ION-SOLID INTERACTIONS

C. O. Reinhold, J. Burgdörfer[1]

The study of the interaction of charged ions with solids (transmission) and surfaces provides an important link between atomic physics and condensed matter physics. Comparative analysis affords the opportunity to extract information about the electronic structure of the solid and many-body interactions. This information is obtained using fast and slow ions and observing image energy gain of ions, electron emission (Auger emission and kinetic emission), sputtering yields, and x-ray emission. Our theoretical work in this area[2–5] is done in close collaboration with experiments at ORNL (Meyer et al., Elston et al., Datz et al.) and LANSCE (Bryant et al.). Recently, our interest has shifted towards the following:

(i) Transport of atomic states of fast ions through solids. Based on our previous experience in classical transport theories,[2] we are presently developing a quantum description for the evolution of atomic states of fast projectiles traveling through matter. Our approach is based on the solution of a quantum Langevin equation, i.e. a stochastic time-dependent Schrödinger equation that describes electronic excitations of atoms during their transport through solids. This description can be considered the quantized version of a previously developed classical transport theory. We plan to analyze in detail the correspondence between classical and quantum transport simulations. Applications to the stripping of relativistic H^- and H through thin carbon foils are also planned. The latter, stripping of H, is important in relation to recent proposals for detecting relativistic anti-hydrogen through the Ly_α emission after controlled excitation in foil transmission. In turn, stripping of H^- plays a key role for the reference design of next-generation spallation neutron sources (SNSs). Typically, an H^- beam in the form of macropulses is accelerated to $\sim$ 1 GeV in a linear accelerator, and is subsequently stripped to bare protons by transmission through a thin foil and injected into and stored in an accumulator ring. The effective conversion of H^- to H^+ and the underlying beam-foil interaction at the point of injection is a crucial element for the design of high-intensity SNSs. A key parameter is the population of excited neutrals H(n) which may get stripped by the strong magnetic field in the first bending magnet. The resulting protons collide with walls and magnets leading to unacceptably high levels of radioactivity along the beam line.

(ii) Neutralization dynamics of slow multicharged ions with insulator surfaces. The interest in these surfaces is largely driven by the potential technological applications of ion-surface interactions to surface modification and diagnostics. We have made considerable theoretical progress towards the understanding of the neutralization of slow multiply charged ions in front of ionic crystals, in particular LiF.[3,4] Our calculations can approximately predict the hole density and distribution created by multiple charge transfer. The subsequent evolution and redistribution of the microscopic charge-up of the surface is important for the understanding of ion neutralization in front of the surface. Two forces influence the trajectory: The ion is attracted by the negative image charge in the surface, and it is repelled by the positive holes that are created in the surface due to electron capture ("trampoline effect"). The balance between these two forces depends critically on the mobility of the

”hot” holes and the efficiency of the charge transfer process. We are currently studying the charge state, the energy distribution, and the angular distribution of the backscattered ions and atoms. One of our main goals is the determination of the contributions from binary collisions and collective backscattering processes to the total reflection coefficient.

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[1]Adjunct staff member from University of Tennessee, Knoxville.

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[5]B Rosner et al., *Phys. Rev.* A **57**, 2737 (1998).