

СООбщения Объединенного Института Ядерных Исследований Дубна

K 80

E1-88-433

1988

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Q_{GG} - SYSTEMATICS OF FRAGMENT YIELDS

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The emission of fragments in high-energy collisions has been the subject of many experimental studies in recent years. Such studies vield valuable information particularly for understanding the reaction mechanism. The interactions of high-energy projectiles with nuclei can be understood in terms of a two-step mechanism/1/in which the excitation and deexcitation stages are assumed. Experimental data are usually discussed in the framework of the intranuclear cascade evaporation $\frac{2}{2}$ and the abrasion-ablation $\frac{3}{2}$ models. Isotopic vields of fragments were found to be consistent with evaporation calculations $^{/4/}$ showing that the process of the interaction is sufficiently slow to permit at least partial statistical equilibration. The statistical features of the process can be displayed by the Q_{cc} systematics $^{/5/}$. The Q_{ne}-analysis has been applied to the yields of fragments emitted in nuclear reactions induced by 400 GeV protons and 1.54 AGeV ¹²C-ions^{/6/}. It may be of interest to explore the applicability of the Q_{cc}-systematics to our recent data on the fragment vields from nuclear reactions induced by 3.65 AGeV ¹²C-ions and 3.65 GeV protons on 181_{Ta} /7/ and 197_{Au} /8/ nuclei. Nevertheless. the validity of limiting fragmentation in this energy region gives a good possibility of comparing previous /6/ and present /7,8/ results.

Following the approach of the Q_{GG} -systematics, the isotopic yields $\mathbf{6}^{\prime}$ can be fitted by the relation

$$\mathbf{6}^{\prime} = C \exp \left(Q_{GG}^{\prime} T \right)$$
, /1/

where C is a constant, $Q_{GG} = M_p - M_f - M_\alpha$ is an energy of the reaction /the subscripts on the masses refer to the fragmenting nucleus P, the observed fragment f, and the complementary fragment c,

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respectively/, and T is a nuclear temperature. Concentrating to the variation of the yield of a particular fragment with target $A_{\rm T}$, it is necessary to reduce ${\rm Q}_{\rm GG}$ by the value of the effective Coulomb barrier/6/

$$kB = \frac{kZ_f Z_c e^2}{R_f + R_c} \qquad . \qquad /2/$$

The constant k is a barrier reduction factor taking into account the fact that the classical barrier overestimates the minimum energy of the fragment^{/9/}, the appropriate radii are $R_f = r_0 A_f^{1/3}$ and $R_c = r_0 A_c^{1/3}$. In the present analysis we have used the same value k=0.7 as given in ref./6/. The Coulomb barrier has also been evaluated for $r_0 = 1.44$ fm. Taking into account that the nuclear temperature is constant for all targets^{/10/} and the total reaction cross section depends on $A_T^{2/3}$, as well, the relation /1/ can be rewritten as

$$\mathbf{6}' = CA_{T}^{2/3} \exp\left(\frac{Q_{GG} - kB}{T}\right). \qquad /3/$$

The experimental isobaric yields of fragments have been examined in the form of Eq./3/. The results for neutron excess fragment 48 Sc and neutron deficient fragment 52 Mn are illustrated in Fig.1 and 2, respectively. These particular fragments were chosen for the same reasons as given in the work of Cole and Porile^{/6/}. Moreover, a simple comparison of both sets of results can be made. As can be seen, our results for Ta and Au targets in both irradiations /3.65 GeV protons and 3.65 AGeV 12 C-ions/ are in agreement with those obtained for the same fragmenting nuclei by 400 GeV protons and 1.54 AGeV 12 G-ions. The results for neutron excess fragment 48 Sc seem to be consistent with the Q_{GG}-systematics of both sets of data. The analysis gives the value of T about 13.5 MeV. On the other hand, the results for neutron deficient fragment 52 Mn are in contrast with those obtained for 48 Sc. The experimental evidence that the Q_{GG} -



Pig.2. Q_{GG} -systematics for the formation of 12 Mn in the interaction of high-energy 12 C-ions /up/ and protons /down/ with U,Au,Ta,Gd and Ag nuclei. The present data for Ta and Au are marked with filled points. The values of $A_2^{2/3}$ are normalised to unity for Ag.

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systematics are not obeyed for 52 Mn suggests that partial statistical equilibration may not be responsible for the neutron deficient fragment emission. This fragment is probably formed as a spallation residue.

At last, what can we say about the nuclear temperature T extracted from the isotopic yields for neutron excess fragment 48 Sc? The value of about 13.5 MeV is too high in order to explain the excitation energy $E^{*} = aT^{2} / a \sim A_{T}/10$ being the level density parameter/, the appropriate values of E^{*} are much higher than those derived from the more realistic model calculations.

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Received by Publishing Department on June 16, 1988.

Козма П., Дамдинсурэн Ц., Чултэм Д. Е1-88-433 Q_{GG} - систематика выходов фрагментов

Анализ выходов фрагментов, образующихся в реакциях, вызванных релятивистскими протонами и ядрами ¹²С, проведен в рамках Q –статистики. В отличии от результатов, полученных для нейтронно-избыточного фрагмента ⁴⁸Sc, выходы нейтронно-недостаточного фрагмента ⁵² Mn в рамках Q –систематики не описываются. Более того, значение ядерной температуры T ≈ 13.5 МэВ, определенное из экспериментальных данных для ⁴⁸Sc, является слишком высоким и не объяс-няет стадию возбуждения в данном взаимодействии.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

Сообщение Объединенного института ядерных исследований. Дубна 1988

Kozma P., Damdinsuren C., Chultem D. Q_{GG} - Systematics of Fragment Yields

E1-88-433

The yields of fragments produced in nuclear reactions induced by high-energy protons and ¹²C-ions have been examined in the framework of the Q_{GG} -systematics. While results for neutron excess fragment ⁴⁸Sc were found to be consistent with the theory, the Q_{GG} -systematics certainly are not obeyed for neutron deficient fragment ⁵²Mn. Nevertheless, the nuclear temperature of about 13.5 MeV extracted from experimental data for ⁴⁸Sc is too high to explain the excitation stage of the interaction.

The investigation has been performed at the Laboratory of High Energies, JINR.

Communication of the Joint Institute for Nuclear Research. Dubna 1988

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