Cross section ratio for *pn* and *d* emission as a probe of level density for light-medium nuclei

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In a compound nucleus decay the same evaporation residuum may be reached by different exit channels. For example, emission of *np* or *pn* as well as emission of deuterons leads to the same final nucleus. The difference is that the cascades of *np* or *pn* pass trough an intermediate nucleus, whereas *d*-evaporation brings the decaying system directly to the final nucleus. Studies of the competition between these two processes i.e. *pn* or *np* evaporation and *d* emission reveal interesting features of nuclear reaction mechanisms [1]. One important aspect is that this competition can reflect the structure of intermediate nuclei, which is pointed out in the present work.

Three nuclear reactions were used to investigate the *pn* and *d* competition. The ^{51}V, ^{54}Fe and ^{59}Co metallic targets were bombarded with the 26.5 MeV α beam from U-120 Kraków cyclotron. Coincidences between γ-rays and light charged particles (p, d, α) were recorded event by event. A ΔE–E telescope was placed at the backward angle θ=140° to select particles evaporated from the compound nucleus, while gammas were measured with a Ge(Li) detector positioned perpendicularly to the telescope axis. The ratios σ_{pn}/σ_d (see Fig. 1) were extracted from the experimental data making use of γ-particle coincidences.

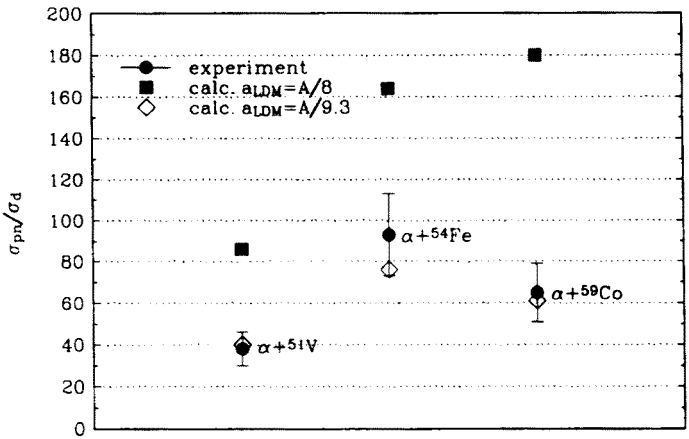

Fig. 1. The σ_{pn}/σ_d ratios obtained from the experiment and the CASCADE calculations.

We then compared the experimental σ_{pn}/σ_d values with predictions of the evaporation code CASCADE [2]. The calculations showed that this ratio was very sensitive to the level density as the function of excitation energy of the residual nucleus. The extent and character of this dependence was tested by varying the level density parameter a_{LDM} (see Fig.2).

The ratios obtained from the calculations with the standard a_{LDM}=A/8 and all other pertinent ingredients such as RLDM yrast line, mass formula parametrization etc. overestimated the experimental values by a factor of more then 2.

† Deceased.

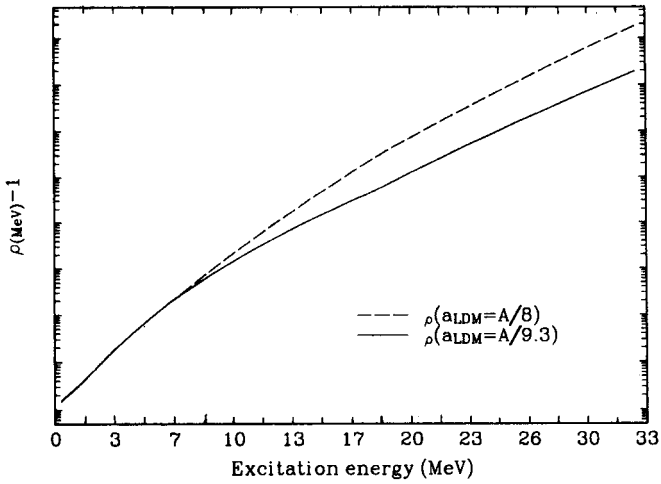

Fig. 2. Level density curves for the ^{54}Cr nucleus calculated for two sets of the a_{LDM} parameter.

Strong changes of the σ_{pn}/σ_d ratios were noticed when altering the level density in the intermediate nucleus. The calculations with a_{LDM}=A/9.3 fit much better the measured ratios as shown in Fig.1. Also singles proton spectra obtained from these calculations with a_{LDM}=A/9.3 fit experimental data very well as shown in Fig. 3.

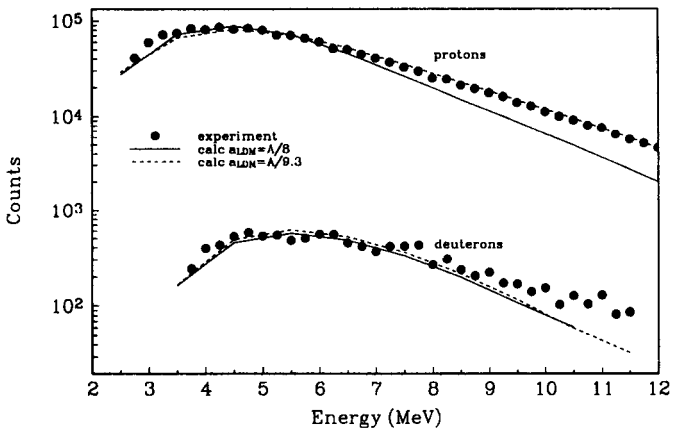

Fig. 3. Spectra of charged particles evaporated in α+^{54}Fe reaction.

It should be mentioned that when using the modified version of the CASCADE code by Harakeh et al.[3], one reproduces the experimental σ_{pn}/σ_d values reasonably well with the a_{LDM}=A/8. Nevertheless, the strong dependence of the σ_{pn}/σ_d ratio on the a_{LDM} parameter remains.

†deceased

References

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[2] F. Puhlhofer, *Nucl. Phys.* **A280** (1977) 267
[3] M.N. Harakeh et al., *Phys. Lett.* **176B** (1986) 297