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THEORETICAL PROGRESS AT CNDC THEORY GROUP

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In 1992, CNDC theory group made progress in model study, code making and data calculations for low energy nuclear reaction, intermediate and high energy nuclear reaction. It also made progress in parameter library establishment. The following are the brief explanations.

I LOW ENERGY NUCLEAR REACTION

1 UNF code has been developed by combining the Hauser–Feshbach theory and Exciton Model. This code can be used for the calculations of double differential cross sections of neutron induced reactions below 20 MeV. In the code, the parity conservation and angular momentum conservation are taken into account in the exciton model, the pick–up mechanism for composite parti-

cle emissions and the recoil–nucleus effect are also taken into account. The discrete level effect in multi–particle emissions was included either.

2 By operating UNF code, (n,t) cross sections are calculated and fit the experimental data pretty well. UNF code is also used to calculate the double differential cross sections of α particle emission. The calculation is carried out for reaction $^{56}Fe(n,x\alpha)$ with incident neutron energy E_n = 14.5 MeV at θ = 30°, 45°, 90° and 135°. The calculations fit the experimental data nicely.

3 Based on MUP–2 code, MUP–3 code has been worked out. In MUP–3 the two time pre–equilibrium emissions, the refraction effect of incident particle on the nuclear surface are taken into account. This code not only can calculate data files 3, 4, 5, i. e, cross section, angle distribution and spectrum, but also can calculate data file 6, i. e, the nucleon double differential cross sections.

4 The direct inelastic scattering cross sections and angular distributions for the first excitation states of ^{56}Fe and ^{238}U at incident neutron energies 14.0 MeV and 20.0 MeV were calculated by coupled–channel optical model (CCOM) and DWBA method. The calculations show that the DWBA method is suitable for ^{56}Fe and the CCOM is suitable for ^{238}U. The inelastic scattering data calculated by DWBA method are always larger than those by coupled–channel theory, but the difference decreases as incident neutron energy increases.

5 In order to estimate the non–uniform effect of the single particle level density on particle–hole state density, a comparison is made by using the single particle level densities of harmonic oscillator potential and Fermi gas model. It is found that the non–uniform effect is stronger at low exciton states than at high exciton states. The calculations also show that the commonly used equidistant spacing model is a good approximation.

II INTERMEDIATE AND HIGH ENERGY REACTION

6 Cross sections for p+^{241}Am reaction in 5.5~35 MeV energy region were calculated by CFUP1 code. Calculations for (p,F) and (p,2n) channels agree well with the experimental data between 8 MeV and 16 MeV. The calculations show that the nonelastic cross sections are mainly contributed from the fission cross section. When incident energy is larger than 15 MeV, the (p,pf) cross section has evident contribution. When incident energy is less than 20 MeV, neutrons are

the main emitted particles and when the incident energy is larger than 20 MeV, the light charged particle emission is important.

7 Using microscopic optical potential (MOP) with Skyrme force parameter, the excitation functions for p+^{89}Y reaction in $E<40$ MeV energy region are calculated. The comparisons with calculations of phenomenological optical potentials and with experimental data show that MOP is suitable for calculations of excitation function in proton induced reactions.

8 Based on Walecka's model and thermo field dynamics (TFD), the temperature dependent relativistic microscopic optical potential for nuclear matter is obtained in which the polarization and correlation contributions is taken into account. The Schrodinger equivalent potential and mean free path for nuclear matter are also obtained. With local density approximation, the same quantities are obtained for finite nuclei. The results are reasonable for single particle energies between $\approx$ 40 MeV and 1000 MeV relative to the Fermi energy.

9 Based on the available experimental data of ^{63}Cu and its neighbor nuclides ^{62}Ni and ^{64}Zn, a set of proton optical potential parameters for $E_p<55$ MeV is obtained. Through adjusting neutron and other charged particle optical potential, level density parameters as well as exciton model parameter K, all cross sections for reaction p + ^{63}Cu are obtained in energy region 3~55 MeV. The calculations agree well with experimental data for reactions (p,p'), (p,n), (p,3n) and (p,np+d), but for reactions (p,2n) and (p,2nd+p3n+nt) further study is needed.

10 In order to generalize the exciton model to high energy nucleon–nucleus scattering, an empirical formula of relativistic exciton transition rate is given by taking account of the relativistic effect. This formula is suitable for atomic number from 40 to 252 and for incident nucleon energy from 40 to 1040 MeV.

11 An attempt of applying QNCD (quantum nucleon cluster dynamics) or QMD (quantum molecular dynamics) to calculate nuclear data for intermediate and high energy is undertaking. It can be expected that the nucleons or light particles are released from the highly excited nucleus during its time–space evolution. A code has been made based on QNCD and applied to study the thermalization in 830 MeV p+Fe reaction. It is found that the thermalization is reached in a tube–like volume along incident direction, i. e, a local thermalization rather the thermalization of the whole nucleus.

III PARAMETER LIBRARY ESTABLISHMENT

12 For the practical and convenient use, the Chinese Evaluated Nuclear Parameter Library (CENPL) is under established, CENPL contains six sub–libraries, each of them consists of two parts, the data files and the management–retrieval code system. The data files store evaluated basic nuclear constants and model parameters. The management–retrieval codes are used to retrieve relative information of parameters.

The six sub–libraries are

(1) Atomic masses and characteristic constants for nuclear ground state (MCC). So far the atomic masses of 4760 nuclides, half–lives or abundances, spin and parities for nuclear ground state have been put into the data file and the retrieval code for single nucleus (SN) is made out.

(2) Discrete level schemes and branch ratio of γ decay (DLD).

(3) Level density parameters (LDL). The data file which contains relative experimental data (LRD) and level density parameters (LDP) is made out. Its retrieval code for SN has been set up.

(4) Giant dipole resonance parameters for γ–ray strength function (GDR). At present, experimental data of 102 nuclides have been put in the data file and the management–retrieval code system is established.

(5) Fission barrier parameters (FBP). The data file, including the parameters recommended by Lynn, Back–Britt and Ohsawa, and the management–retrieval code system have been set up.

(6) Optical model parameters (OMP).

IV OTHERS

13 Besides the influence of nuclear deformation fluctuation on particle emission has been studied, the influence of temperature at each local equilibrium stage with exciton number n on the particle emission is also studied. It is found that the temperature of the thermal bath provided by different local equilibrium stage of exciton number n taking as a constant as $kT = (E/a)^{1/2}$ is just reasonable and suitable.

14 To explain the double–slope behavior of $\ln\langle Fi\rangle \sim -\ln\delta y$ drawings in particle production in high energy hadronic interactions and heavy ion collisions, the weighted distribution in particle production is proposed. The second slope is due to the random cascade process, while the first one is mainly due to the unflat of the average distribution.