3	22
0.315	6.656E+05	32255	3	23
0.358	7.158E+05	32255	3	24
0.374	6.279E+05	32255	3	25
0.404	6.851E+05	32255	3	26
0.442	7.923E+05	32255	3	27
0.501	7.260E+05	32255	3	28
0.551	7.806E+05	32255	3	29
0.576	8.154E+05	32255	3	30
0.627	7.363E+05	32255	3	31
0.682	8.894E+05	32255	3	32
0.699	1.279E+06	32255	3	33
0.728	1.225E+06	32255	3	34
0.753	1.122E+06	32255	3	35
0.795	1.189E+06	32255	3	36
0.812	1.028E+06	32255	3	37
0.842	9.843E+05	32255	3	38
0.888	1.043E+06	32255	3	39
0.913	9.421E+05	32255	3	40
0.951	8.888E+05	32255	3	41
0.980	8.508E+05	32255	3	42
1.010	8.758E+05	32255	3	43
1.048	8.631E+05	32255	3	44
1.069	7.462E+05	32255	3	45
1.132	7.039E+05	32255	3	46
1.166	8.503E+05	32255	3	47
1.208	8.259E+05	32255	3	48
1.258	9.550E+05	32255	3	49
1.275	9.010E+05	32255	3	50
1.305	9.275E+05	32255	3	51

1.342	1.012E+06	32255	3	52
1.376	9.139E+05	32255	3	53
1.431	8.748E+05	32255	3	54
1.469	7.786E+05	32255	3	55
1.502	1.222E+06	32255	3	56
1.503	2.641E+06	32255	3	57
1.536	2.603E+06	32255	3	58
1.570	2.062E+06	32255	3	59
1.587	1.863E+06	32255	3	60
1.620	2.032E+06	32255	3	61
1.637	1.732E+06	32255	3	62
1.662	1.541E+06	32255	3	63
1.696	1.352E+06	32255	3	64
1.713	1.475E+06	32255	3	65
1.734	1.294E+06	32255	3	66
1.759	1.103E+06	32255	3	67
1.793	1.239E+06	32255	3	68
1.818	1.071E+06	32255	3	69
1.843	1.056E+06	32255	3	70
1.885	1.103E+06	32255	3	71
1.915	9.260E+05	32255	3	72
1.948	8.006E+05	32255	3	73
1.978	9.258E+05	32255	3	74
1.999	1.086E+06	32255	3	75
2.033	1.025E+06	32255	3	76
2.066	1.135E+06	32255	3	77
2.092	1.070E+06	32255	3	78
2.125	1.102E+06	32255	3	79
2.159	1.220E+06	32255	3	80
2.188	1.102E+06	32255	3	81
2.218	9.950E+05	32255	3	82
2.243	1.151E+06	32255	3	83
2.268	9.805E+05	32255	3	84
2.302	1.024E+06	32255	3	85
2.340	8.726E+05	32255	3	86
2.386	8.982E+05	32255	3	87
2.411	9.801E+05	32255	3	88
2.441	8.598E+05	32255	3	89
2.474	8.597E+05	32255	3	90
2.504	7.652E+05	32255	3	91
2.517	8.472E+05	32255	3	92

2.554	7.992E+05	32255	3	93
2.588	8.848E+05	32255	3	94
2.634	8.226E+05	32255	3	95
2.668	7.761E+05	32255	3	96
2.702	7.538E+05	32255	3	97
2.727	6.423E+05	32255	3	98
2.761	6.238E+05	32255	3	99
2.782	5.553E+05	32255	3	100
2.828	5.393E+05	32255	3	101
2.857	5.970E+05	32255	3	102
2.899	5.798E+05	32255	3	103
2.950	6.513E+05	32255	3	104
2.979	6.144E+05	32255	3	105
2.996	4.661E+05	32255	3	106
3.017	5.469E+05	32255	3	107
3.030	4.209E+05	32255	3	108
3.047	4.868E+05	32255	3	109
3.076	4.461E+05	32255	3	110
3.110	4.029E+05	32255	3	111
3.144	4.867E+05	32255	3	112
3.165	4.395E+05	32255	3	113
3.207	5.083E+05	32255	3	114
3.219	4.207E+05	32255	3	115
3.245	4.658E+05	32255	3	116
3.274	3.432E+05	32255	3	117
3.299	4.330E+05	32255	3	118
3.333	5.008E+05	32255	3	119
3.346	5.791E+05	32255	3	120
3.383	5.464E+05	32255	3	121
3.400	7.633E+05	32255	3	122
3.413	6.411E+05	32255	3	123
3.455	7.522E+05	32255	3	124
3.472	6.410E+05	32255	3	125
3.493	7.413E+05	32255	3	126
3.535	5.705E+05	32255	3	127
3.556	3.966E+05	32255	3	128
3.590	4.264E+05	32255	3	129
3.606	3.479E+05	32255	3	130
3.644	3.687E+05	32255	3	131
3.669	2.526E+05	32255	3	132
3.696	3.110E+05	32255	3	133

3.741	3.580E+05	32255	3	134
3.766	2.248E+05	32255	3	135
3.787	2.920E+05	32255	3	136
3.829	2.878E+05	32255	3	137
3.867	2.452E+05	32255	3	138
3.935	2.835E+05	32255	3	139
3.964	2.280E+05	32255	3	140
4.023	2.279E+05	32255	3	141
4.036	2.674E+05	32255	3	142
4.065	1.999E+05	32255	3	143
4.099	2.560E+05	32255	3	144
4.149	2.088E+05	32255	3	145
4.187	2.345E+05	32255	3	146
4.221	1.516E+05	32255	3	147
4.225	1.970E+05	32255	3	148
4.250	2.345E+05	32255	3	149
4.288	1.779E+05	32255	3	150
4.292	2.277E+05	32255	3	151
4.317	1.451E+05	32255	3	152
4.339	2.148E+05	32255	3	153
4.351	1.885E+05	32255	3	154
4.385	1.727E+05	32255	3	155
4.424	1.877E+05	32255	3	156
4.439	1.560E+05	32255	3	157
4.452	2.148E+05	32255	3	158
4.486	1.677E+05	32255	3	159
4.494	1.310E+05	32255	3	160
4.515	1.559E+05	32255	3	161
4.536	1.368E+05	32255	3	162
4.574	1.777E+05	32255	3	163
4.620	1.537E+05	32255	3	164
4.642	1.911E+05	32255	3	165
4.679	1.348E+05	32255	3	166
4.696	1.582E+05	32255	3	167
4.738	1.559E+05	32255	3	168
4.747	1.290E+05	32255	3	169
4.776	1.182E+05	32255	3	170
4.827	9.642E+04	32255	3	171
4.869	1.182E+05	32255	3	172
4.890	1.535E+05	32255	3	173
4.919	1.387E+05	32255	3	174

4.949	1.271E+05	32255	3	175
4.974	8.456E+04	32255	3	176
4.991	1.036E+05	32255	3	177
4.995	1.252E+05	32255	3	178
5.045	1.164E+05	32255	3	179
5.087	9.091E+04	32255	3	180
5.096	1.308E+05	32255	3	181
5.138	1.021E+05	32255	3	182
5.163	1.557E+05	32255	3	183
5.180	1.307E+05	32255	3	184
5.197	1.114E+05	32255	3	185
5.252	1.447E+05	32255	3	186
5.273	1.066E+05	32255	3	187
5.311	1.251E+05	32255	3	188
5.332	9.629E+04	32255	3	189
5.353	1.180E+05	32255	3	190
5.382	1.288E+05	32255	3	191
5.399	1.006E+05	32255	3	192
5.437	1.251E+05	32255	3	193
5.449	1.035E+05	32255	3	194
5.483	8.084E+04	32255	3	195
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5.584	8.948E+04	32255	3	199
5.597	1.113E+05	32255	3	200
5.626	1.020E+05	32255	3	201
5.639	1.325E+05	32255	3	202
5.677	8.563E+04	32255	3	203
5.731	7.512E+04	32255	3	204
5.765	8.687E+04	32255	3	205
5.803	9.757E+04	32255	3	206
5.837	7.294E+04	32255	3	207
5.849	7.959E+04	32255	3	208
5.870	9.476E+04	32255	3	209
5.891	8.193E+04	32255	3	210
5.917	7.508E+04	32255	3	211
5.938	9.613E+04	32255	3	212
5.967	7.728E+04	32255	3	213
5.980	1.096E+05	32255	3	214
6.022	1.323E+05	32255	3	215

```
                    6.030  1.111E+05                                  32255  3  216
                    6.064  1.382E+05                                  32255  3  217
                    6.102  1.248E+05                                  32255  3  218
                    6.110  1.508E+05                                  32255  3  219
                    6.148  1.876E+05                                  32255  3  220
                    6.178  1.694E+05                                  32255  3  221
                    6.211  1.988E+05                                  32255  3  222
                    6.279  2.401E+05                                  32255  3  223
                    6.296  2.776E+05                                  32255  3  224
                    6.325  3.119E+05                                  32255  3  225
                    6.342  3.713E+05                                  32255  3  226
                    6.397  4.294E+05                                  32255  3  227
                    6.414  6.087E+05                                  32255  3  228
                    6.431  1.278E+06                                  32255  3  229
                    6.452  3.536E+06                                  32255  3  230
                    6.477  9.644E+06                                  32255  3  231
                    6.499  2.376E+07                                  32255  3  232
                    6.520  4.775E+07                                  32255  3  233
                    6.545  8.667E+07                                  32255  3  234
                    6.554  1.380E+08                                  32255  3  235
                    6.583  1.928E+08                                  32255  3  236
                    6.596  2.469E+08                                  32255  3  237
                    6.613  2.940E+08                                  32255  3  238
                    6.651  3.399E+08                                  32255  3  239
                    6.680  3.874E+08                                  32255  3  240
                    6.718  4.166E+08                                  32255  3  241
                    6.752  4.546E+08                                  32255  3  242
                    6.786  4.960E+08                                  32255  3  243
                    6.836  5.490E+08                                  32255  3  244
                    6.878  6.349E+08                                  32255  3  245
                    6.899  1.056E+09                                  32255  3  246
                    6.921  2.123E+09                                  32255  3  247
                    6.937  3.480E+09                                  32255  3  248
                    6.971  3.906E+09                                  32255  3  249
                    7.001  2.797E+09                                  32255  3  250
                    7.026  1.352E+09                                  32255  3  251
                    7.038  1.124E+08                                  32255  3  252
                    7.052  1.011E+03                                  32255  3  253
STATUS      (CURVE,23255001,N.Dzysiuk+,J,NP/A,936,6,2015) Fig.4.      32255  3  254
HISTORY     (20250604C) Spectrum was digitized by compiler using       32255  3  255
            the GSYS-2.4.9 code                                        32255  3  256
```

ENDBIB	254	0	32255	3	257
NOCOMMON	0	0	32255	3	258
NODATA	0	0	32255	3	259
ENDSUBENT	258	0	32255	399999	
ENDENTRY	3	0	3225599999999		