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学位論文題目	Microscopic evaluation of widths in preequilibrium reactions. (前平衡反応における幅の微視的評価)
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論 文 内 容 要 旨

Many models have been proposed for explaining the preequilibrium spectra in nuclear reactions. Feshbach et.al. [1] (FKK) have distinguished between the statistical multistep compound emission (SMCE) mechanism and the multistep direct reaction mechanism. This paper deals with the SMCE mechanism only. Bonetti et al. [2] have pointed out some of the drawbacks in the FKK calculations and have made some improvements. However, the exction state density for a single type of fermion was used in both calcutions (no distinction was made between proton and neutrons). Some authors have done calculations using the exciton state density in which protons and neutrons are distinguished. But these involve complicated numerical calculations. Akkermans et al. have proposed a renormalized exciton state density such that the summed state density is that for a two component fermi gas. We have evaluated the preequilibrium spectra using this renormalized state density and have dincussed the advantages of using it.

The master equation, which describes the balance of population of each exciton state, is written in terms of the exciton state densities and the escape and spreading widths [3]. For the exction state densities for a n-exciton state (p particles and h holes) at excitation energy E and angular momentum J we have used the expression,

$$\rho\ (\mathrm{EJn}) = \rho^{R}_{ph}\ (\mathrm{E})\ \mathbf{R_n}\ (\mathrm{J}) \qquad (1)$$

In eq. (1) Rn (J) describes the J-distribution of the level density [1]. And ρ^{R}_{ph} (E) is the renormalised level density [4] given by,

$$\rho^{R}_{ph}\ (\mathrm{E}) = \rho^{W}_{ph}\ (\mathrm{E})\ \mathrm{F}\ (\mathrm{E}) \qquad (2)$$

where ρ^{R}_{ph} (E) is the usual particle hole level density given by Williams, and F (E) = (3 gE／2) $^{-1/4}$ is the renormalization factor given in terms of the single particle level density g.

The escape and spreading widths were calculated using a δ-function type residual interaction. The bound and continum radial wave functions, apppearing in the radial integral for bound to bound and to continuum transitions, were obtained by solving the Woods-Saxon potential and the optical potential with the parameters given in Bohr and Mottelson and the Becchetti Greenlees parameters respectively. In the case of radial integrals for bound to continuum transitions $|\ I_j\ |^2$ the outgoing particle angular momentum j upto ten was cons idered. Calculations were done for ^{40}Ca (n,p), ^{89}Y (p,n) and ^{208}Pb (n,p) reactions at E_n = 14.5 Mev, E_p = 14.8 Mev and E_n = 18.0 Mev respectively. The mean square of the radial integral $|\ I_j\ |^2$ divided by the corresponding transmission coefficient T_j was caculated in differ-

ent energy ranges irrespective of the angular momentum of the outgoing particle. There was no drastic variation in the mean in the different energy ranges for each mode ($n \rightarrow n$, $n \pm 2$). So the average was found for each of the three modes and the radial integral was replaced by this average value.

In the same way the mean of the radial integral for bound to bound transitions was found. However, this average was found to be independent of the mode ($n \rightarrow n \pm 2$), but the value was about $4 - 5$ times smaller than that predicted by FKK [1].

The strength of the residual interaction was fixed to fit the compound nucleus formation crossection obtained from the optical potential. The value of the two body residual interaction strength was in agreement with that obtained from other shell model coniderations [8].

In the calculation of the spreading widths the correction factor $C^{\downarrow}$ was required to fit the experimental spectra. Both the escape and spreading widths had a weak angular momentum dependence only. The escape width drops with increasing exciton number. The spreading width also decreases initially with the exciton number but again increases with increasing exciton number. This is due to the inclusion of the exciton number decreasing process also in the spreading, width.

The master equation was solved using these widths and there was no necessity of introducing r^{th} stage where equilibrium sets in. The distribution function P (EJn) was almost independent of J,fig. 1 . This implies that the master equation needs to be solved for one J-value only which amounts to a great simplification.

The spectra for the reaction ^{89}Y (p,n) at $E_p = 14.8$ Mev is shown in fig. 2 . The agreement with experimental data is quite good. The dotted line shows the equilibrium contribution.

In short, realistic wave functions have been used for calculating the radial integral. Further the renormalized level density has been used to evaluate the escape and spreading widths. The distribution probability was found to be almost independent of J. Thus the calculations become simpler. The value of $C^{\downarrow}$, which is the only parameter in the present calculations, may be reduced by using experimental values for the single particle level density instead of the approximation $g = A/13$ used here.

Reference

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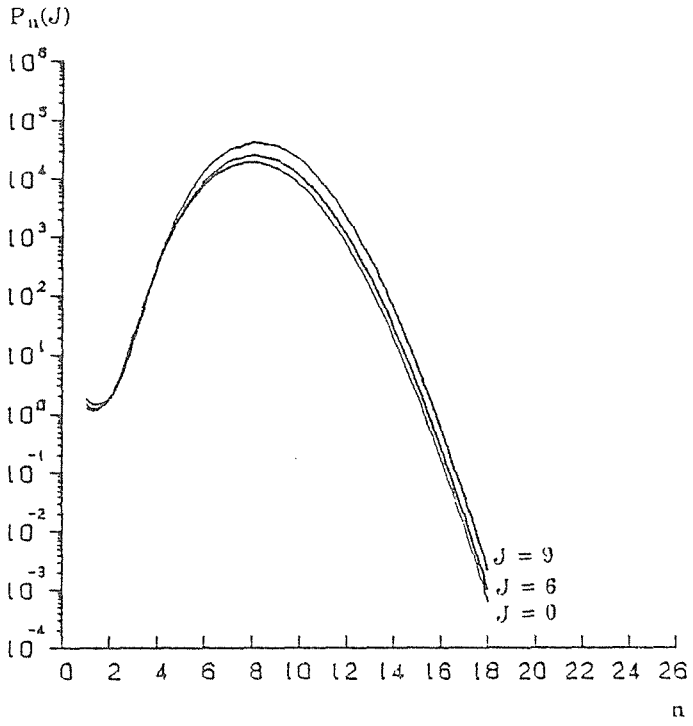
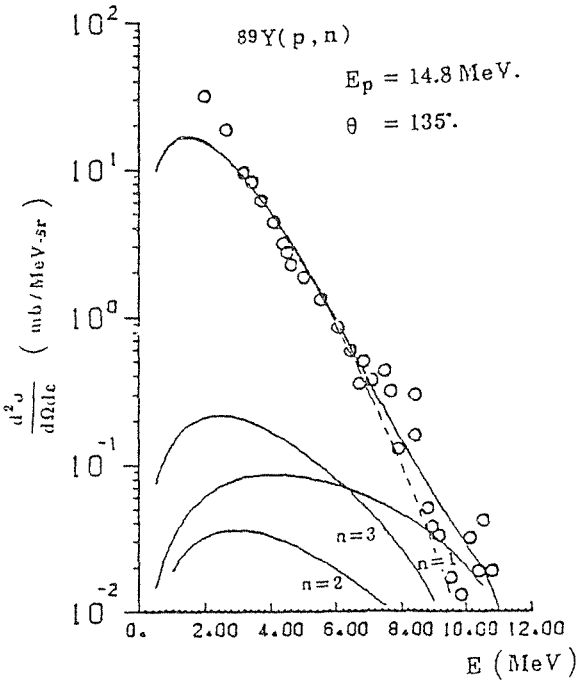
3. S.Yoshida, Z.Phys.A 308,133 (1982).
4. J.M.Akkermans and H.Gruppelar, Z.Phys.A 321,321 (1985).


$P_n(J)$
10^6
10^5
10^4
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0 2 4 6 8 10 12 14 16 18 20 22 24 26
n
J = 9
J = 6
J = 0


$^{89}Y(p,n)$
E_p = 14.8 MeV.
θ = 135°.
$\frac{d^2\sigma}{d\Omega dE}$ (mb / MeV-sr)
10^2
10^1
10^0
10^{-1}
10^{-2}
n=3
n=2
0. 2.00 4.00 6.00 8.00 10.00 12.00
E (MeV)

論文審査の結果の要旨

原子核反応には直接反応と複合核反応があることはよく知られているが，その中間の前平衡反応については最近活発な研究が進められている。しかし，実験データを現象論的パラメーターを使って解折するという方法と，もっと基本的な微視的な立場から出発して問題を解くという二つのやり方があるが，その間には大きなギャップがある。これを埋めようとしたのがこの論文の目的である。

核反応は核子・核子衝突によってだんだんと入射エネルギーが核に分配されて進行するが，平衡状態に達する前に粒子が放出されるのが前平衡過程である。核子－核子衝突の行列要素の絶対値の自乗の平均と，核子が他の核子と衝突することによって連続状態に放出される行列要素の絶対値の自乗とは前平衡過程にとって重要な物理量である。現象論的やり方ではこれをパラメーターとしたが，この論文では波動関数としてはSaxon - Woods型のポテンシャルに対するものを用い，核力には簡単なδ－関数型のものを用いて，いくつかの例により計算を行って，これらの量は簡単な質量数依存性を持ってるを示した。

前平衡過程の発展方程式には拡散幅と逃げ幅として現れるが，これらの量の計算には上述の行列要素と，粒子数一空孔数を指定した準位密度が必要である。後者にはこれまでは簡単な式が用いられたが，これにも改良を加えた。全体の準位密度が，実験データから求められた準位密度に合うように補正をしたものが用いられた。

更に角運動量の保存を考慮に入れて，幅の計算を行って，発展方程式に入れて，これを解き，実験データと比較した。その結果これまでは拡散幅は簡単な評価から得られたものに係数5～10位小さくしなければ実験と合わなかったのが，今度の計算では係数は大体2になり，前よりもずっと改良された。又幅の角運動量依存性はほとんどなく，従って発展方程式も角運動量を考慮に入れないで，解くというやり方でもよい近似になっていることが分った。

現象論的にこれまで求められていた幅を微視的な立場から計算すると実験データを相当よく説明出来ること，並びに幅の角運動量依存性がほとんどないという結論を得たが，これはこれまで知られていなかった新知見で，核反応の理論の発展に大きな寄与をしたと認める。このことは自立して研究活動を行うに必要な高度の研究能力と学識を有することを示している。よってGargi Keeni提出の論文は，理学博士の論文として合格と認める。