1 - 2 Hypernucleus Production in Antiproton-nucleus Collisions*

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Studies of hypernuclei attract much attention over the past several decades. The interested topics related to hypernuclei are the hyperon-nucleon and hyperon-hyperon interactions, opening a new horizon with strangeness (three-dimensional nuclear chart) in nuclear physics and probing the in-medium properties of hadrons and the inner structure of a nucleus. A more localized energy deposition enables the secondary collisions available for producing hyperons. Hyperons produced in antiproton induced reactions can be captured in the potential of nucleon fragments to form hypernuclei. The dynamics of antiproton-nucleus collisions is complicated, which is associated with the mean-field potentials of hadrons in nuclear medium, and also with a number of reaction channels, *i.e.*, the annihilation channels, charge-exchange reaction, elastic and inelastic collisions. The larger yields of strange particles in antiproton induced reactions are favorable to form hypernuclei in comparison to proton-nucleus and heavy-ion collisions[1].

Formation mechanism of fragments with strangeness in collisions of antiprotons on nuclei has been investigated within the Lanzhou quantum molecular dynamics (LQMD) transport model. Production of strange particles in the antiproton induced nuclear reactions is modeled within the LQMD model, in which all possible reaction channels such as elastic scattering, annihilation, charge exchange and inelastic scattering in antibaryon-baryon, baryon-baryon and meson-baryon collisions have been included. A coalescence approach is developed for constructing hyperfragments in phase space. The phase-space structure of nucleonic fragments and hyperfragments produced in antiproton induced reactions would be helpful for the detector management in experiments. Furthermore, the estimation of cross sections for hypernucleus production with an optimal projectile-target combination and incident energy is favorable to produce hypernuclei with less costs. Shown in Fig. 1 are the rapidity distributions of nucleonic fragments and Λ-hyperfragments formed in collisions of $\overline{\mathrm{p}}$ on ^{20}Ne, ^{63}Cu and ^{181}Ta at an incident momentum of 4 GeV/c. Hyperons Λ and $\overline{\Lambda}$ produced in the $\overline{\mathrm{p}}$ induced reactions are indicated for a comparison. The hyperons are captured by nucleonic fragments and a narrow rapidity distribution of Λ-fragments is formed. Here, we assume a larger relative distance (R_0 = 5 fm) and the relative momentum similar to nucleonic ones (P_0 = 200 MeV/c) between hyperon and nucleon in constructing a hypernucleus. Shown in Fig. 2 is the mass and charged number distributions of hyperfragments with strangeness $s = -1$ ($_{\Lambda}X$), s=1 ($_{\overline{\Lambda}}X$) and $s = -2$ ($_{\Lambda\Lambda}X$) in collisions of $\overline{\mathrm{p}}$ + ^{63}Cu and $\overline{\mathrm{p}}$ + ^{181}Ta at the same incident momentum of 4 GeV/c. The Λ-hyperfragments spread the whole isotope range with the larger yields. The maximal cross sections for $s = -1$ and $s = -2$ hyperfragments are at the levels of 1 mb and 0.01 mb, respectively. The lower production yields of $\overline{\Lambda}$-hyperfragments at the level of 1 μb are found[2].

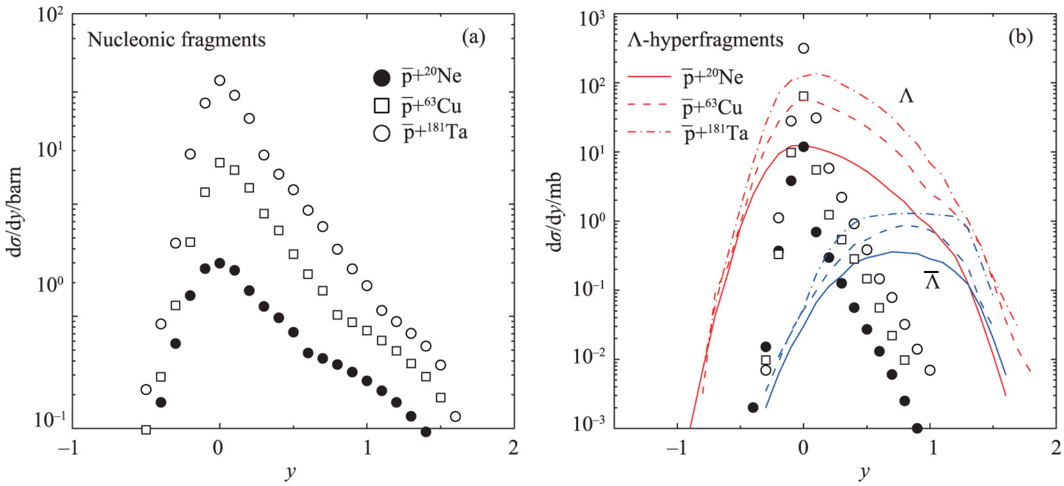

Fig. 1 (color online) Rapidity distributions of all fragments and Λ-hyperfragments formed in collisions of $\overline{\mathrm{p}}$ on ^{20}Ne, ^{63}Cu and ^{181}Ta at incident momentum of 4 GeV/c. Hyperons Λ and $\overline{\Lambda}$ are indicated for a comparison.

In summary, the formation mechanism of nucleonic fragments and hyperfragments in antiprotons induced reactions has been investigated within the LQMD transport model. The de-excitation of fragments is described

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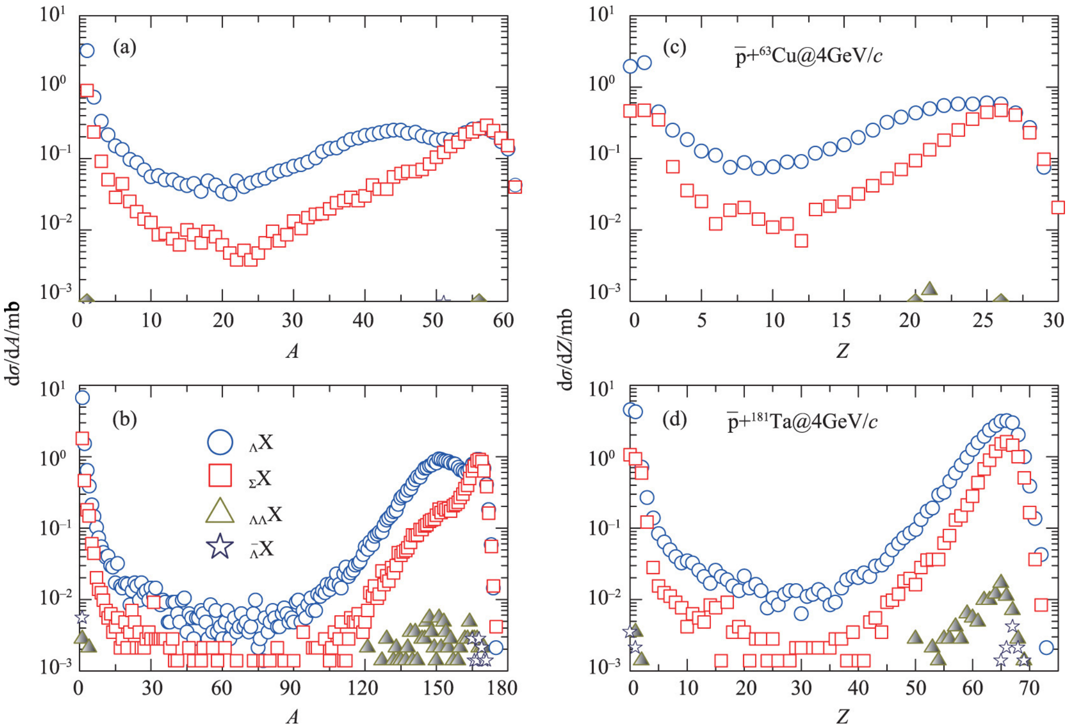

Fig. 2 (color online) Hyperfragments with strangeness $s = -1$ ($_\Lambda$X), s=1 ($_{\overline{\Lambda}}X$) and $s = -2$ ($_{\Lambda\Lambda}X$) spectra as functions of atomic number (left panel) and charged number (right panel) in collisions of $\overline{\mathrm{p}}$ on ^{63}Cu (upper window) and ^{181}Ta (down window) at incident momentum of 4 GeV/c.

with the help of the GEMINI approach. The fragmentation reactions induced by low-energy antiprotons can be nicely described with the combined approach. The production of hyperons is mainly attributed from the direct contribution of N$\overline{\mathrm{N}}$ collisions, mesons induced and strangeness exchange reactions. Hyperfragments are formed within the narrower rapidities in comparison with nucleonic fragments and hyperons. Heavy hyperfragments close to the target-mass region have larger cross sections. The hypernuclei with strangeness $s=-2$ (double Λ-hypernucleus) and s=1 ($\overline{\Lambda}$-hypernucleus) would be feasible with the antiproton beams at PANDA (Antiproton Annihilation at Darmstadt, Germany) in the near future experiments.

References

[1] Z. Q. Feng, H. Lenske, Phys. Rev. C, 89(2014)044617.

[2] Z. Q. Feng, Phys. Rev. C, 93(2016)041601; Phys. Rev. C, 94(2016)064601.