INTERNATIONAL NUCLEAR DATA COMMITTEE

Report on Australian Activities May 1968-May 1969

1. Data for A.A.E.C. Master Library Tape

CINDA has been used both by experimental and theoretical teams for tracking down useful information to be used in the analysis of experiments and theories. Requests to the Nuclear Data Unit for cross section information has been met as promptly as the available data files can be provided and the data is transmitted from other centres. In particular, inelastic scattering data has been used in evaluation of theoretical methods for providing data.

2. Evaluation of Nuclear Data

(a) Elastic and Inelastic Neutron Scattering Cross Sections

A computer code is being developed for the purpose of evaluating elastic and inelastic scattering cross sections, the basic constituents of the program being:

1. an optical model code which calculates elastic scattering cross sections and transmission coefficients. The optical potentials used are the non-local optical potentials of Perey and Buck, and include spin-orbit interactions;

2. a Hauser-Feshbach inelastic scattering code which will handle scattering to the continuum of highly excited levels as well as to the discrete lower levels.

Data prepared with this code are to be stored in the GYMEA nuclear data library which is being developed as a controllable interface between basic nuclear data (master library tape) and reactor physics codes in normal use. Apart from the evaluation work involved in this use of it, it will be used to examine systematically the effect of spin-orbit interactions on inelastic scattering, and the effect of non-local (or energy dependent) potentials on Hauser-Feshbach calculations.

(b) Statistical Studies of Neutron Resonance Parameters

A new and direct method for calculating the probability of missing levels in neutron spectroscopy was developed, using the Breit-Wigner resonance profile between adjacent levels to give the missing probability directly as a function of D/Γ.

Statistical estimation of unknown thermal neutron cross sections was attempted. For practical purposes it was found that the cross section for neutron capture is determined by the contribution of the first level only but when the position of this level is unknown, the extreme

variances expected do not allow a good estimate to be made. However, it is at least possible to provide an upper bound (Musgrove, A.R. de L. (1968) - Aust. J. Phys. 22, 657).

The error in estimating the average level spacing is currently being investigated for even-A and odd-A nuclei. The two cases show considerable differences and the error is generally larger than the probable errors usually quoted.

All available data for the radiative capture cross sections in the keV energy region have been parametrically fitted. Using interpolated values for the p-wave and d-wave neutron strength functions, calculations of the cross sections of nuclei not yet studied have been made. This estimated data for radiative capture cross sections is to be transmitted to the Nuclear Data Unit (Report in preparation).

3. Measurement Programme

(a) Nubar versus E_n for U235

A detailed study of the variation of nubar for U235 with neutron energy has shown a definite linear relationship with energy given by

$$(2.412 \pm 0.007) + (0.112 \pm 0.014)E_n$$

relative to nubar for Cf252, taken as 3.782. Between 0 - 2 MeV, a good linear fit has been obtained to data collected taken together from the following groups: A.A.E.C.; Hopkins and Diven (1963); Meadows and Whalen (1962); Butler (1961); Mather, Moat and Fieldhouse (1964); Prokhorova et al; and Blyumkina et al. The possible disagreements with the above deduction are:

(a) Nubar data from Meadows and Whalen (1965)
(b) Indirect evidence from Blyumkina et al - measurements of average total kinetic energy versus incident neutron energy.
(c) Several values from Colvin and Sowerby.

It should be noted that the two data points from Blyumkina et al which disagree with a straight line fit are

E_n	$\Delta\bar{E}_k$
220 keV	-0.51 ± 0.22 MeV
375 keV	-0.71 ± 0.33 MeV

From consideration of conservation of energy, it has been suggested that the values for nubar at these two energies are high. There is some mild support for the 220 keV point from other sources but none for the 375 keV point. It is interesting to note that Meadows and Whalen (1965), the only group reporting significant departures from linear dependence, obtain a minimum in nubar at 375 keV. From the latest accurate measurement of $\Delta\bar{E}_k$ versus E_n made at the A.A.E.C., no structure whatsoever can be seen. The accuracy of all points is such that all values of $\Delta\bar{E}_k$ are determined to better than 0.20 MeV.

(b) Neutron Capture Gamma Ray Studies

Measurements of keV neutron capture gamma ray spectra have now been completed for all elements from calcium to zinc. In this mass region, there are many commonly used materials for which nuclear effects such as closed shells and strength function peaks are particularly important. Nuclei with even atomic number in this region usually have a neutron resonance spacing sufficiently large to allow observation of individual resonances. The closer spacing for odd atomic number nuclei usually results in the measurement of averaged resonance capture information. Nevertheless, some structure can be observed in the neutron time-of-flight spectra even with close resonance spacings (1.5 keV) and there are associated changes in the gamma ray spectra.

The interesting feature of the keV neutron capture gamma ray spectra is that the spectra resemble those for thermal neutron capture but additional gamma rays may be observed and intensities differ. Contributions from d-wave resonances are indicated, sometimes higher than expected and these effects are being closely examined for information on the behaviour of d-wave strength functions.

Consideration is being given to the production of an A.A.E.C. report covering all the Ge(Li) data on keV neutron capture gamma ray spectra measured by Allen, Bird and Kenny. A combined compilation for keV capture covering about one third of the elements would be possible and is being canvassed. Practically all keV capture spectra work has been devoted to resonance studies whereas thermal neutron capture studies have usually involved other aspects of nuclear structure. While the actual details of capture spectra are not needed in the same sense as are resonance parameters and cross sections, it would seem reasonable that neutron data centres should take account of cross sections and resonance parameters which may be derived from capture spectra studies. The most appropriate place for details of the spectra (transition rates, etc.) is in compilations of nuclear levels (particularly 'Nuclear Data', for example).

Data from the University of Melbourne bright line scattering measurements on U233 and the capture gamma width of the 132 eV resonance of cobalt are complete and are being prepared for publication.