is straightforward, the inelastic atom-atom collision calculations are much more difficult. *Cornwall* [1971] uses an estimate that bound electrons are 8% as effective as free electrons in absorbing energy.

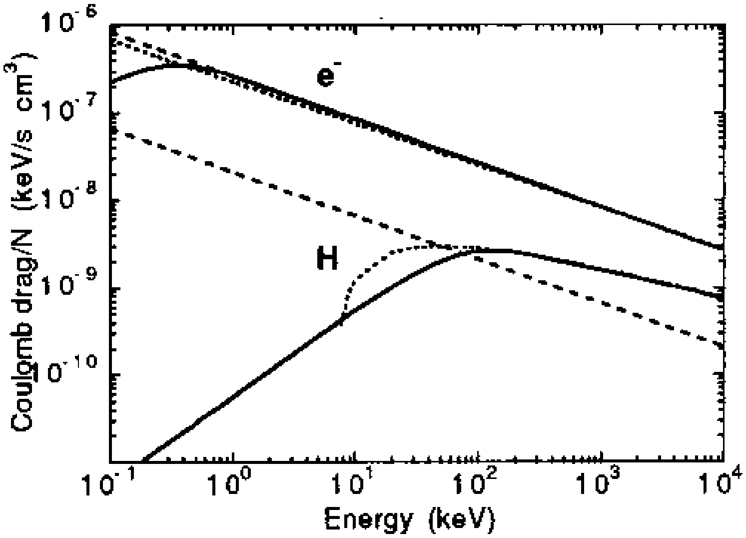

Fig. 7. Normalized Coulomb rate σv (keV/s-particle) for collisions with free electrons (upper curves), and collisions with neutral hydrogen (lower curves). Dotted lines are from *Schulz and Lanzerotti* [1974], dashed lines are from *Cornwall* [1972], upper solid line is from *Itikawa and Aono* [1966], and lower solid line is from *Ziegler* [1980].

we normalized the experimental cross section in the high-energy limit to the Bethe approximation. We plot these cross sections as normalized rates (σv, where v is the relative velocity) in Figure 7, setting $T_e = 1$ eV.

Charge Exchange Losses

Charge exchange becomes a significant loss mechanism when a singly ionized atom captures an electron and becomes an untrapped neutral. For $Z > 1$, charge exchange also can be a source term; e.g., He^{++} can capture an electron to become He^{+}, and He^{+} can lose an electron to become He^{++}, coupling the two diffusion equations for helium. In Appendix B on microfiche we plot the cross sections for all potentially important reactions. We have fit cubic splines to the logarithms of the cross sections, σ, at logarithmically spaced energies, and multiplied by the target density and the projectile velocity to obtain the reaction rates $n\sigma v$ which are shown in Figure 8. The four magnetospheric charge exchange loss processes listed above are displayed in four columns, while target species are listed by rows. The row indicated by an asterisk displays cold electron targets in the first three columns, and double electron capture from He in the last column. The row indicated by two asterisks displays O^{+} in columns 1 and 2, H^{+} in column 3, and double electron capture from O in column 4. All the target species are taken to be at rest or at zero temperature, which is only critical for the electron

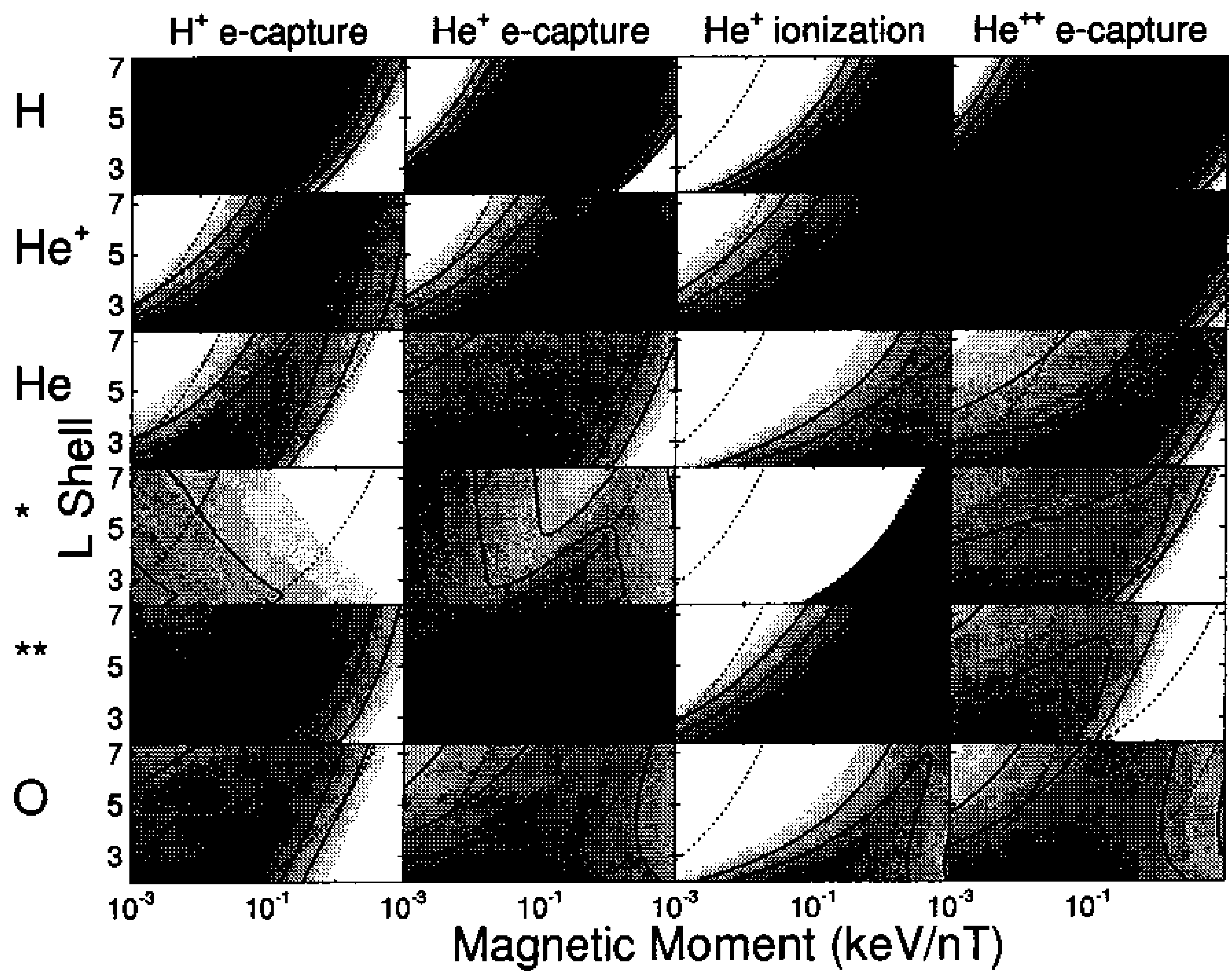

Fig. 8. Charge exchange rates $n\sigma v$ (s^{-1}) for H^{+}, He^{+}, and He^{++}. Contours are drawn every decade, from 10^{-12} (white) to 10^{-4} (black). Dashed lines bracket the AMPTE/CCE/CHEM energy range. The row indicated by an asterisk displays rates with cold plasmasphere electrons in columns 1-3, and double electron capture from He in column 4. The row indicated by two asterisks displays rates with O^{+} in columns 1-2, H^{+} in column 3, and double electron capture from O in column 4. Free electron capture by ring current H^{+} and He^{++} is very unlikely. Other O and O^{+} cross sections were unavailable.