E882-A – Measurement of Charge-Changing Cross Sections for Au Ions

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Physics Goals:	Cross Sections for Nuclear Fragmentation, Electromagnetic Dissociation, Charge Pickup, and Electron Capture and Stripping
Beams:	Au at 11.4 A GeV
Targets:	CH_2, C, Al, Fe, Cu, Sn, and Pb

Experiment Description

Using a novel phosphate glass track-etch detector BP-1 and an automated scanning system, E882-A carried out a series of small-scale experiments. We exposed several stacks of the glass detectors interleaved with various targets to a beam of 11.4 A GeV ^{197}Au at a density of ~ 1000 cm^{-2}. Fragments with $Z \geq 68$ were identified in BP-1 detector with a charge resolution of $\sigma_Z \sim 0.1$ charge unit. Data were taken by automatically scanning the sheets with a computer-controlled microscope and using automated image-processing techniques to fit the ellipses to the intercepts of etchpit mouths with the surfaces.

Physics Summary

We measured the cross sections for several interesting charge-changing interactions in peripheral collisions of 11.4 A GeV ^{197}Au nuclei with various targets. The main topics studied are nuclear charge pickup reaction, nuclear spallation, electromagnetic dissociation, and electron capture and stripping processes. We also measured the cross sections for fragmentation of secondary beams with $68 \leq Z \leq 80$.

1. Charge Pickup Reaction

We established that the charge pickup cross section scales with target mass as $\sim A_T^{0.37}$. We found that the projectile dependence is more rapid than linear, and not inconsistent with the quadratic dependence as found at ~ 1 A GeV. We discovered that the cross section for charge-changing fragmentation of the secondary beams with $Z = 80$ formed in charge pickup is enhanced roughly by a factor of two compared to that for a Au ion.

2. Nuclear and Electromagnetic Spallation

We discovered that the large Coulomb barrier for Au reduces the electromagnetic contribution σ_{em} in a Pb target to only $\sim 18\%$ of nuclear contribution σ_{nuc}, compared with $\sim 70\%$ for 14.5 A GeV ^{28}Si and $\sim 120\%$ for 200 A GeV ^{32}S. With σ_{em} taken to be $\propto Z_T^{1.8}$, σ_{nuc} can be fitted with $\sigma_{nuc} = \alpha(A_P^{1/3} + A_T^{1/3} - b)^2$, with $b = 0.83$ and $\alpha = 59$ mb, essentially the same as found at energies of ~ 1 A GeV.

3. Fragmentation of Secondary beams

We observed an enhancement in total charge-changing cross sections for secondary beams compared to those for stable beams with similar charges. The amount of enhancement depends on the target in which the secondary fragments are produced, being 10 to 30% for light targets and up to 80% for a Pb target. We found an enhancement in partial cross sections for breakup into visible charge loss channels.

4. Electron Capture and Stripping Processes

The measured electron capture cross section in BP-1 glass is consistent with the prediction of radiative capture, and with the calculation of the vacuum capture. However, the measured cross section for stripping differs from the prediction by a factor of 2. We set an upper limit for vacuum capture which constrains recent non-perturbative calculations. In 1994 run we are measuring the cross section for electron capture and loss processes in C, Al, Cu, and Au. The experimentally determined target dependence will enable us to measure the vacuum capture contribution. Since the vacuum capture is expected to become the dominant electron-capture process at high energies, it could intrinsically limit the beam lifetime for future heavy ion colliders such as RHIC. Our measurements are of interest for RHIC.

Selected Publications

"Measurement of cross section for charge pickup by 11.4 A GeV gold ions", Y. D. He and P. B. Price, Phys. Lett. B **298** (1993) 50–53.

"Measurement of cross sections for electron capture and stripping by highly relativistic ions", A. J. Westphal and Y. D. He, Phys. Rev. Lett. **71** (1993) 1160–1163.

"Response of BP-1 phosphate glass track-etch detector to relativistic heavy ions", Y. D. He, A. J. Westphal, and P. B. Price, Nucl. Instrum. Meth. B **84** (1994) 67–76.

"First measurement of charge-changing cross sections for 11.4 A GeV ^{197}Au in various targets", Y. D. He and P. B. Price, Nucl. Phys. A **566** (1994) 363c–366c.

"Nuclear and electromagnetic fragmentation of 2.25-TeV ^{197}Au", Y. D. He and P. B. Price, Z. Phys. A **348** (1994) 105–109.

Related Experiments

E793, E882-B