Charge Fraction Measurements for Ar^{q+}(Q=2-13) Incident Projectiles Backscattered from Au(110) During Quasi-binary Collisions in the Energy Range 5-35 keV

S. Datz, F.W. Meyer, V.A. Morozov, and R. Vane (meyerfw@ornl.gov)
Physics Division, Oak Ridge National Laboratory*, Oak Ridge, Tennessee 37831-6372

We have utilized a linear time-of-flight (TOF) analyzer to perform measurements of projectile backscattering from a clean, well-characterized metal surface as function of incident projectile energy and charge state. A biased drift region in the TOF analyzer [1] permits separation of scattered charged states including neutrals, and thus permits the determination of absolute scattered charge fractions. In this contribution we report on measurements of 120° backscattered charge fractions for Ar^{q+} (q=2-13) projectiles incident on Au(110) in the energy range 5 - 35 keV that undergo large-angle quasi-binary collisions with Au atoms. The measurements were carried out at the ORNL Multicharged Ion Research Facility (MIRF).

Motivation for this work arises from previous low energy measurements of scattered charge fractions for grazing multicharged ion-surface interactions [2], which found the observed scattered charge fractions to be essentially equilibrated, i.e. the dominant charge fraction was found to be largely independent of initial charge, with neutrals being the dominant scattered charge state. In the case of grazing incidence, the final scattered charge state is the result of many distant collisions with surface atoms, and total interaction times for few-keV range incident energies are typically tens of femtoseconds. The intent of the present investigation was to restrict the interaction to one, or at most two, well-defined large scattering angle binary collisions, and thereby to reduce the interaction times sufficiently to permit study of the scattered charge states prior to equilibration.

We briefly summarize the present results as follows. For incident charge states $Q_i < +8$, essentially complete equilibration of the scattered charge states is observed, even at the higher energies in the investigated range. For incident charge states with L-shell vacancies, however, significant deviations from charge equilibration in the scattered charge states are now seen. While at the lowest investigated energies, the dominant scattered fraction is still neutral, its fraction changes from about 90% for incident $Q_i = +2$ to about 50% for incident $Q_i = +13$. At the high energy extreme of the measurements, the neutral fraction is less than 20% for projectiles carrying initial L-shell vacancies, with the peak of the distribution having shifted to q = +1 for incident $Q_i = +9$, and to q = +2 for incident $Q_i = +13$. The fractions of scattered charge states $q > +1$ all increase monotonically within increasing energy, while the q +1 fraction goes through an extremum for all incident charge states $Q_i > +8$. As expected, the neutral fraction decreases in all cases monotonically with energy.

Systematic similarities between the magnitudes and energy dependences of scattered charge states differing from the respective incident charge states with initial L-shell vacancies by fixed numbers of charges, may provide information on the mechanism and time scale by which the projectile L-shell vacancies are filled. More quantitative analysis and interpretation of the data will be presented at the conference.

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[1] V.A. Morozov and F.W. Meyer, *Rev. Sci. Instrum*. **70,** 4515 (1999).
[2] e.g., L. Folkerts, S. Schippers, D.M. Zehner, and F.W. Meyer, *Phys. Rev. Lett.* **75**, 983 (1995), *Nucl. Instrum. Methods Phys. Res. B* **100**, 366 (1995).