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A STUDY OF Λ -PRODUCTION
IN CENTRAL NUCLEUS-NUCLEUS
INTERACTIONS AT A MOMENTUM
OF 4.5 GeV/c PER INCIDENT NUCLEON

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Recently the strange particle production in nucleus-nucleus ($A_p - A_r$) collisions has been of increasing interest as a possible signature for highly compressed hadron matter in which a phase transition probably can occur^{/1,2/}.

According to the existing theoretical consideration, one can expect an enhancement of strange particle production, an anomalously large $\bar{\Lambda}/\Lambda$ ratio, and/or some other anomalies in their characteristics such as transverse momentum (p_r), polarization (α_P) and so on.

Up to now experimental data on strange particle production in $A_p A_T$ -interactions are very poor. The Λ -hyperons produced in central $Ar - KCl$ collisions at 1.8 GeV/ A_p have been studied^{/3/}. Other sets of data have been obtained on Λ and K^0 production in inelastic interactions of ${}^4\text{He}-{}^6\text{Li}$ at 4.5 GeV/c $\cdot A_p$ ^{/4/} and ${}^2\text{H}-\text{Ta}$, ${}^{12}\text{C}-\text{Ta}$ at 4.2 GeV/c $\cdot A_p$ ^{/5/}.

The main problem of a search for some anomalous effects in central AA collisions is: what object of comparison should be if one takes into account that pp-interactions cannot be adequately used for this purpose^{/3,4/}.

In our preliminary papers^{/6/} we compared $\Lambda(K^0)$ production in central ${}^{12}\text{C}-{}^{12}\text{C}$ and ${}^{12}\text{C}-\text{Ne}$ collisions with that in inelastic ${}^4\text{He}-{}^6\text{Li}$ interactions (mainly peripheral). In contrast to the situation for pp-interactions, the characteristics of $\Lambda(K^0)$ production in ${}^4\text{He}-{}^6\text{Li}$ collisions are averaged over Fermi motion and the charge of colliding nucleons whereas other (collective) nuclear effects can be neglected in this case.

Thus to search for possible anomalous signatures, the sample of Λ 's produced in inelastic ${}^4\text{He}-{}^6\text{Li}$ collisions is very suitable as the object of comparison in a study of Λ 's produced in central collisions of heavier nuclei. In this paper we present our results concerning Λ -hyperons produced in central collisions of ${}^{12}\text{C}$ and ${}^{16}\text{O}$ (4.5 GeV/c per nucleon) with pure nuclear targets (C, Ne, Cu, Zr, Pb). The interactions and Λ -decays were registered in the 2 m streamer spectrometer SKM-200^{/7/}. The spectrometer was triggered for central collisions (anticoincidence counters for projectile charged and neutral spectators emitted at an angle of $2^\circ \pm 3^\circ$ ^{/8/}). As was

* The anticoincidence counter for neutrons-spectators was included in the triggering system in last runs of the "central" exposure of SKM-200^{/8/}.

mentioned, another sample of Λ -events considered in this paper consists of He-Li interactions at the same momentum per incident nucleon. The events were registered under the same experimental conditions but with the triggering for all inelastic collisions.

The sample of ν^0 events was selected out of double-scanned films. The ν^0 events were measured and analyzed by a ν^0 pointing fit of kinematical equations. The analysis of χ^2 distributions and various kinematical characteristics for Λ , K^0 , γ and also $\bar{\Lambda}$ hypotheses permitted Λ hyperon decays to be identified and selected. A cut on the Λ proper lifetime, $\tau/\tau^0 \leq 5.5$, was introduced. The possible contamination of the sample due to K 's and γ 's is smaller than 4%. The obtained Λ mass distribution yields $M = \langle M \rangle = (1117 + 0.4) \text{ MeV}/c^2$ with a dispersion of $D = (7.7 + 0.3) \text{ MeV}/c^2$. Λ 's from $A_p A_T$ collisions are divided into three groups: 1) CC + CNe + ONe, 2) CCu + CZr, 3) CPb + OPb.

In order to reduce biases due to scanning losses in the region of high track density in the vicinity of the target, the lifetime analysis based on the maximum likelihood approach (Bartlett method) was used, which permitted one to estimate for each group the radius R of the region in which ν^0 events are either undetected or detected with low (and momentum-dependent) efficiency. The value of R depends on the mass number of target nucleus ranging from 13 to 18 cm. To calculate average rapidities and transverse momenta, the cut off $R_{\text{cut.}} = 18 \text{ cm}$ is used for all groups. It should be stressed that the rejection of Λ 's decaying at a distance smaller than $R_{\text{cut.}}$ from the point of interaction corresponds to the rejection of Λ 's with momenta lower than $P_{\text{min}} = (M_{\Lambda} \cdot R_{\text{cut.}}) / (5.5 \cdot c \cdot \tau)$.

The Y - p_T plots are presented in Fig.1. The region containing excluded Λ events is shown with a hatched curve. Two other solid contours show the phase space limits corresponding to $NN \rightarrow NAK$ and $NN \rightarrow NAK_T$ production channels.

In order to obtain the dependence of average rapidity, $\langle Y \rangle$, transverse momentum, $\langle p_T \rangle$, on target mass number (Figs.1,2), corrections were introduced for undetected Λ hyperons decaying at a distance smaller than $R_{\text{cut.}}$ or beyond the chamber fiducial value. The average value of weighting factors is $\langle w \rangle = 4.4$. Any momentum dependence of the other losses was found to be negligible.

No striking dependence of $\langle p_T \rangle$ on target mass number is observed. The values of average rapidity, $\langle Y \rangle$, do not differ, within the errors, for the three groups, but $\langle Y \rangle$ is significantly smaller for Λ 's from the interactions on Pb.

The polarization of Λ -hyperons found in this experiment, (no R cut-off and weighting factors being applied) a_P , is consistent, within the statistical errors, with zero for all

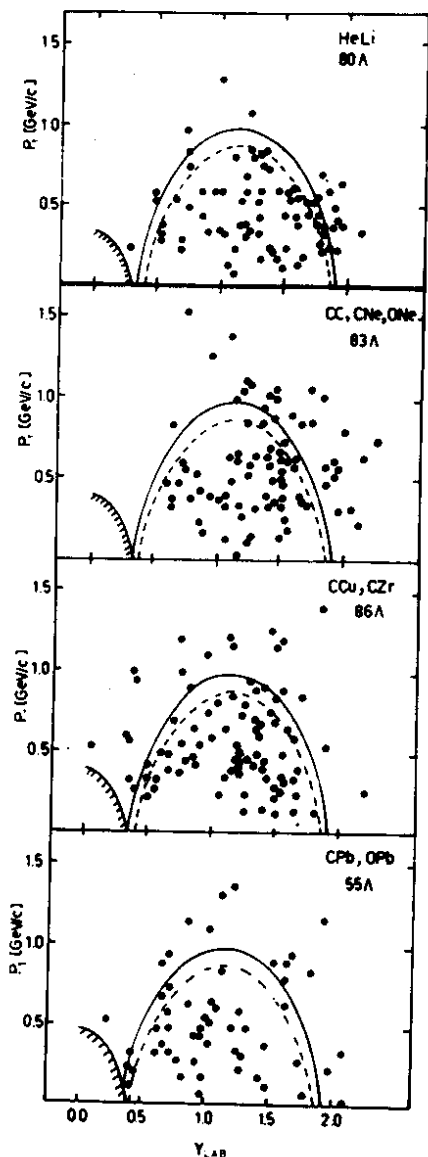


Fig.1.

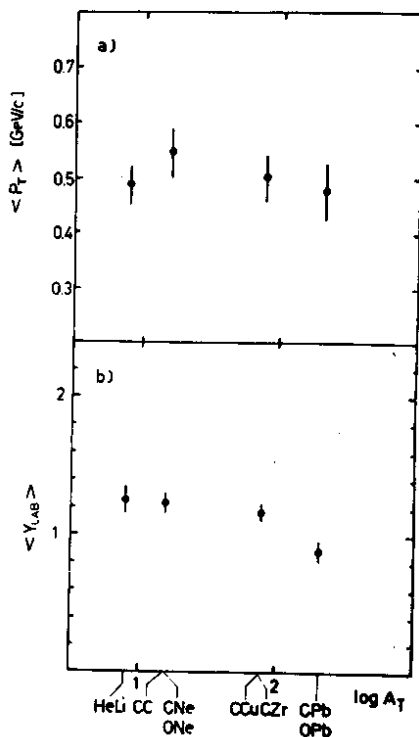


Fig.2.

pairs of colliding nuclei. The obtained values are $\langle aP \rangle = -0.06 \pm 0.17$ for all 224 Λ 's from central collisions and $\langle aP \rangle = -0.12 \pm 0.17$ for 80 Λ 's from ${}^4\text{He-Li}$ interactions.

Particular attention has been given to all V^0 events in their identification from the point of view of the $\bar{\Lambda}$ hypothesis. The fitting of $\bar{\Lambda}$ hypothesis was satisfied in less than 1% of the total V^0 sample, but in each case it was accompanied by an

acceptable (within our criteria) hypothesis for Λ , K^0 , or γ identification. We conclude that no $\bar{\Lambda}$ decays have been uniquely identified, thus yielding an estimation of the upper limit of the ratio $\sigma_{\bar{\Lambda}}/\sigma_{\Lambda} \leq 4.5 \cdot 10^{-3}$. The above analysis of the data on Λ production for the three groups of central $A_P A_T$ collisions and their comparison with similar data on

inelastic ${}^4\text{He}-{}^6\text{Li}$ interactions have revealed the following main features:

- 1) In $\langle p_T \rangle$ no striking difference is observed for all four groups of A_T (fig.2a), but some abundance of Λ 's with large p_T (say, $p_T \geq 1$ GeV/c) seemed to occur for central $A_P A_T$ collisions as compared to those for inelastic He-Li interactions (fig.1) (an additional analysis is needed here).
- 2) The values of $\langle Y \rangle$ do not differ, within the errors, but for CPb+OPb events being less (fig.2b) what can be due to secondary processes inside the heavy target nuclei ($\pi + N \rightarrow \Lambda + K$, Λ - rescattering).
- 3) On the $p_T - Y$ plots (fig.1) most of our Λ 's are within the kinematical limits for $NN \rightarrow \Lambda KN$ - reaction in contrast with Λ 's observed in ${}^{3/}$ which lie (almost all) beyond these limits, probably, due to a smaller phase volume for the mentioned reaction.
- 4) The observed polarization for 224 "central" Λ -events, $a_P = -0.06 \pm 0.11$, does not differ, within the errors, from 0, from $a_P = -0.12 \pm 0.17$ for Λ 's in He-Li inelastic interactions and also from $a_P = 0.06 \pm 0.03$ obtained in ${}^{3/}$ as a result of the analysis of 63 "central" Λ -events.
- 5) No iniquely identified $\bar{\Lambda}$ was found among 224 "central" Λ 's what gives $\sim 10^{-2}$ for the limit of $\sigma_{\bar{\Lambda}} / \sigma_{\Lambda}$ -ratio at a 90% confidence level.

We are grateful to the engineering and technical staffs of the SKM-200 setup and of the Dubna synchrophasotron which have participated in the exposures of the spectrometer, and particularly to V.Iovcheva, V.Rozuvakina, L.Stempinska and E.Novikova for their great contribution to the measurement and analysis of the experimental data.

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Исследования рождения Λ -гиперонов
в центральных ядро-ядерных взаимодействиях
при импульсе 4,5 ГэВ/с на нуклон

Исследованы поперечные импульсы и быстроты в центральных ядро-ядерных взаимодействиях при 4,5 ГэВ/с на нуклон /CC, CNe, ONe, CCu, CZr, CPb, OPb/ в сравнении с соответствующими характеристиками для неупругих He-Li - взаимодействий при том же импульсе налетающего ядра. Было обнаружено, что поляризация Λ -гиперонов совпадает /в пределах ошибок/ со значением 0 ($\alpha_P = -0.12 \pm 0.17$) для 224 Λ^0 -частиц, рожденных в центральных взаимодействиях. Оценка верхнего предела для отношения выходов рождения $\bar{\Lambda}/\Lambda$ дает величину меньше 10^{-2} на 90% доверительном интервале.

Проанализированные экспериментальные данные были получены с использованием 2-метрового стримерного спектрометра SKM-200 с соответствующей триггерной системой.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

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A Study of Λ -Production
in Central Nucleus-Nucleus Interactions
at a Momentum of 4.5 GeV/c Per Incident Nucleon

Transverse momenta and rapidities of Λ 's produced in central nucleus-nucleus collisions at 4.5 GeV/c per nucleon /CC, CNe, ONe, CCu, CZr, CPb, OPb/ have been studied and compared with those from inelastic He-Li interactions at the same incident momentum. Polarization of Λ hyperons was found to be consistent /within the errors/ with zero ($\alpha_P = -0.06 \pm 0.11$) for 224 Λ 's from central collisions. The upper limit of $\bar{\Lambda}/\Lambda$ production ratio was estimated to be less than 10^{-2} at a 90% confidence level.

The analyzed experimental data were obtained using the triggered 2 m streamer spectrometer SKM-200.

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

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