

Splicing EXFOR for the next decades and beyond

J.-Ch. Sublet, N. Otsuka, S. Okumura and V. Zerkin

International Atomic Energy Agency Department of Nuclear Sciences and Applications Nuclear Data Section Nuclear Data Services Unit 1400 Vienna, Austria



https://www-nds.iaea.org/exfor/



- criteria starting with "^" will be used as logical NOT

- wildcards (*) and intervals (..) are available

Statistics of usage: visits: 165, data search: 634, since 25-Jan-2019



EXFOR metrics: 42 quantities ! what was really measured?

- ALF α -value ($\sigma_{capt}/\sigma_{fis}$)
- AMP Length or amplitude
- CHG Fragment charge
- CS Cross section
- CSN Differential with respect to number of particles
- CSP Partial cross section
- CST Temperature dependent cross section
- D3A Triple differential $d\Omega_1/d\Omega_2/dE'$
- D3E Triple differential $d\Omega/dE'_1/dE'_2$
- D4A Quadruple diff. $d\Omega_1/d\Omega_2/dE'_1/dE'_2$
- DA Differential d/dΩ
- DAA Double differential $d\Omega_1/d\Omega_2$
- DAE Double differential $d\Omega/dE'$
- DAP Partial differential d/dΩ
- DAT Temperature-dependent Legendre coefficient
- DE Differential d/dE'
- DEP Energy spectrum for specific group
- DP Diff. by linear momentum of outgoing part.
- DT Diff. by 4-momentum transfer squared
- ETA η -value $\bar{\nu}\sigma_{\rm fis}/(\sigma_{\rm capt}+\sigma_{\rm fis})$
- EVL Evaluation

Special codes in incident energy field

- FastFast reactor spectrum averageFissFission spectrum average
 - Maxw Maxwellian spectrum average Spont Spontaneous (for fission)

- FY Fission product yield
- INT Cross section integral over incident energy
- KE Kinetic energy
- KER Kerma factor
- MLT Multiplicity
- NQ Nuclear quantity
- NU Fission neutron multiplicity $\bar{\nu}$
- NUD Delayed fission neutron multiplicity $\bar{\nu_d}$
- NUF Fragment neutrons
- POL Polarization
- POD Differential polarization
- PY Product yield (other than fission)
- RI Resonance integral
- RP Resonance parameter
- RR Reaction rate
- SIF Self indication
- SPC Gamma spectrum
- TSL Thermal scattering
- TT Thick target yield
- TTD Differential thick target yield, $d/d\Omega$
- TTP Partial thick target yield

Special codes in outgoing particle field

abs	Absorption	fus	Fusion	sct	Scattering	tot	Total
el	Elastic	inel	Inelastic	tcx	Total charge changing		
fis	Fission	non	Nonelastic	ths	Thermal scattering	3	



EXFOR metrics

EXFOR Quantity

#	Code	Quantity	Counts	Percent
1	CS	Cross section data	11495	51.2
2	DAP	Partial differential data with respect to angle	4338	19.3
3	DA	Differential data with respect to angle	4333	19.3
4	RP	Resonance parameters	1996	
5	CSP	Partial cross section data	1923	
6	FY	Fission product yields	1119	4.99
7	POL	Polarization data	1114	4.97
8	DAE	Differential data with respect to angle and energy	1094	4.88
9	MFQ	Fission neutron quantities	529	□ 2.36
10	SP	Gamma spectra	464	□ 2.07
11	RI	Resonance integrals	458	□ 2.04
12	DE	Differential data with respect to energy	383	₪ 1.7
13	TT	Thick target yields	342	II 1.52
14	E	Kinetic energies	338	₪ 1.5
15	L	Scattering amplitudes	222	0.99
16	INT	Cross section integral over incident energy	193	0.86
17	PY	Product yields	176	0.78
18	NQ	Nuclear quantities	112	0.49
19	MLT	Outgoing particle multiplicities	109	0.48
20	RR	Reaction rates	105	0.46
21	TTD	Differential thick target yields	51	0.22
22	CST	Temperature dependent cross section data	40	0.17
23	DEP	Partial differential data with respect to energy	12	0.053
24	SQ	Special quantities	8	0.035
25	COR	Secondary particle correlations	3	0.013
26	TTP	Partial thick target yields	3	0.013





13 centres from 8 countries and 2 international organisations (China, Hungary, India, Japan, Korea, Russia, Ukraine, USA, NEA, IAEA)



Growth of EXFOR's content



As of today more than **22,400 experimental works** have been compiled in EXFOR, corresponding to ten's of billions in investment the World over



EXFOR is always evolving !!

Centre	New entries	Revised entries	Backlog articles
NNDC	49	69	542
NDS 🙂	13	64	26
NEADB	35	62	382
NDPCI 🚨	3	9	63
CJD 📥	2	141	12
CNDC	3	14	53
CDFE	10	58	4
JCPRG •	12	0	172
CNPD	19	87	24
ΑΤΟΜΚΙ	7	11	6
UkrNDC	0	15	39
KNDC 冬	1	0	30
Total	154	530	1353

In average ~400 new entries per years



- NDS regularly scans 77 journals
- NDS also regularly receives reports of journal scanned by NNDC, CNPD (Sarov) and JAEA

Exfor Work	c Flow							_0
raq scan	Query							
Publication PR/C Phys	i ical Reviev	v, Part C, Nuclear I	Comm Ph Vol. 65	ent i (2002) -		Last Volume La 0	ist Issue Last Scan	V
G Issues		YYYY-MM-DD						
Volume	Issue	Published	Covered	Info		Comments		
7 3		01-Mar-2018	01-Apr-2018	V				-
97 2		01-Feb-2018	14-Feb-2018	~				
97 1		01-Jan-2018	02-Feb-2018	V				
6 6		01-Dec-2017	11-Dec-2017	~				
6 5		01-Nov-2017	30-Nov-2017	V				
6 4		01-Oct-2017	31-Oct-2017	~				
96 3		01-Sep-2017	18-Sep-2017	~				
96 2		01-Aug-2017	28-Aug-2017					
96 1		01-Jul-2017	17-Jul-2017	~				
95 6		01-Jun-2017	14-Jun-2017	2				-
Refere	ences					0.11	0 17	
Page		work type	Hiera	rcny	Laboratory	Quality	Quantity	Project
1000000	2 - EXPUR	relevant - experimen	tal 3 - Regular publi	cation	ZGRCATH - NCSR Demokritos, A	1 - table	CS - Cross section	cp - charg
035801	2 - EXFOR	relevant - experimen	tal 3 - Regular publi	cation	ICANTME - Thi University Meson	1 - table	RP - Resonance parameter	cp - charg
M034059	2 - EXFUR	relevant - experimen	tal 3 - Regular publi	cauon	362LUSP - Univ.de Sao Paulo, S	3 - graphic, useful for digitizing	CS - Cross section	cp - charg
- UOD 4C 40	2 - EXPUR	reievant - experimen	tal 3 - Regular publi	cation	IUSALAS - LOS Alamos National L	3 - graphic, usefull for digitizing	CS - Cross section	n - neutro
034618	2. 57500	relevant - everimen				1 - IGUE	C3 - CI 055 SECUOI	III - NEUVO
034618 034615	2 - EXFOR	relevant - experimen	tal 3 - Regular publi	cation	2CED.CEL Cosolledoaft fuer Sch	2 graphic useful for digitizing	DE Differential d/dE'	bi bonu
34618 3034615 3034612 034612	2 - EXFOR 2 - EXFOR	relevant - experimen relevant - experimen	tal 3 - Regular publi tal 3 - Regular publi	cation	2GERGSI - Gesellschaft fuer Sch 2TNDTDM Bhakka Atomia Dan	3 - graphic, useful for digitizing	DE - Differential d/dE`	hi - heavy
034618 034615 034612 034607	2 - EXFOR 2 - EXFOR 2 - EXFOR	relevant - experimen relevant - experimen relevant - experimen	tal 3 - Regular publi tal 3 - Regular publi tal 3 - Regular publi	cation cation	2GERGSI - Gesellschaft fuer Sch 3INDTRM - Bhabha Atomic Res	3 - graphic, usefull for digitizing 3 - graphic, usefull for digitizing graphic, usefull for digitizing	DE - Differential d/dE` DAE - Double differential dAngle/dE` DA Differential d/dangle	hi - heavy hi - heavy
034618 034615 034612 034607 034603	2 - EXFOR 2 - EXFOR 2 - EXFOR 2 - EXFOR	relevant - experimen relevant - experimen relevant - experimen relevant - experimen	tal 3 - Regular publi tal 3 - Regular publi tal 3 - Regular publi tal 3 - Regular publi	cation cation cation	2GRGST - Gesellschaft fuer Sch 3INDTRM - Bhabha Atomic Res 3INDTRM - Bhabha Atomic Res	3 - graphic, usefull for digitizing 3 - graphic, usefull for digitizing 3 - graphic, usefull for digitizing 2 - graphic, usefull for digitizing	DE - Differential d/dE` DAE - Double differential dAngle/dE` DA - Differential d/dAngle DA - Differential d/dAngle	hi - heavy hi - heavy hi - heavy

Internal database for article registration

 Recent comparison between EXFOR and NSR (Nuclear Science References) databases shows that at least 3% of proton, 20% of alpha induced data are still not in EXFOR



Re

قسم البيانات النو

ENDF CINDA IBANDL Medical PGAA NGAtlas RIPL FENDL IRDFF

Articles for EXFOR Compilation (Allocation List)

Send your feedback

Number of inputs and outstanding articles from each centre

roc. published within 5 years.

Centre	ATOMKI	CDFE	CJD	CNDC	CNPD	JCPRG	KNDC	NDPCI	NDS ³	NEADB	NNDC	UKRNDC	Total	TRANS analyz
New entries since last meeting ²	0	5	2	0	0	8	0	0	0	0	5	0	20	3183, 4178, 41
Revised entries since last meeting ²	0	48	141	0	0	0	0	0	2	0	1	0	192	E115, L035, M0
Articles not transmitted yet in EXFOR entries ¹	10	5	13	52	25	156	28	52	21	373	555	27	1317	

 Number of articles excluding conference proceedings published within 5 years. (Conference: Articles registered with conference codes as well as EPJ/CS, JP/CS, NSTP, NSTS, AIP-, JAEA-C-)

2. Number of entries transmitted after preparation of the full summary (WP2017-02) for the last NRDC meeting (2018-04-26). TRANS N2 is consider as the date of the transmission.

3. Including articles for compilation at Almaty and Ulaanbaatar.

	Entry#	1st author	Reference	Published	Centre	Registered Memo	Comment
	22877	V.Semkova+	C,2007NICE,1,559,2007	2007	NEADB	2017-02-09	Requester: R.Capote Entry exists
\checkmark	C1850	R.W.Bauer+	J,NP,56,117,1964	1964	NNDC	2018-03-15	Be(p,n) spectrum
/ ` L	10000		C,2006VANCOU,1,(B057),2006	2006	NNDC	2006-11-20	
	10000		C,2006VANCOU,1,(C033),2006	2006	NNDC	2006-11-20	
	10000	Mukhopadhyay	J,PR/C,78,034317,2008	2008	NNDC	2008-10-06	
	.				م ما ل	A	
eques	τς ότ (compliation	on from EXFOR u	sers or	the	тор	
	10000	Mac Innes	J,NDS,112,3135,2011	2011	NNDC	2011-12-08	
	10000	Krticka	J,JP/CS,337,012012,2012	2012	NNDC	2012-04-03	
	10000		C,2009VARENN,1,217,2010	2010	NNDC	2012-06-28	



EXFOR is a dynamic database !!

All comments are registered in the feedback list and are monitored

ł	ENDF CIN	IDA 🛛	IBANDL	Medic	al F	PGAA	NG	Atlas	RIPL	FEND	L IRC)FF								
	EXFOR Entries for Corrections (Feedback List) Send your feedback																			
				Nu	mb	ber	of	per	ndir	ng c	orre	ecti	ons	fro	m e	ach	ori	igina	ating cent	re
Ľ	Area	1	2	4	^	в	C	D	F	F	ĸ		м	0	D	D	т	Total		
	Centre	NND		S CJD (CNPD	NDS	NND	C NDS	JCPRG	CNPD	JCPRG	NNDC	CDFE	NEADB	NNDC	JCPRG	NNDO	Total	! //	
Ľ	Total	68	134	139	50	2	61	1	114	62	5	3	15	136	3	49	5	847		
	Very urger	nt 3	29	4	20	0	10	0	74	48	0	1	1	16	2	6	1	215		
i.	Urgent	13	52	8	10	2	27	0	24	0	3	0	4	104	0	40	3	290		
L	Normal	52	53	127	20	0	24	1	16	14	2	2	10	16	1	3	1	342	;	
	Entry #		From		Ke	ywo	rd	Comm	ent										Reference	Registered
	11125.0	01	N.Otsuka	а	AUT	HOR		Blanks	are no	t permi	tted fo	llowing	initial	s (W. BA	ARTOLI	NI)			N/A	2018-05-22
	11596.0	01	N.Otsuka	а	FAC	ILITY		Add (Ri	EAC,1U	JSAANL	.) (c.f. 9	Sect.I o	of J,PR	,91,142	3,1953	;)			N/A	2014-09-01
	11735.0	01	N.Otsuka	а —	AUT	HOR		Blanks	are no	t permi	tted fo	llowing	initial	s (R.C. E	BLOCK)			N/A	2018-05-22
	11817.0	20	N.Otsuka	a	DEC	CAY-D	ATA	M2->M	1										CP-D/888	2015-11-19
	11958.0	01	N.Otsuka	а	REF	EREN	CE	page: 1	1272 -:	> 1272	(1)								N/A	2018-01-02
	11961.0	06	N.Otsuka	а	DEC	CAY-D	ATA	Give in	free te	ext. 400) day is	a lowe	er boui	ndary of	T1/2.				CP-D/888	2015-11-19
	11990.0	01	N.Otsuka	а	AUT	HOR		Use cor	mma ir	stead (of "and	(AND	R.D.W	ERNER)				N/A	2017-04-12



Fast track entry, this could be your data

LETTER

2019 from Nature (already 17 entries)

https://doi.org/10.1038/s41586-018-0838-z



The surprisingly large neutron capture cross-section of ⁸⁸Zr

Jennifer A. Shusterman^{1,2,3}*, Nicholas D. Scielzo¹, Keenan J. Thomas¹, Eric B. Norman⁴, Suzanne E. Lapi⁵, C. Shaun Loveless⁵, Nickie J. Peters⁶, J. David Robertson⁶, Dawn A. Shaughnessy¹ & Anton P. Tonchev¹



- 88 Zr T_{1/2} = 83.4 d
- σ_{th}= 861,000 +/- 69,000
 barns
- Fortunately not produced in the Zircalloy of the World's PWRs



 During NRDC 2018 it has been decided that Nucl. Data Sheets 120(2014)272 should be used as the EXFOR citation



Towards a More Complete and Accurate Experimental Nuclear Reaction Data Library (EXFOR): International Collaboration Between Nuclear Reaction Data Centres (NRDC)

N. Otuka,^{1, *} E. Dupont,² V. Semkova,¹ B. Pritychenko,³ A.I. Blokhin,⁴ M. Aikawa,⁵ S. Babykina,⁶ M. Bossant,² G. Chen,⁷ S. Dunaeva,⁸ R.A. Forrest,¹ T. Fukahori,⁹ N. Furutachi,⁵ S. Ganesan,¹⁰ Z. Ge,⁷ O.O. Gritzay,¹¹ M. Herman,³ S. Hlavač,¹² K. Katō,⁵ B. Lalremruata,¹³ Y.O. Lee,¹⁴ A. Makinaga,⁵ K. Matsumoto,² M. Mikhaylyukova,⁴ G. Pikulina,⁸ V.G. Pronyaev,⁴ A. Saxena,¹⁰ O. Schwerer,¹⁵ S.P. Simakov,¹ N. Soppera,² R. Suzuki,⁵ S. Takács,¹⁶ X. Tao,⁷ S. Taova,⁸ F. Tárkányi,¹⁶ V.V. Varlamov,¹⁷ J. Wang,⁷ S.C. Yang,¹⁴ V. Zerkin,¹ and Y. Zhuang⁷ ¹Nuclear Data Section (NDS), International Atomic Energy Agency, A-1400 Vienna, Austria ²OECD Nuclear Energy Agency Data Bank (NEA DB), F-92130 Issy-les-Moulineaux, France ³National Nuclear Data Center (NNDC), Brookhaven National Laboratory, Upton, NY 11973, USA ⁴Nuclear Data Centre (CJD), Institute for Physics and Power Engineering, 249033 Obninsk, Russia ⁵Nuclear Reaction Data Centre (JCPRG), Hokkaido University, Sapporo 060-0810, Japan ⁶Centre for Nuclear Structure and Reaction Data (CAJaD), Kurchatov Institute, 123182 Moscow, Russia ⁷China Nuclear Data Centre (CNDC), China Institute of Atomic Energy, Beijing 102413, China ⁸Centre of Nuclear Physics Data (CNPD), All-Russian Research Institute of Experimental Physics (VNIIEF), 607190 Sarov, Russia ⁹Nuclear Data Center, Japan Atomic Energy Agency (JAEA), Tokai-mura, Naka-gun, Ibaraki 319-1195, Japan ¹⁰Bhabha Atomic Research Centre, Mumbai 400085, India ¹¹Ukrainian Nuclear Data Centre (UkrNDC), Institute for Nuclear Research, 03680 Kiev, Ukraine ¹²Department of Nuclear Physics, Institute of Physics, Slovak Academy of Sciences, 845 11 Bratislava, Slovakia ¹³Department of Physics, Mizoram University, Aizawl 796004, India ¹⁴Korea Nuclear Data Center (KNDC), Korea Atomic Energy Research Institute, Daejeon 305-600, Republic of Korea ¹⁵Under contract with the National Nuclear Data Center, Brookhaven National Laboratory, Upton, NY 11973, USA ¹⁶Cyclotron Application Department, Institute of Nuclear Research (ATOMKI), H-4001 Debrecen, Hungary ¹⁷Centre for Photonuclear Experiments Data (CDFE). Institute of Nuclear Physics, Moscow State University, 119234 Moscow, Russia



EXFOR Web Database & Tools Paper: <u>NIM A 888 (2018) 31</u>.

Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment Volume 888, 21 April 2018, Pages 31-43

The experimental nuclear reaction data (EXFOR): Extended computer database and Web retrieval system

V.V. Zerkin^a, B. Pritychenko^b [∧] ⊠



• Reference list (Bibliographic) in Robert William Mills' Ph.D. thesis and England-Rider's evaluation.

	Mills' list	In EXFOR
Data 1	498	361
2	16	8
3	69	30
4	56	19

Number of Bibliographic in Robert William Mills' Ph.D. thesis

- Most of the missing data is from old issues of two journals (written in Russian and German), some conference proceedings, and master or others Ph.D. thesis.
- Compilations need to be done while a CRP on FPY is running
 - 1. Completeness check and statistical analysis by NDS
 - 2. Assemblage of missing entries by NDS
 - 3. Compilation by NRDC
- Fission cross-sections are well known, but what about the fission observables?



A culprit, GEFY-5 Pu239





U235 FY's uncertainty @ 0.0253 eV





Global picture shows method changes





FPY Plotting ENDF vs. EXFOR data -under development-



Charge particles ; INCL++ and ABLA.



IAEA



EXFOR serves different scientific communities, the World over and those are traditionally involved in:

- Physics models
 - Allows to pin down the physics at play
- Nuclear data evaluation
 - Allows to shape the different data forms
- Verification and Validation of codes
 - Allows to constrain the simulations



Multi-scales modelling: material sciences



Traditionally different disciplines focus on different length scales. Multiscale modelling of materials across the length scales requires overcoming the borders between the disciplines for a seamless integration of the models on different length scales into one coherent multi-scale modelling framework (After D. Pettifor, 1991).



- Increases charges particles entries
- Completes/corrects the neutron entries
- Fills up the fission yields and observables entries
- Search for new ways to:
 - Better exploit the data
 - Deploys, pushes some of its metrics further
 - Develops analytics
 - Serves a broader community



EXFOR future, modernisation, deployment?

Help > Manual PDF Lexfor NNDC-Help Output Piot+ R3 Database NNDC	es NDF CINDA IBANDL CD-ROM N Car Reaction Data (EXF Version of 2018-12-07 Ware Version of 2018-07-11 imental nuclear reaction data. Neutron reactic ed particle and photon reactions have been co- periments (see statistics and recent database Nucl. Data Sheets 120(2014)272 apper. NIM A 888 (2018) 31. Mirror-sites ±	
Examples of requests: :]:]:]:]:]:]:]: 1 Cross section o(E) /updates/ More examples I Cross section o(E) /updates/ More examples Request Submit Target ♥ Dy-164 Reaction ♥ D-16,a Quantity ♥ Product Energy from to Publication year Jast modified	Go to: [upload your data] Options Exclude superseded data No reaction combinations (ratios) Exclude evaluated data Enhanced search of Products Retrieve listing only Disable Prompt-Help Sort by: © reaction _ publication Reaction-Accession# View: basic © extended Xeances (Z,A) Reaction Sub-Fields 1	Single form (with a clever interpreter)
Last modified ?? Accession # ?? Extended quantity ?? 1-st Author ?? Area ?? Country ??	SF1 ? Target SF2 ? Incident F SF3 ? Product SF4 ? Product SF5 ? Branch SF6 ? Paramete SF7 ? 2 SF6 ? Paramete	●IAEA Nuclear Data Services - Mozilla Firefox ファイル(F) 編集(E) 表示(V) 履歴(S) ブックマーク(B) ツール(T) ヘルブ(H) ● ● ● ● ● ● ● ● ● ● ● ● ● ● ● ● ● ● ●
Compilation date 2 Short Reference 2 DOI 0 NSR-KeyNo 2 Full Reference 2 Title 2 Keywords Expert 8 Submit Reset	SF8 Data Cod SF58 Data Cod Quantity 1 SF9 Cone Request: CINDA ENDF More Web Tools	Exfor IAEA NDS
Many input forms (Relational database or	iented design)	Dy-164 & O-16 & alpha & gamma & multiplicity Search



Dy-164 & O-16 & alpha & gamma & multiplicity



Experimental Nuclear Reaction Data (EXFOR)

Database Version of 2019-01-22

E Software Version of 2019-01-30
 ■



The EXFOR library contains an extensive compilation of experimental nuclear reaction data. Neutron reactions have been compiled systematically since the discovery of the neutron, while charged particle and photon reactions have been covered less extensively. EXFOR Reference Paper: Nucl. Data Sheets 120(2014)272.

EXFOR Web database retrieval system provides: data search, output to various formats (incl.XML), plotting and comparison to ENDF, re-normalization old data to new standards, calculating data for inverse reactions and inverse kinematics, constructing correlation matrices from partial uncertainties, etc. EXFOR Web Database & Tools Paper: NIM A 888 (2018) 31. The EXFOR database contains data from 22410 experiments (see statistics and recent database updates). Mirror-sites =

				 	& alpha & gamma & mul	tiplicity Go ?	t
				S	ort by: 💿 Year 🔿 Author 🔾	Entry	
				View	w: 🗹 extended 🛛 Page: 20	Entries	
					Text search help is [here].		
					[rinde] options. [Reset] form.	-	
←	\rightarrow	С	企	https://www-nds.iaea.org/exfor/servlet/X4sSearch5			

Request #379

Access-Level=2 /pdf/ Text search Dy-164&O-16&alpha&gamma&multiplicity Found EXFOR Entries: 1 List: [full] [compact] Page: 1.

1) 2009, Y.K.Gupta+, Jour: Physical Review, Part C, Nuclear Physics, Vol.80, p.054611 (2009). ENTRY #C1772: [E] [R] [x4+] REACTION: (66-DY-164 (8-0-16, X) 2-HE-4, , DA/DE, , MSC) REACTION: (66-DY-164 (8-0-16, X) 2-HE-4, , DA/DE, , MSC)

DETECTOR: (TELES, SIBAR, SIBAR) The alpha particles emitted in

detector: (BGO) Gamma-ray multiplicity setup consisting of 14

detector: (BGO) Gamma-ray multiplicity setup consisting of 14

Subent:21 Pnt:393 Ene=77-86MeV An=125-153° Target:Dy-164;Ta-181 Reaction:(c-12,x);(o-16,x)

 [pdf]+ Jour: Physical Review, Part C, Nuclear Physics, Vol.80, p.054611 (2009) DOI: 10.1103/PhysRevC.80.054611 NSR: 2009GU30 [pdf] Nuclear level-density parameters of nuclei in the Z ≈ 70 and A ≈ 180 mid-shell regions Y.K.Gupta, D.C.Biswas, B.John, B.K.Nayak, A.Saxena, R.K.Choudhury

Select Entries on the Page: [all] [none] Go to EXFOR [Request] with selected Entries (0):