Coulomb production of relativistic hypernuclei

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The cross sections for the electromagnetic production of hypernuclei in nuclear Coulomb fields are calculated for ^{16}O, ^{28}Si, ^{32}S, ^{197}Au, and ^{238}U as they collide with U and Pt nuclei. The collisions occur in external targets and in incident beams of relativistic ions, at energies up to the values which will be realized at the RHIC. The calculations are carried out by the Williams–Weizsäcker method.

The production of relativistic hypernuclei by relativistic nuclei creates new opportunities for identifying and measuring the lifetimes of hypernuclei, because of the large Lorentz factor γ of the secondary particles, which are emitted in a narrow cone.[1,2] So far, the theoretical[3–7] and experimental[8,9] research on these processes has been confined to the nuclear mechanism at $\gamma < 15$.

According to the Williams–Weizsäcker method, the cross section $\sigma_{\rm em}^{\rm tot}$, summed over all multipolarities, for the Coulomb production of some hypernucleus can be written (Ref. 10, for example)

$$\sigma_{\rm em}^{\rm tot} = \int n_{bb}(E_\gamma)\sigma_\gamma(E_\gamma)dE_\gamma, \tag{1}$$

where $n_{bb}(E_\gamma)$ is the well-known spectrum of virtual photons, and $\sigma_\gamma(E_\gamma)$ is the cross section for the photoproduction of a given hypernucleus by a photon of energy E_γ. In view of the various approximations in this study, we used the results of a numerical simulation[11] of the interaction of photons with bismuth nuclei in present calculations. Those results show that the branching ratio for the production of hypernuclei, in comparison with the production of a Λ hyperon, ranges from 12.5% near the threshold to 5% at $E_\gamma \simeq 1$–2 GeV. The cross section for the production of a Λ hyperon at nucleons[12] is ≈ 2 μb at $E_\gamma \simeq 1$–2 GeV and then falls off with increasing E_γ. To find

TABLE I. Cross sections (in microbarns) for the Coulomb production of hypernuclei in collisions of various nuclei with various effective values of γ.

Nuclei	$\gamma = 60$	$\gamma = 200$	$\gamma = 20000$
$^{28}Si + U$	10,6	85,1	625.0
$^{197}Au + U$	34.2	440,0	4152.8
$^{238}U + U$	37.0	502.0	5017.0
$^{16}O + Pt$	5.6	38.7	258.0
$^{32}S + Pt$	9.3	71,7	516.0

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a lower limit on the cross section, we carry out the integration in (1) over the interval from 1 to 2 GeV, and we assume that the cross section for production at nuclei with an atomic weight A is proportional to A. The limiting energy of the spectrum of virtual photons is assumed to be $E_{\gamma\max} = \gamma\hbar c/b_{\min}$, where the minimum impact parameter is $b_{\min} = R_1 + R_2$ ($R_{1,2}$ are the mean square radii of the colliding nuclei). Some of the results of our calculations are shown in Table I.

It follows from this table that σ_{em}^{tot} increases with increasing energy of the colliding nuclei (at $\gamma > 100$, the cross section σ_{em}^{tot} is more than several millibarns). The Coulomb production of hypernuclei could thus be studied experimentally and utilized at the SPS and the RHIC.

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