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Comments on Resonance Region Requests - Non Fissile Isotopes

by

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In the absence of a formal definition of resonance region, it is assumed that this category is intended to apply to those requests capable of being attempted, at least in part, by the techniques used in the resonance region, i.e. by time of flight techniques. The guiding principle here is that the lower limit of the energy range of the request should be 100 keV or less except for a few cases of very light nuclei where the limit is relaxed to 200 keV.

When this condition is applied to the requests in EANDC 55 'U', there are altogether 198 requests for data, of which 158 are for capture or activation cross sections as a function of energy, 25 are for absorption or total cross sections as a function of energy, 14 are for resonance parameters or resonance integrals and 11 for $\sigma_{n\alpha}$ or σ_{np} as a function of energy.

The entries in the last three categories are listed in the table with comments. No attempt has been made to comment in detail on the 158 requests for capture cross section and activation measurements, since these are in general covered in Newsletter No. 1 on the status of neutron capture cross section measurements, edited by K.H. Beckurts and W. Pönitz. We list below some general comments on the requests in the resonance region.

$\sigma_{n\alpha}$ and σ_{np} Requests

There are 11 requests in this category, 3 for $^{3}He(n,p)$ 6 for $^{6}Li(n,\alpha)$ and 2 for $^{10}B(n,\alpha)$. The energy ranges, accuracies and priorities all vary, and certainly this set of requests could be reduced in number. It is probable that at this point, most of the category I requests have been met. These requests fall very much within the sphere of interest of the EANDC Standards Sub-Committee.

σ_{nA} and σ_{nT} Requests

Here a number of the requests, particularly the 5 which refer to active nuclides (T, ^{147}Pm, ^{151}Sm, ^{154}Eu and ^{155}Eu) require special techniques available at only a few labs. Apart from this the 4 requests for σ_{nA} for ^{6}Li and ^{10}B can probably be satisfied by measurements of σ_{nT} and σ_{nn} up to ~ 200 keV. Above

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that energy, and in the case of F, shell transmission or measurement of partial cross sections would be necessary and these requests represent major undertakings. The remainder of the σ_{nT} requests appear straightforward apart from the provision of separated isotope targets, except for No. 285 which requests σ_{nT} for Co to 1°/o in the region of the 132 eV resonance. This would seem to be stretching techniques to the limit.

Requests for Resonance Parameters

Of these, one particularly difficult request, No. 536 for ^{233}Pa, has been satisfied in part by the great efforts of MTR - it is unlikely to be attempted again except possibly with a nuclear explosion source. Apart from the use of separated isotope targets, the remainder of the requests are again straightforward, except for No. 490 which requests the parameters of the 5 eV gold resonance to better than 1°/o. This is again a major undertaking.

Requests for Capture and Activation Cross Sections

This is by far the largest group of requests in the resonance region, and if we interpret the resonance region literally so that high neutron energy resolution is implied, then all of these requests require measurement of prompt capture γ-rays, and are requests for measurements with large scintillator tanks, or Moxon-Rae type detectors, used in conjunction with electron linacs or cyclotron pulsed neutron sources. Many of the requests run into the MeV region at their upper energy limit and so overlap with Van de Graaff measurements with prompt gamma ray detectors, and with activation measurements where the compound nucleus is β-unstable and has a suitable half-life. A few requests are for active target nuclei. In these cases the only possibility of a measurement of capture cross section as a function of neutron energy, is an experiment with a nuclear explosion. Many other requests are for measurements with stable isotopes so that the supply of separated isotopes is once again an important factor.

There is, of course, considerable duplication in the list of capture cross section requests. In two or three cases identical requests have been submitted by different requestors, and there are also multiple slightly different requests. For example, there are no fewer than 9 requests for measurements on ^{240}Pu of which 8 are in category I. Because of the variations in category and accuracies requested however, no large reduction in the number of requests seems possible. About 1/3 of all the requests for capture measurements are in category I. We must note also that at least a dozen requests (mainly category II and III) are for accuracies of 2°/o or better which are certainly at the limit of present experimental techniques.

Conclusion

To sum up these comments on the requests for cross section measurements of non fissile isotopes in the resonance region we should note the following points -

(1) Although there is duplication and overlapping in the requests, no large reduction in the total number of requests seems possible on this score, because of variations in category and accuracy requirements. Some reduction however can surely be made because of recent measurements.

(2) By far the largest number of requests (about $^2/_3$ of all requests) are for capture or activation cross section measurements so that there is much work to be done in this field both with linacs and Van de Graaff machines for some years to come.

(3) The remaining $^1/_3$ of the requests are distributed between requests for σ_{nT}, $\sigma_{n\Lambda}$, σ_{np}, $\sigma_{n\alpha}$ and direct requests for resonance parameters.

(4) There are many requests for cross sections of stable isotopes which will require separated isotopic targets.

(5) There is an appreciable number of requests for cross sections of active isotopes which will require a variety of special techniques according to the particular cross section and energy range required.

(6) There is also an appreciable number of requests for capture cross section measurements to an accuracy of 2°/o or better and for some resonance parameters to 1°/o. These requests will require major efforts if they are to be met.

$\sigma_{n\alpha}$ and σ_{np}

Req. No.	Isotope	Quantity	Energy Range	Accuracy	Priority	Comments
27	He^3	$\sigma_{n,p}(E)$	10 keV - 3 MeV	10%	I	Probably satisfied. BNL-325 Suppt. No. 2 to 2nd Ed. Vol. I.
28	He^3	$\sigma_{n,p}(E)$	20 keV - 3 MeV	2%	II	Very difficult.
29	He^3	$\sigma_{n,p}(E;\theta)$	20 keV - 5 MeV	10%	III	White experiment abandoned.
38	Li^6	$\sigma_{n,\alpha}(E)$	0 to 10 MeV	5%	I	Possibly satisfied by now.
39	Li^6	$\sigma_{n,\alpha}(E)$	0 to 10 MeV	10%	II	(Included in 38). Probably satisfied. BNL 325 Suppt. No. 2 to 2nd Ed. Vol. I.
40	Li^6	$\sigma_{n,\alpha}(E)$	20 keV - 5 MeV	2%	II	Very difficult.
41	Li^6	$\sigma_{n,\alpha}(E)$	100 keV - 14 MeV	10%, 20% acceptable	III	Probably satisfied. BNL 325 Suppt. No. 2 to 2nd Ed. Vol. I.
42	Li^6	$\sigma_{n,\alpha}(E,\theta)$	0 - 500 keV		II	No accuracy stated.
43	Li^6	$\sigma_{n,\alpha}(E;\theta)$	20 keV - 5 MeV	10%	III	Some data available.
80	B^{10}	$\sigma_{n,\alpha}(E)$ } $\sigma_{n,\alpha\gamma}(E)$ }	0.01 eV - 40 keV	To be used as flux monitor	I	Probably met - see report of sub-committee on standards
81	B^{10}	$\sigma_{n,\alpha}(E)$ } $\sigma_{n,\alpha\gamma}(E)$ }	40 keV - 1 MeV	To be used as flux monitor	I	Better scattering measurements needed - see report of sub-committee on standards

Resonance Parameters and Resonance Integrals

Req. No.	Iso-tope	Quantity	Energy Range	Accuracy	Priority	Comments
129	Na	Resonance Parameters	eV - 5 keV		II	Probably satisfied (Paris Conference)
130	Na	Γ_γ	Res. 2.95 keV	10%	I	More work needed (difficult)
247	Mn	Γ_γ	340 eV res.	5% or better.	II	More work needed (difficult).
374	Mo	Γ_n, Γ_γ	700 eV - 10 keV	5%	II	Some data in Antwerp Paper 95.
414	Xe^{131}	$\sigma_{n\gamma}$	Thermal and Γ_γ	5% thermal 10% R.I.	II	Difficult.
419	Cs^{133}	Resonance Parameters	1 eV	10% in resonance integral	II	Straightforward.
455	Dy^{164}	Res. Integral		10%	II	Straightforward.
490	Au	Γ_n, Γ_γ	4,906 eV res.	Better than 1%	II	Difficult.
495	Tl^{204}	Resonance Parameters	1 eV	10% in resonance integrals	III	Some work done at MTR (WASH-1056)
536	Pa^{233}	Γ_n, Γ_γ	Up to 100 eV	10%	II	Possible bomb experiment (see Cinda).
713	U^{238}	Resonance Parameters Γ_n, Γ_γ	2 - 10 keV	10%	I	Satisfied to 4 keV. BNL 325 2nd Suppt. 2nd Ed. Vol. III (1965).

Req. No.	Isotope	Quantity	Energy Range	Accuracy	Priority	Comments
813	Pu^{240}	Γ_n, Γ_γ	50 eV - 10 keV	10% or better	I	Satisfied to few keV by current work at BCMN/AERE/RPI.
814	Pu^{240}	Γ_γ, Γ_n	50 eV - 10 keV	10% or better	I	" " " " " " " "
815	Pu^{240}	Resonance Parameters	100 eV - 5 keV	10%	I	" " " " " " " "

σ_{nA} and σ_{nT}

Req. No.	Isotope	Quantity	Energy Range	Accuracy	Priority	Comments
19	T^3	$\sigma_{nT}(E)$	eV - 300 keV	5%	I	LASL working on this.
32	Li^6	$\sigma_{n,A}(E)$	—> 200 keV	2%	II	See report of sub-committee on standards.
33	Li^6	$\sigma_{n,A}(E)$	0.2 MeV - 1 MeV	5%	II	" " " " " "
71	B^{10}	$\sigma_{n,T}(E)$	1 keV - 40 keV	5%	III	Data available EANDC(UK)85 'S'
72	B^{10}	$\sigma_{n,A}(E)$	—> 200 keV	2%	II	Some data available - EANDC(UK)85'S' See report of sub-committee on standards.
73	B^{10}	$\sigma_{n,A}(E)$	0.2 MeV - 1 MeV	5%	II	See report of sub-committee on standards.
103	O	$\sigma_{nT}(E)$	40 keV - 200 keV	5%	III	Probably satisfied.
113	F	$\sigma_{n,A}(E)$	100 eV - 10 MeV	10%	I	Some data in UNC Report NDA-57-27 (1956).
115	Na	$\sigma_{nT}(E)$	40 keV - 1 MeV	High resolution resonance structure	II	See Proc. Paris Conf. (1966) Moxon and Langsford.
195	Ca	$\sigma_{nT}(E)$	eV - 10 keV	5% in cross section	I	See EANDC(E)66'U'
256	Fe	$\sigma_{nT}(E)$	50 keV - 300 keV	3%	II	Much recent work - see Cinda.
285	Co	$\sigma_{nT}(E)$	132 eV	1%	I	Difficult.

Req. No.	Isotope	Quantity	Energy Range	Accuracy	Priority	Comments
339	Kr^{83}	σ_{nT}	Thermal - 1 keV	50%		No recent data. Straightforward.
349	Zr^{90}	$\sigma_{nT}(E)$	keV - 10 keV	10% in parameters	I	See Paper 67 Antwerp Conference and Cinda.
390	Rh	$\sigma_{nT}(E)$	keV - 1 keV	10%	II	Satisfied.
417	Cs	σ_{nT}	eV - 1 keV	10% in res. integ.	II	Satisfied.
425	Nd^{143}	$\sigma_{nT}(E)$	eV - 1 keV	10% in res. integ.	II	See EANDC(Can)33 'A'
430	Pm^{147}	$\sigma_{nT}(E)$	eV - 1 keV	10% in res. integ.	II	" "
442	Sm^{151}	$\sigma_{nT}(E)$	eV - 1 keV	10% in res. integ.	II	" "
450	Eu^{154}	$\sigma_{nT}(E)$	eV - 1 keV	10%	II	" "
452	Eu^{155}	$\sigma_{nT}(E)$	eV - 1 keV	10%	II	" "
596	U^{234}	$\sigma_{nT}(E)$	Thermal - 1 keV	5% in Γ_n	III	No recent work.
667	U^{236}	$\sigma_{nT}(E)$	Thermal - 1 keV	5% in Γ_n	II	No recent work.
796	Pu^{240}	$\sigma_{nT}(E)$	10 keV - 10 MeV	10% or better	I	Possibly satisfied by BCMN
797	Pu^{240}	$\sigma_{nT}(E)$	10 keV - 10 MeV	10%	I	" " " "