P R O L O G U E

"There is no higher or lower knowledge, but one only, flowing out of experimentation."

Leonardo da Vinci

In this thesis we present an experimental measurement of the total (p,n) reaction cross section for nuclei and two-fold exploitation of the experimental data to study the isobaric analogue resonances and the proton-nucleus optical model potential at low energies. The experiments were performed using the 5.5 MeV Van de Graaff accelerator at Bhabha Atomic Research Centre, Trombay (Bombay). At the energies available from this accelerator, nuclear reactions proceed primarily via the formation of a compound nucleus. This compound nucleus is in a highly excited state and for proton bombarding energies above the (p,n) threshold, neutron decay of the compound nucleus is the predominant mode of de-excitation, other channels having almost negligible contribution. This is true in particular for incident proton energies below the Coulomb barrier. In such a situation THE total (p,n) cross section is approximately equal to the compound nucleus formation cross section, which can be predicted by the optical model.

The measurement of total (p,n) cross section as a function of energy at finer energy interval serves two purposes - (i) If the energy interval is much less compared to the average widths of compound nuclear resonances, the resulting fine structure excitation function will show resonances representing states in the compound nucleus at high excitation which are isobaric analogues of the low-lying bound levels of the target plus neutron system. These resonances can be studied in detail to test the single particle purity of the compound nuclear states and the validity of the isospin quantum number. (ii) The fine structure excitation function can also be suitably averaged to smoothen out the compound nuclear fluctuations and the resulting structureless excitation function can be analysed to provide information on the proton-nucleus optical model potential at sub-Coulomb energies.

We have measured the (p,n) excitation functions on ^{55}Mn and ^{80}Se. (p,n) reactions on these two targets have not been studied in detail earlier. In the fine structure excitation functions measured at an energy interval of 5 keV, many isobaric analogue resonances, known earlier as well as several new ones, have been observed. These resonances have been studied in detail at smaller energy intervals and their shapes have been analysed to deduce the spectroscopic factors. The results have been compared with other measurements of elastic scattering and stripping reactions. This comparison clearly indicates the superiority of (p,n) studies as a spectroscopic tool over elastic scattering at sub-Coulomb energies.

In several investigations over the last decade, proton optical model potential at sub-Coulomb energies has shown certain features which appear to be anomalous when compared with the systematic trends of the potential at higher energies. The earlier investigations have been inadequate in not having fully recognized the importance of Coulomb correction and the energy dependence at lower incident energies. We have emphasized and undertaken a systematic study of the proton optical model potential at low energies by analysing the (p,n) excitation functions for forty five nuclei in the mass region A = 40 - 140 using our own experimental data and others taken from literature. Our results indicate that the contribution of the Coulomb correction to both the real and imaginary potential is much more significant at lower energies than hitherto believed. We have derived a global set of optical model parameters for protons which is found to be applicable over a wide mass range above A ~ 40 and upto energies several MeV above the Coulomb barrier. This global set is, therefore, expected to be complemetary to the ones available in literature for energies higher than 10 MeV.

A major portion of the material contained in this thesis is the elucidation of the work reported in the following publications :

1. "Study of the Reaction ^{55}Mn (p,n)^{55}Fe from E_p= 1.35 MeV to 5.4 MeV", S. Kailas, Y. P. Viyogi, S. S. Saini, S. K. Gupta, N. K. Ganguly, M. K. Mehta, A. Banerjee and S. S. Kerekatte, Nucl. Phys. and Solid State Physics (India) 17B , 78 (1974)

2. "Study of Isobaric Analogue Reasonances in the Reaction ^{55}Mn (p,n)^{55}Fe at E_p = 1.54 MeV", S. Kailas, Y. P. Viyogi, P. Satyamurthy, S.Saini, N. K. Ganguly and M. K. Mehta, Nucl. Phys. and Solid State Phys. (India) 18B , 8 (1975)

3. "Isobaric Analogue Resonances in ^{80}Se (p,n)^{80}Br Reaction", Y. P. Viyogi, S. Kailas, S. Saini, M. K. Mehta, N. K. Ganguly, N. Veerbahu and T. K. Bhattacharya, Nucl. Phys. and Solid State Phys. (India) 19B, 36 (1976)

4. "Reaction ^{55}Mn (p,n)^{55}Fe from E_p= 1.35 to 5.42 MeV", Y. P. Viyogi, P. Satyamurthy, N. K. Ganguly, S. Kailas, S. Saini and M. K. Mehta, Phys. Rev. C18 , 1178 (1978)

5. "Isobaric Analogue Resonances in the ^{80}Se (p,n)^{80}Br Reaction", S. Kailas, S. Saini, M. K. Mehta, N. Veerbahu, Y. P. Viyogi and N. K. Ganguly, Nucl. Phys. A315 , 157 (1979)

6. "Proton Optical Model Potential at sub-Coulomb Energies for Medium Weight Nuclei", S. Kailas, M. K. Mehta, S. K. Gupta, Y. P. Viyogi and N. K. Ganguly, Phys. Rev. C20 , 1272 (1979)

7. "Imaginary Part of the Proton Optical Model Potential at sub-Coulomb Energies near A = 100", Y. P. Viyogi, N. K. Ganguly, S. Kailas, S. K. Gupta and M. K. Mehta, Silver Jubilee Phys. Symp. (India) 24B , 7 (1981)

Some of the results presented in Chapter 4 are also under preparation for publication.

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