

Contents

Preface	i
Acknowledgement	iii
List of Publications	v
List of Figures	xiv
List of Tables	xviii
1. Introduction	1
1.1 Importance of the present work	2
1.2 Basic concept of Neutron-induced reaction	5
1.2.1 Neutron-induced fission reaction	6
1.2.1.1 Fission Barrier	7
1.2.1.2 Brief overview of Fission Theory	7
1.2.1.3 Types of Fission Yields	11
1.2.2 Neutron Activation method – A tool for Neutron Cross-section Measurement	14
1.2.2.1 Principle of Neutron Activation Analysis	14
1.2.2.2 Kinetics of activation	14
1.2.2.3 Advantages and Limitations of NAA	15
1.2.3 Role of Structural materials in reactor technology	16
1.3 Various types of neutron sources	16
1.3.1 Neutrons from uranium fission - Nuclear Reactors	16
1.3.2 Radioactive (α , n) sources	17
1.3.3 Accelerated charged particle based neutron sources	18
1.3.4 Photo-neutron sources	19

1.4 Solid State Nuclear Track Detector (SSNTD)	19
1.4.1 An application of solid state nuclear track detector in nuclear fission	20
1.5 A detailed literature survey related to the present work	21
1.6 Objective of the present thesis	23
1.7 Content of the present thesis	24
References	26
2. Brief description of Advanced Heavy Water Reactor and Accelerator	
Driven Subcritical Systems	30
2.1 Introduction	31
2.2 AHWR – The thorium fuelled Indian nuclear reactor	32
2.2.1 Evaluation of the AHWR	32
2.2.2 Brief description of AHWR configuration	33
2.2.3 Fuel for AHWR	35
2.3 ADS – A new concept for nuclear waste transmutation and nuclear energy generation	36
2.3.1 The major subsystems of ADS	36
2.3.2 ADS as an “Incinerator”	40
2.4 Summary and Conclusion	41
References	42
3. Fission products yield in the neutron-induced fission of ^{232}Th with average energies of 5.42 MeV, 7.75 MeV and 10.09 MeV	43
3.1 Introduction	44
3.2 Preparation of Lithium Target by Rolling Technique	45
3.3 Experimental method	47

3.4 Analysis of Experimental Data	49
3.4.1 Calculation of the neutron energy	49
3.4.2 Calculation of the fission yields	50
3.5 Results and Discussions	50
3.6 Summary and Conclusions	57
References	58
4. Measurement of $^{232}\text{Th}(n, \gamma)^{233}\text{Th}$ and $^{232}\text{Th}(n, 2n)^{231}\text{Th}$ reaction cross-sections using activation technique	60
4.1 Introduction	61
4.2 Six meter irradiation set-up at BARC-TIFR Pelletron Facility	64
4.2.1 Neutron Irradiation	66
4.3 Experimental Details	66
4.4 Analysis of Experimental Data	73
4.4.1 Calculation of the neutron energy	73
4.4.2 Calculation of the neutron flux	83
4.4.3 Determination of $^{232}\text{Th}(n, \gamma)^{233}\text{Th}$ and $^{232}\text{Th}(n, 2n)^{231}\text{Th}$ reaction cross-sections	85
4.5 Theoretical calculations of $^{232}\text{Th}(n, \gamma)^{233}\text{Th}$ and $^{232}\text{Th}(n, 2n)^{231}\text{Th}$ reaction cross-sections using nuclear model based computer code Talys 1.2	91
4.5.1 Nuclear Model based TALYS Code	91
4.5.2 Optical model potential	92

4.5.3 Pre-equilibrium reactions	93
4.5.4 Level densities	94
4.6 Result and Discussions	95
4.7 Summary and Conclusions	99
References	101
5. Determination of $^{233}\text{Pa}(2n_{\text{th}}, f)$ cross-section using a fission track technique	106
5.1 Introduction	107
5.2 India's first Nuclear reactor – APSARA	109
5.3 Experimental Details and Calculations	110
5.3.1 Radiochemical separation of ^{233}Pa from irradiated Thorium Nitrate (e.g. $(\text{Th}(\text{NO}_3)_4 \cdot 4\text{H}_2\text{O})$)	110
5.3.2 ^{233}Pa sample preparation	115
5.3.3 Calculations	115
5.4 Results and Discussion	119
5.5 Summary and Conclusion	123
References	124
6. Neutron induced reaction cross-section measurements for Zr isotopes	126
6.1 Introduction	127
6.2 Experimental Method	129
6.2.1 Thermal neutron activation cross-section measurements of $^{94}\text{Zr}(n,\gamma)^{95}\text{Zr}$ and $^{96}\text{Zr}(n,\gamma)^{97}\text{Zr}$ at APSARA reactor, B.A.R.C	129

6.2.2 Measurement of $^{94}\text{Zr}(n,\gamma)^{95}\text{Zr}$ reaction cross-section at $E_n=2.45$ MeV, Purnima Neutron Generator, B.A.R.C	131
6.2.3 Measurement of $^{90}\text{Zr}(n,p)^{90}\text{Y}^m$ reaction cross-section at average $E_n=9.85 \pm 0.38$ MeV, T.I.F.R-B.A.R.C Pelletron Facility	133
6.3 Calculations	135
6.3.1 Calculations of neutron flux	135
6.3.2 Calculations of neutron cross-section	137
6.4 Result and Discussions	139
6.5 Summary and Conclusions	142
References	143
7. The Indian Experimental Nuclear Physics data compilation into IAEA-EXFOR database	145
7.1 Introduction	146
7.2 What is EXFOR?	148
7.3 Structure of the EXFOR-Exchange Format	149
7.3.1 Structure of an EXFOR file and Definition of Subentry	149
7.3.2 Identification Files, Entries and Subentries	150
7.4 Quantities in EXFOR and EXFOR retrieval (WWW/ZVView)	152
7.5 List of newly created EXFOR entry for the Indian experimentally measured Nuclear Physics data into IAEA-EXFOR database, NDS, IAEA	154
7.5.1 Exfor entries related to the present work	156

7.6 Summary and Conclusions	170
References	171
8. Summary and Conclusions	173