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Memo CP-D/596

Date: 27 November 2009
To: Distribution
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Subject: **Secondary energy in capture reaction – E-LVL or E-LVL-FIN?**

Below I propose to use `E-LVL` rather than `E-LVL-FIN` for energies of levels to which gamma transitions from capture states are measured.

Example: 23002.002 $^{12}C(n,\gamma)^{13}C$

Possible cascade gamma cascades are summarized below. Note that the 4th excitation level at 6864 keV (5/2+) is always higher than the capture state in this work. In this figure, branching ratios (Ajzenberg-Selove, 1990) are not normalized to 100 for each initial level. For example, it is normalized to 100.75 for the gamma from the second excitation level.

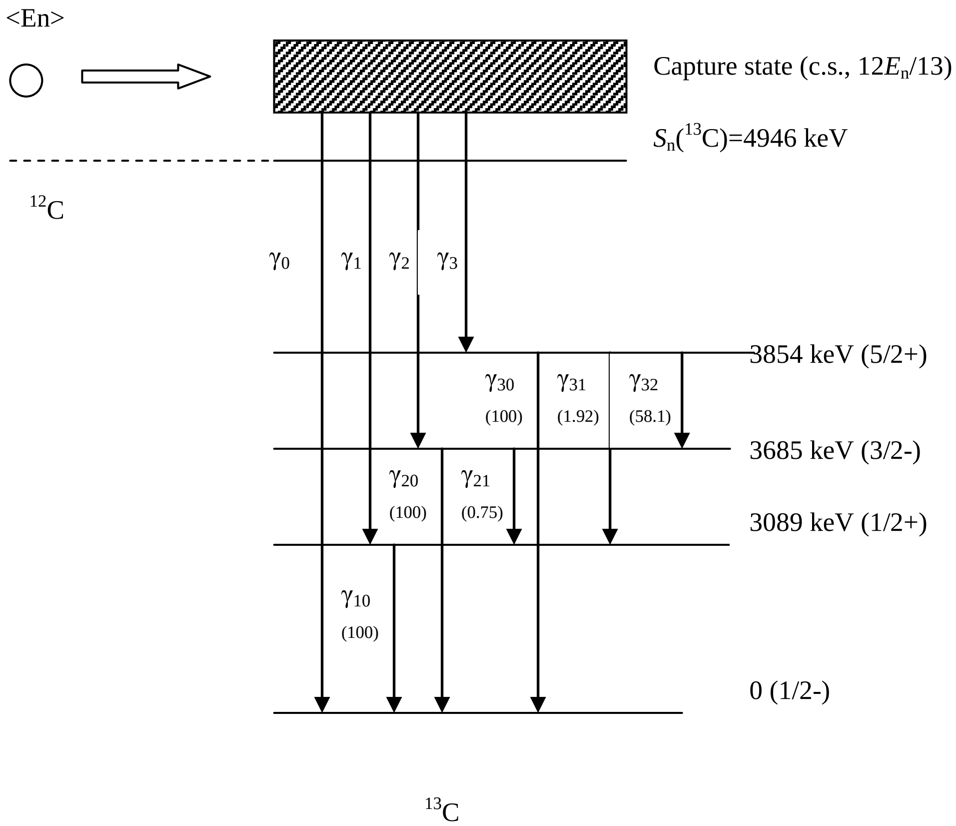

TABLE 2

NEUTRON ENERGY DEPENDENCE

E_n REGION (keV)	$\bar{E}_n$ (keV)	CAPTURE CROSS SECTION (μbarn)				
		Partial				Total
		c.s. → gnd	c.s. → 1st	c.s. → 2d	c.s. → 3d	
12–26	21	3.0 (8)	6.7 (12)	1.3 (13)	0.9 (9)	11.9 (22)
30–50	40	1.2 (4)	8.7 (10)	0.9 (12)	0.4 (5)	11.2 (17)
30–70	50	1.8 (6)	8.6 (11)	1.0 (5)	1.9 (9)	13.1 (16)
30–75	60	2.2 (7)	11.2 (15)	1.1 (10)	1.5 (28)	15.9 (34)
70–130	97	1.0 (3)	12.3 (13)	0.6 (4)	1.3 (10)	15.2 (17)
160–250	199	1.6 (7)	16.5 (22)	0.7 (7)	2.8 (34)	21.6 (41)

NOTES.—Neutron energy (E_n) dependence of the partial capture cross sections corresponding to the γ-rays from a captured state of ^{13}C to low-lying states and of the total capture cross section. They were obtained by using two different proton energies of 1.895 and 1.995 MeV, respectively.

The cross sections for transition from the capture state to these four states are given in Table 2 of T. Ohsaki *et al*., Astrophys. J. **422**(1994)912 (See above.). This is compiled in 23002.002 as follows:

```
REACTION   (6-C-12(N,G)6-C-13,PAR,SIG)
...
EN-MEAN    +EN-RSL    -EN-RSL    E-LVL-FIN  DATA       DATA-ERR
KEV        KEV        KEV        KEV        MICRO-B    MICRO-B
 21.        5.         9.         0.00       3.0        0.8
 21.        5.         9.         3.09       6.7        1.2
 21.        5.         9.         3.68       1.3        1.3
 21.        5.         9.         3.85       0.9        0.9
...
```

The first line of the EXFOR data table (E-LVL-FIN=0.0 keV) means

$$\sum_i \sigma(i \to \text{g.s.}) = \sigma(\text{c.s.} \to \text{g.s.}) + \sigma(\text{1st} \to \text{g.s.}) + \sigma(\text{2nd} \to \text{g.s.}) + \sigma(\text{3rd} \to \text{g.s.})$$

. But it is not true. The 3.0 μb is corresponding to the first term of the right hand side. Namely this should be recognized as the most typical partial reaction (= reaction which leaves residual nucleus to a specific level.) and the heading of the fourth column should be E-LVL rather than E-LVL-FIN.

Note that we can easily obtain the cross sections for transition between two discrete levels by the compiled data and known decay data:

$$\sigma(\text{1st} \to \text{g.s.}) = \sigma(\text{c.s.} \to \text{g.s.}) + 0.007\sigma(\text{c.s.} \to \text{2nd}) + 0.0121\sigma(\text{c.s.} \to \text{3rd})$$

$$\sigma(\text{2nd} \to \text{g.s.}) = 0.993\sigma(\text{c.s.} \to \text{2nd}) + 0.363\sigma(\text{c.s.} \to \text{3rd})$$

$$\sigma(\text{3rd} \to \text{g.s.}) = 0.624\sigma(\text{c.s.} \to \text{3rd})$$

The quantity in the right hand sides can be characterized by γ energy E in EXFOR. (Eqs. (2)-(4) of the article are not right, as confirmed with Prof. Y. Nagai.)

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