Average transverse momenta of pions produced in nucleus-nucleus interactions at $p = 4.5$ GeV/c per nucleon

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Analysis of $\langle p_t \rangle$ for the negative pions produced in the interactions ^{4}He + ^{6}Li, C, Al, Cu, Pb; ^{12}C + C, Ne, Cu; and ^{20}Ne + Ne at projectile-nucleus momentum per nucleon of 4.5 GeV/c shows that $\langle p_t \rangle$ does not depend on the centrality of the interaction, on the mass of the projectile nucleus in the interval $A_P = 4$–20, or on the mass of the target nucleus in the interval $A_T = 6$–64. The values found for $\langle p_t \rangle$ are at odds with calculations from a thermodynamic model.

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Hagedorn and Rafelski[1] assert that the simplest and most reliable way to test the predictions of their thermodynamic model for nucleus-nucleus interactions is to measure the average transverse momentum $\langle p_T \rangle$ of the protons or pions emitted from the common blob of headed and/or compressed hadronic matter—a fireball—produced at small impact parameters in nucleus-nucleus collisions. Hagedorn and Rafelski's calculations[1] were carried out for symmetric nuclei ($A_P = A_T$).

We have used the SKM-200 two-meter streamer spectrometer[2,3] to study the average transverse momenta $\langle p_T \rangle$ of the π^- mesons produced in the interactions of carbon and neon nuclei with other nuclei at $p = 4.5$ GeV/c per nucleon. A selection criterion (a trigger) for inelastic interactions was that the projectile nucleus A_P be removed from the beam; a selection criterion for central interactions was that there be no spectator fragments A_P in the forward cone within the forbidden angle θ_{ch} for charged fragments or θ_n for neutral fragments. We will designate the trigger as $T(\theta_{ch},\theta_n)$ (Ref. 4), where the limiting forbidden emission angles θ_{ch} and θ_n are rounded to the nearest degree. An inelastic interaction thus corresponds to the trigger $T(0,0)$. We also introduce the following terms for the subensemble of the total ensemble of inelastic interactions: "quasicentral" interactions (for which the total number of charged particles, $N_\pm$, is greater than $\langle N_\pm \rangle$) and peripheral interactions (for which there are at least two fast fragment nucleons A_P within the stripping cone—solely for ^{4}He + A interactions).

The values of $\langle p_T \rangle$ in central ^{12}C + C interactions were found for the ensembles with the triggers $T(2,0)$, $T(2,2)$, and $T(4,0)_{ch.f} \leqslant 1$ (no more than one charged fragment A_P is emitted within 4°). The corresponding cross sections (33, 12, and 10 mb) are about 4–1% of σ_{in}. We also studied $\langle p_t \rangle$ in central ^{12}C + Ne interactions [$T(2,0)$, 87 mb, 8%; and $T(2,2)$, 28 mb, 3%] and ^{12}C + Cu interactions [$T(2,0)$, 330 mb, 19%], in

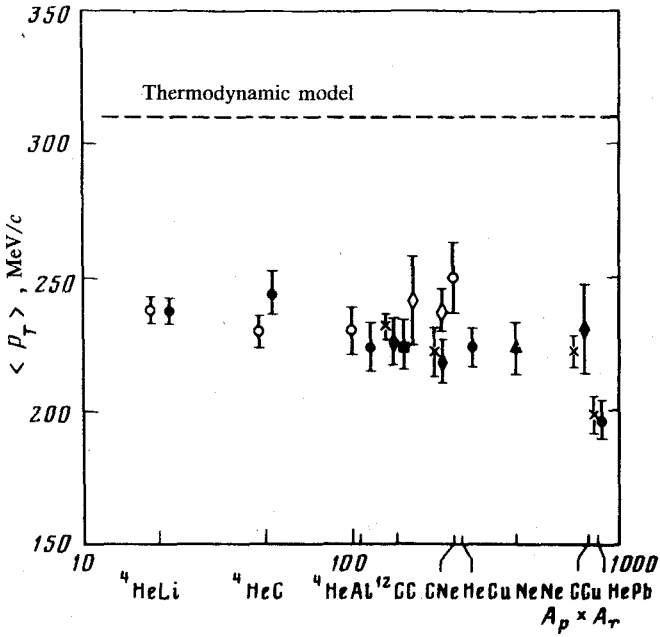

FIG. 1. Average transverse momentum of the π^- mesons produced in nucleus-nucleus interactions, $\langle p_t \rangle$, as a function of the product $A_P \cdot A_T$. The different symbols correspond to the following selection criteria (explained in the text):

×—Inelastic interaction,		
○—Peripheral interaction,		$^4\text{He} + A$
●—Central interaction,	$T(5,0)$	
◆—Central interaction,	$T(2,0)$	
■—Central interaction,	$T(4,0)_{\text{ch.f.}} \leqslant 1$	$^{12}\text{C} + A$
◇—Central interaction,	$T(2,2)$	
▲—Quasicentral interaction,	$T(N_{\pm} > 20)$	$^{20}\text{Ne} + \text{Ne}$

the inelastic $^{12}C + C$, Ne, and Cu interactions; and in quasicentral $^{20}Ne + Ne$ interactions ($N_{\pm} > 20$).

The values found for $\langle p_T \rangle$ in these interactions and with the specified triggers are shown in Fig. 1 in a plot against the product $A_P \cdot A_T$. Shown for comparison are some data published by us previously[5] for $^4He + {}^6Li$, C, Al, Cu, and Pb interactions, from which we singled out peripheral and central interactions [$T(5,0)$, 16–60%]. The dashed line, which corresponds to 310 MeV/c, is the prediction of the thermodynamic model[1] for $p = 4.5$ GeV/c per nucleon.

We can draw some conclusions from Fig. 1. 1) In nucleus-nucleus interactions, $\langle p_t \rangle$, does not depend on the degree of centrality of the interaction. 2) It appears that $\langle p_t \rangle$ is independent of the mass of the projectile nucleus, at least over the interval $A_P = 4$–20. 3) There is a weak dependence of $\langle p_t \rangle$ on the mass of the target nucleus; this average transverse momentum remains at 230 ± 10 MeV/c at least up to $A_T = 64$. 4) The predictions of the thermodynamic model[1] are at odds with the results on the

central interaction of symmetric nuclei $^{12}C + C$. When conclusions 1)–3) are taken into account, these model-based predictions are at odds with all the experimental data.

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