



## Evaluation of $(\gamma, n)$ , $(\gamma, p)$ , and $(\gamma, np)$ Reaction Cross Sections for $^{20,22}\text{Ne}$

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The high energy (above 17 MeV)  $^{20}\text{Ne}(\gamma, n)^{19}\text{Ne}$  reaction is a concern to several scientific both basic and applied problems. From the point of view of interesting application there are the needs for this reaction cross section data for the energies of incident photons higher than reaction threshold 16.9 MeV because its competition to the reaction  $^{20}\text{Ne}(n, 2n)^{19}\text{Ne}$  which is the one of several threshold neutron reactions widely used for the problems of DT plasma diagnostics solving. At the same time the pair of nuclei  $^{20}\text{Ne}$  ( $Z = N = 10$ ) and  $^{22}\text{Ne}$  ( $Z = 10, N = 12$ ) is very interesting from the point of view of basic research of Giant Dipole Resonance excitation and decay mechanisms investigation.

Unfortunately the experimental photonuclear reaction cross section data available for both nuclei under discussion are very poor (Table 1).

Table 1.

Published Ne photoneutron and photoproton reaction cross section data

Isotope	Reaction	Energy region (MeV)	Upper limit of integration (MeV)	Интегр. сечение (MeV*mb)	First author	Reference	Comment
nat. Ne	$(\gamma, n) + (\gamma, np)$	16 - 26	20.6 26.7	15.8 $42 \pm 3$	Veyssiere	/1/	*
	$(\gamma, 2n)$	16 - 26					
	$(\gamma, n_0 + n_1 + n_2)$	17 - 31	31.0	55 - 77	Woodworth	/2/	**
$^{20}\text{Ne}$	$(\gamma, n) + (\gamma, np)$	16 - 28	20.6 26.7 28.5	$20 \pm 2$ $49 \pm 5$ $58 \pm 6$	Allen	/3/	
	$(\gamma, p) + (\gamma, np)$	16 - 28	32.5	$61 \pm 11$	Hoffman	/4/	***
	$(\gamma, 2n)$	16 - 26			Veyssiere	/1/	*
$^{22}\text{Ne}$	$(\gamma, p) + (\gamma, np)$	18 - 30	32.5	$45 \pm 8$	Hoffman	/4/	***

\*) up to the threshold energy ( $E_{\text{thr.}} = 28.5$  MeV) of reaction  $^{20}\text{Ne}(\gamma, 2n)$  the cross sections of reactions  $^{nat}\text{Ne}(\gamma, 2n)$  и  $^{22}\text{Ne}(\gamma, 2n)$  are identical ( $^{21}\text{Ne}$  abundance is 0.27 %);

\*\*\*) differential reaction cross section obtained from the 90-degree photoneutron energy spectra multiplied to  $4\pi$ ;

\*\*\*\*) differential reaction cross section obtained from the 90-degree photoproton energy spectra multiplied to  $4\pi$ ;

The evaluation of the  $^{22}\text{Ne}[(\gamma, n) + (\gamma, np)]$  reaction cross section has been done /5 - 8/ on the base of  $^{nat}\text{Ne}[(\gamma, n) + (\gamma, np)]$  /1/ and  $^{20}\text{Ne}[(\gamma, n) + (\gamma, np)]$  /3/ reaction cross sections using the data on

the isotopes  $^{20}\text{Ne}$  and  $^{22}\text{Ne}$  abundances (90.51 and 9.22 % correspondingly), the contribution of  $^{21}\text{Ne}$  isotope with abundance 0.27 % has been neglected

The following formulae has been applied:

$$\sigma^V = 90.51\sigma^{A-n} + 9.22\sigma^X,$$

where  $\sigma^X = \sigma\{^{22}\text{Ne}(\gamma, np)\}$  is the evaluated cross section,

$\sigma^{A-n} = \sigma^A \cdot N(E_\gamma)$  is the Allen's /3/ cross section  $\sigma^A$ , normalized to the Veysiere's /1/ cross section  $\sigma^V = \{\text{nat. Ne}[(\gamma, n) + (\gamma, np)]\}$ ,

$N(E_\gamma) = 0.048387 \cdot E_\gamma - 0.3016$  is the empirical function obtained using the integrated cross section data for 5 different energy ranges.

The  $(\gamma, n)$  and  $(\gamma, np)$  reaction cross sections for  $^{20}\text{Ne}$  and  $^{22}\text{Ne}$  have been evaluated for energies till about 28.0 MeV using the gaussian line separation of the  $^{20,22}\text{Ne}[(\gamma, n) + (\gamma, np)]$  reaction cross sections into corresponding parts below and above the  $(\gamma, np)$  reaction threshold energy values ( $E_{\text{thr.}} = 23.3$  and  $23.4$  MeV correspondingly for  $^{20}\text{Ne}$  and  $^{22}\text{Ne}$  isotopes). The appropriate subtraction procedures have been applied.

The  $^{20,22}\text{Ne}(\gamma, n)^{19,21}\text{Ne}$  reactions cross sections have been evaluated for photon energy range  $E_\gamma = 16.0 - 28.0$  MeV, the  $^{20}\text{Ne}(\gamma, np)^{18}\text{F}$  reaction cross section - for photon energy range  $E_\gamma = 23.3 - 28.0$  MeV. There was no obtained enough information for evaluation of  $^{22}\text{Ne}(\gamma, np)^{20}\text{F}$  reaction cross section.

The data for  $^{20,22}\text{Ne}(\gamma, Xp)$  reaction cross sections /4/ have been used for separation of the  $(\gamma, p)$  and  $(\gamma, pn)$  reactions contributions. The  $^{20,22}\text{Ne}(\gamma, p)^{19,21}\text{F}$  reaction cross sections have been evaluated for incident photon energies from 15.3 to 28.0 MeV.

The evaluated  $^{20,22}\text{Ne}(\gamma, n)^{19,21}\text{Ne}$ ,  $^{20,22}\text{Ne}(\gamma, p)^{19,21}\text{F}$ , and  $^{20}\text{Ne}(\gamma, np)^{18}\text{F}$  reaction cross sections /7, 8/ have been included into the preliminary version of the CDFE EPNDL3 library.

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