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ATOMIC-PHYSICS RESEARCH RELEVANT TO FUSION: D- FORMATION, AND FAST MULTICHARGED ION-ATOM COLLISIONS

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Presented in the session on Atomic Data Relevant to Fusion at the XII International Conference on the Physics of Electronic and Atomic Collisions, Gatlinburg, TN, July 21, 1981

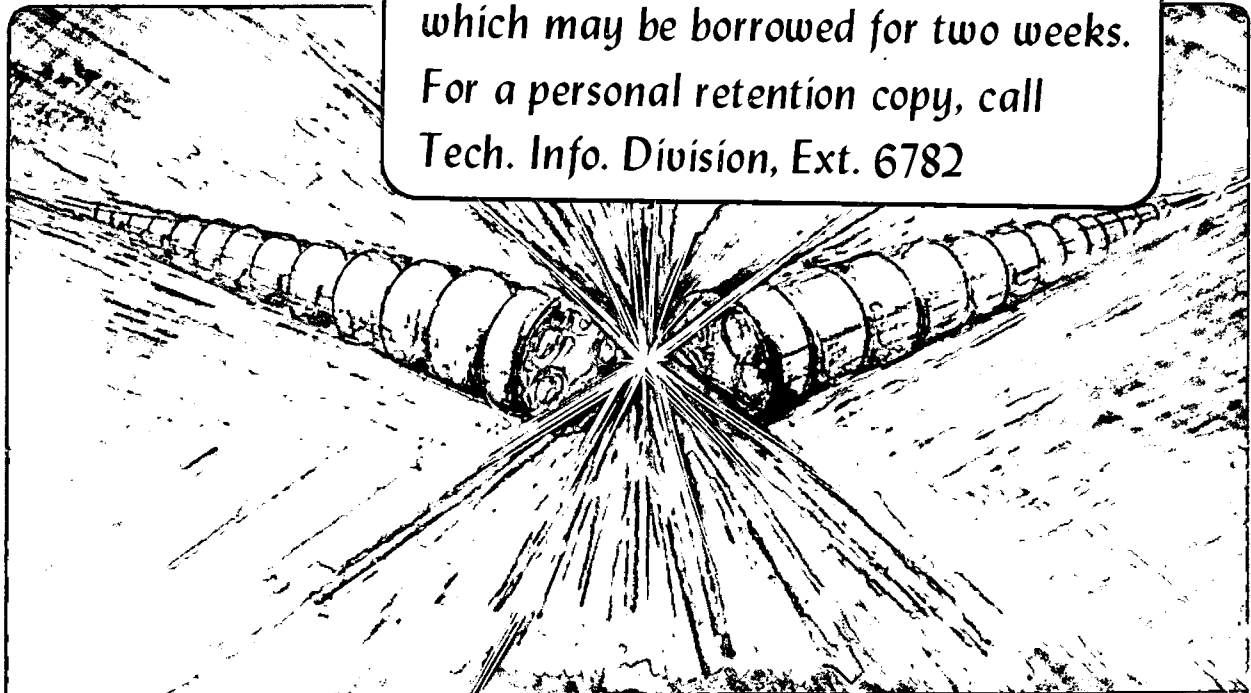
ATOMIC-PHYSICS RESEARCH RELEVANT TO FUSION:  
D<sup>-</sup> FORMATION, AND FAST MULTICHARGED ION-ATOM COLLISIONS

Alfred S. Schlachter

July 1981

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Atomic-Physics Research Relevant to Fusion:  
D<sup>-</sup> Formation, and Fast Multicharged Ion-Atom Collisions\*

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July 1981

Presented in the session on Atomic Data Relevant to Fusion  
at the XII ICPEAC in Gatlinburg, Tennessee (July 21, 1981).

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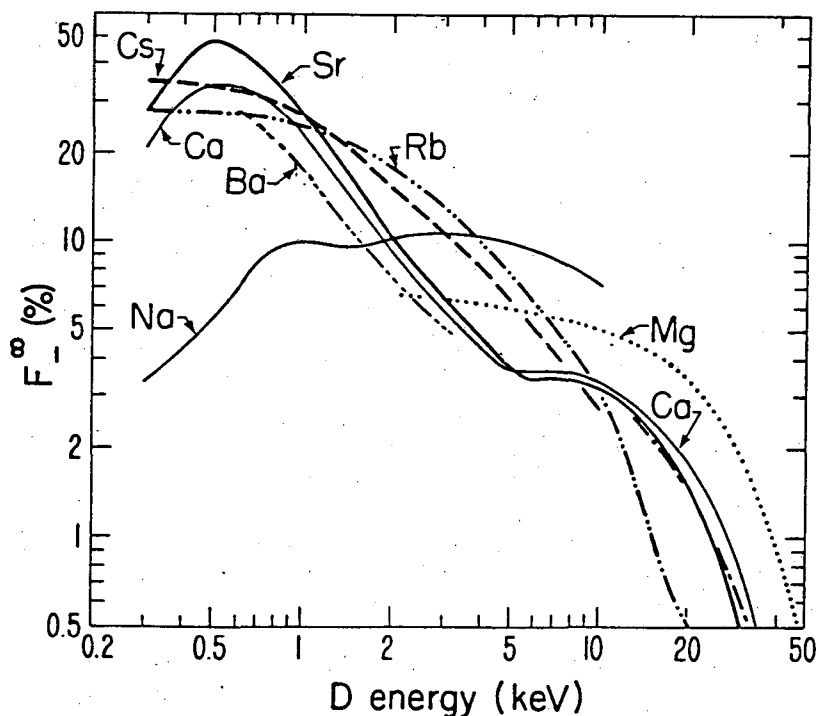
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Intense beams of D<sup>-</sup> are of interest for the formation of fast D<sup>0</sup> beams for the heating and fueling of magnetically confined plasmas. Methods of creating D<sup>-</sup> beams include charge transfer<sup>1-2</sup> of low-energy D<sup>+</sup> in a vapour target, back-scattering<sup>3</sup> of a D<sup>+</sup> or D<sup>0</sup> beam from a surface, direct extraction from a discharge, and surface conversion in a discharge. The atomic-physics and neutral-beam groups at the Lawrence Berkeley Laboratory have studied all these methods. Results for D<sup>-</sup> formation by charge transfer<sup>4</sup> are shown in Figure 1.



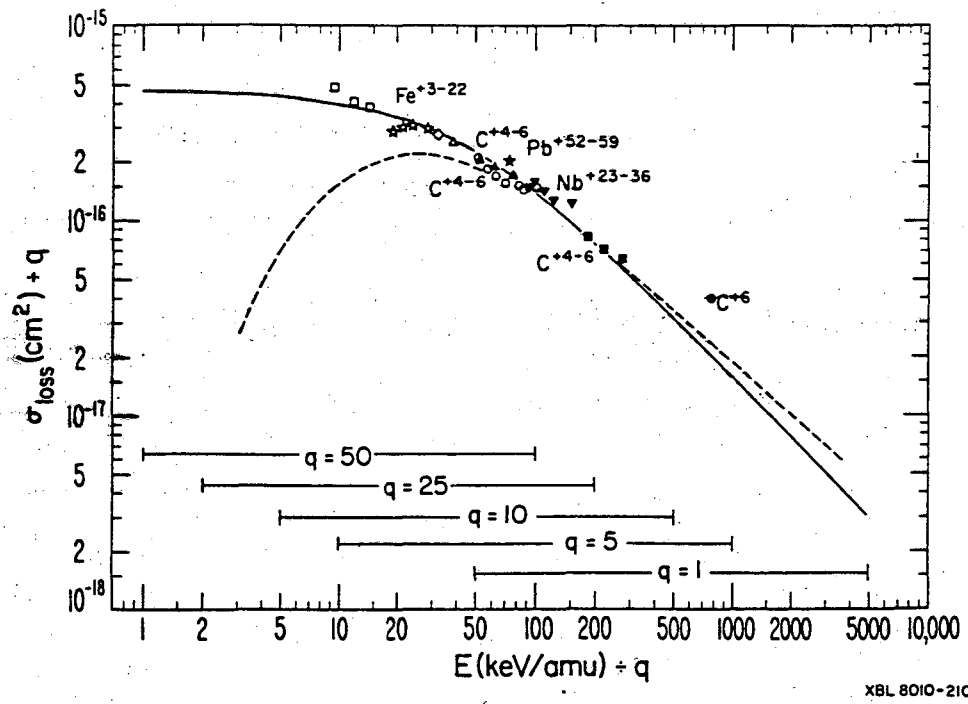
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Fig.1 Equilibrium yield  $F_{\infty}^{\circ}$  for D in various vapour targets.

The high  $D^-$  yield from charge transfer in a thick cesium-vapor target <sup>1</sup> is consistent with recent cross-section calculations and measurements. Recent theoretical calculations of cross sections in thick alkaline-earth-vapor targets, leading to prediction of a large  $D^-$  yield at low energy, have been confirmed <sup>4</sup> in recent measurements in which a  $D^-$  yield of 50% was observed at a D energy of 500 eV.

The energy deposition or ionization profile of a fast  $D^0$  beam injected into a plasma can be altered by the presence of highly stripped impurity ions which are present in the plasma. In order to estimate how large an effect an impurity ion could have on the trapping profile, it is necessary to know the cross section for electron loss (electron removal) from the hydrogen atom. We have made measurements <sup>5,6</sup> of electron loss with fast highly stripped ion beams incident on  $H_2$ , using the approximation that, at sufficiently high energies, the ionization of  $H_2$  is nearly that of 2 H atoms. The measurements agree very well with classical-trajectory Monte Carlo calculations and with our scaling rule <sup>7,8</sup> for electron loss, shown in Fig.2.

We have recently extended ionization measurements <sup>9</sup> to multielectron targets. Net ionization cross sections are found to reduce to a common curve when plotted as cross section divided by charge state versus energy per nucleon divided by charge state. Furthermore, we have used a time-of-flight coincidence technique to measure recoil-ion charge-state spectra <sup>10</sup> created by passage of a fast highly



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Fig. 2 Hydrogen electron-loss cross section  $\sigma_{loss}$ . Solid line: calculation for electron loss by atomic H in collision with an ion in charge state  $q$ ; valid for  $1 \leq q \leq 50$  and for energy range 50 to 5000 keV/amu. Dashed line: plane-wave Born approximation (ionization only).

charged beam through a rare-gas target. A sample spectrum for 1.4 MeV/amu  $U^{44+}$  in Ne is shown in Fig. 3.

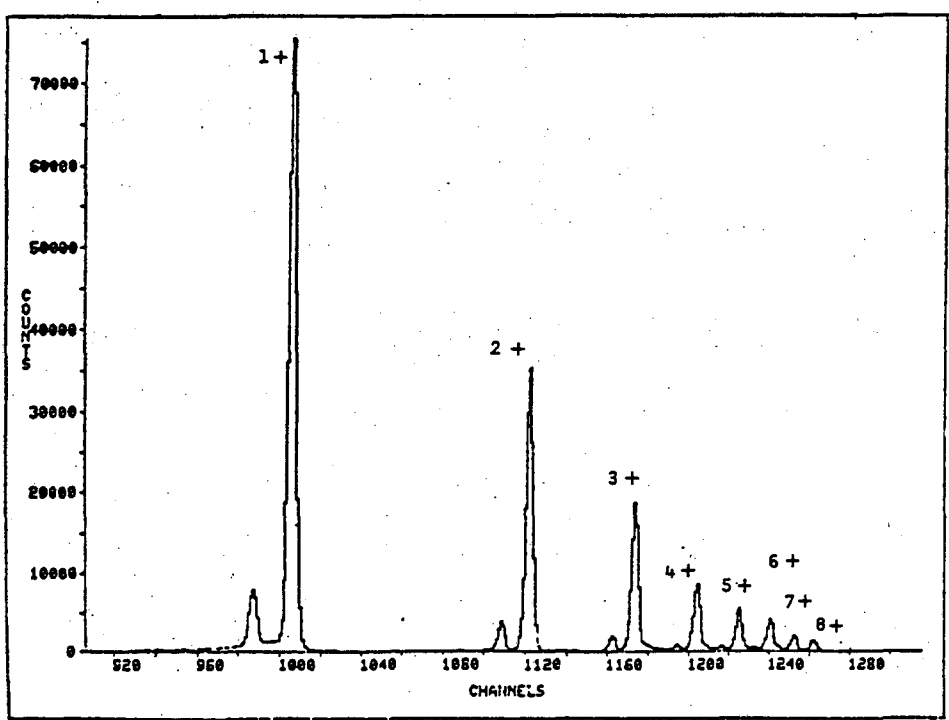


Fig. 3 Recoil-ion time-of-flight spectrum for 1.4 MeV/amu  $U^{44+}$  in Ne. The Ne recoil charge states 1+ to 8+ are identified. The small peaks to the left of the larger peaks are due to the  $^{22}Ne$  isotope.

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1. A.S.Schlachter, K.R.Stalder, and J.W.Stearns, Phys.Rev. A 22, 2494 (1980).
2. A.S.Schlachter in Proceedings of the Second International Symposium on the Production and Neutralization of Negative Hydrogen Ions and Beams (Brookhaven, 1980), BNL 51304, p.42.
3. P.J.Schneider, K.H.Berkner, W.G.Graham, R.V.Pyle, and J.W.Stearns, Phys.Rev. B 23, 941 (1981); J.R.Hiskes and P.J.Schneider, Phys.Rev. B 23, 949 (1981).
4. R.H.McFarland, A.S.Schlachter, J.W.Stearns, and R.E.Olson, in Proceedings of the XII ICPEAC (Gatlinburg, 1981), p. 634; R.H.McFarland, A.S.Schlachter, J.W.Stearns, R.E.Olson, and B.Liu, article in preparation.
5. K.H.Berkner, W.G.Graham, R.V.Pyle, A.S.Schlachter, J.W.Stearns, and R.E.Olson, J.Phys. B 11, 875 (1978).
6. K.H.Berkner, W.G.Graham, R.V.Pyle, A.S.Schlachter, and J.W.Stearns, Phys.Rev. A 23, 2891 (1981).
7. R.E.Olson, K.H.Berkner, W.G.Graham, R.V.Pyle, A.S.Schlachter, and J.W.Stearns, Phys.Rev.Lett. 41, 163 (1978).
8. A.S.Schlachter, K.H.Berkner, W.G.Graham, R.V.Pyle, J.W.Stearns, and J.W.Tanis, Phys.Rev. A 24, 1110 (1981).



9. A.S.Schlachter, K.H.Berkner, W.G.Graham, R.V.Pyle, P.J.Schneider, K.R.Stalder, J.W.Stearns, J.A.Tanis, and R.E.Olson, Phys.Rev. A 23, 2331 (1981); A.S.Schlachter, IEEE Trans.Nucl.Sci. NS-28, 1039 (1981).
  
10. A.S.Schlachter, in Second Workshop on EBIS and Related Topics, Saclay and Orsay, 1981; H.F.Beyer, W.Groh, R.Mann, A.Müller, R.E.Olson, and A.S.Schlachter, article in preparation.

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