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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 yield 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[2] and the abrasion-ablation[3] models. Isotopic yields 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_{GG}-systematics[5]. The Q_{GG}-analysis has been applied to the yields of fragments emitted in nuclear reactions induced by 400 GeV protons and 1.54 AGeV ^{12}C-ions[6]. It may be of interest to explore the applicability of the Q_{GG}-systematics to our recent data on the fragment yields from nuclear reactions induced by 3.65 AGeV ^{12}C-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 σ can be fitted by the relation

$$\sigma = C \exp\left(Q_{GG}/T\right) , \qquad /1/$$

where C is a constant, $Q_{GG} = M_F - M_f - M_c$ is an energy of the reaction /the subscripts on the masses refer to the fragmenting nucleus F, the observed fragment f, and the complementary fragment c, respectively/, and T is a nuclear temperature. Concentrating to the variation of the yield of a particular fragment with target A_T, it is necessary to reduce Q_{GG} by the value of the effective Coulomb barrier/6/

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

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 $R_f = r_o A_f^{1/3}$ and $R_c = r_o A_c^{1/3}$. 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_o=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

$$\sigma = CA_T^{2/3} \exp\left(\frac{Q_{GG} - kB}{T}\right) . \qquad /3/$$

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}C-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} -

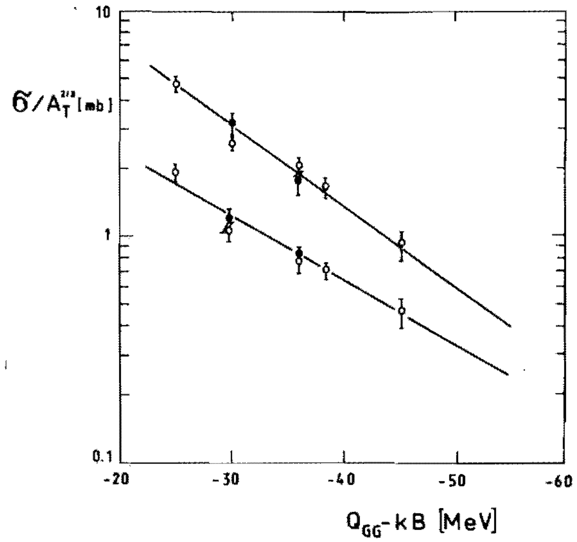

Fig. 1. Q_{GG}-systematics for the formation of ^{48}Sc in the interaction of high-energy ^{12}C-ions (up) and protons (down) with U, Au, Ta, Gd and Ag nuclei. The present data for Ta and Au are marked with filled points. The values of $A_T^{2/3}$ are normalized to unity for Ag.

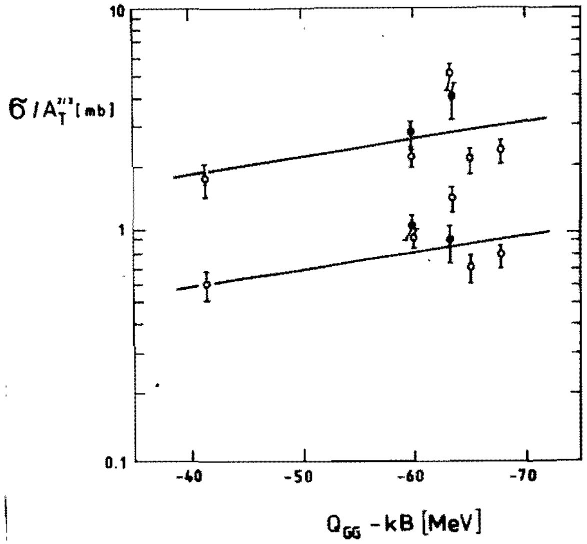

Fig.2. Q_{GG}-systematics for the formation of ^{52}Mn in the interaction of high-energy ^{12}C-ions /up/ and protons /down/ with U, Au, Ta, Gd and Ag nuclei. The present data for Ta and Au are marked with filled points. The values of $A_T^{2/3}$ are normalised to unity for Ag.

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.

References

1. Barashenkov V.S.,Toneev V.D. - Interactions of High-Energy Particles and Atomic Nuclei with Nuclei. Atomizdat,Moscow,1972.
2. Bertini H.W.,Guthrie M.P. - Nucl.Phys., A 169, 1971,p.670.
3. Bowman J.D.,Swiatecki W.J.,Tsang C.F. - LBL Report, LBL-2908, 1973.
4. Porile N.T. - Phys.Rev., 141, 1966, p.1082.
5. Artukh A.G.,Avdeichikov V.V.,Erö J.,Gridnev G.F.,Mikheev V.L., Wilczynski J.- Nucl.Phys., A 160, 1971, p.511.
6. Cole G.D.,Porile N.T. - Phys.Rev., C 24, 1981, p.2038.
7. Damdinsuren C.,Kozma P.,Tumendemberel B.,Khorolyjav R.,Chultem D. - JINR Report E1-88-135, Dubna, 1988 , submitted to Nucl.Phys.A.
8. Kozma P.,Damdinsuren C. - Czech.J.Phys.B.,to be published and JINR Report E1-88-245, Dubna, 1988.
9. Fortney D.R.,Porile N.T. - Phys.Rev.,C 21, 1980, p.664.
10. Gaidos J.A.,Gutai L.J.,Hirsch A.S.,Mitchell R.,Ragland T.V., Wilkinson C.L. - Phys.Rev.Lett.,42, 1979,p.82.

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Q_{GG} - систематика выходов фрагментов

Анализ выходов фрагментов, образующихся в реакциях, вызванных релятивистскими протонами и ядрами ^{12}C, проведен в рамках Q_{GG}-статистики. В отличии от результатов, полученных для нейтронно-избыточного фрагмента ^{48}Sc, выходы нейтронно-недостаточного фрагмента ^{52}Mn в рамках Q_{GG}-систематики не описываются. Более того, значение ядерной температуры $T \approx 13.5$ МэВ, определенное из экспериментальных данных для ^{48}Sc, является слишком высоким и не объясняет стадию возбуждения в данном взаимодействии.

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Q_{GG} - Systematics of Fragment Yields

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

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

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