ATOMIC DATA NEEDED FOR X-RAY AND EUV ASTRONOMY

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ABSTRACT. The astronomical X-ray and EUV satellites of the past generally had low enough spectral resolution that atomic data of modest quality was sufficient for most interpretation of the data. Typical proportional counter resolution Δ E/E $\sim$ 1 permits a determination of the spectral shape sufficient for an estimate of the temperature of the emitting gas, but only the Fe K feature at 6.7 keV stands out as a distinct emission line. The higher spectral resolution *Einstein* Transmission Grating, Solid State Spectrometer, and Focal Plane Crystal Spectrometer instruments measured a score of emission lines or line blends, permitting determinations of the elemental abundances, temperature, and ionization state of the emitting gas. The higher spectral resolution and throughput of the BBXRT aboard the ASTRO mission and the instruments planned for EUVE, ASTRO-D, AXAF, and XMM will make possible a far more detailed analysis of the data. It should be possible to derive better abundances for more elements, accurate temperature distributions, electron densities, and accurate ionization states.

The earlier analyses were not greatly limited by the quality of available atomic data, but those planned for the future will be. The ionization balance is computed from the collisional ionization and recombination rates. Those now available are typically accurate to about 30%. Different theoretical ionization equilibrium calculations show differences in the peak temperature for a given ion of about 0.1 in Log T. The predictions of different ionization balance models for the abundance of an ion away from its peak abundance often differ by a factor of two. After a decade of investigation, there remains a discrepancy between the ratio of Li-like to He-like iron observed in solar flares and that predicted theoretically. The largest contributor to the uncertainty is the dielectronic recombination rate. Radiative recombination rates appear to be generally more reliable.

The second part of the analysis of a measured emission line intensity is the collisional excitation rate. Collision rates for some transitions have been measured

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in the laboratory, but measurements at the 10% accuracy level are mostly made on ultraviolet lines of ions of low charge. Theoretical collision rates are often based on Distorted Wave or Close-Coupling computations of the collision strengths. Distorted Wave collision strengths are available for most of the strongest transitions, and the usual accuracy estimate of such calculations is about 20%. Close-Coupling calculations require far more computer time, so they are available for far fewer transitions. They are in principle more accurate in that they include resonance structure in the collision cross sections, but they can be seriously wrong if an important state is not included in the scattering matrix. Laboratory measurements of resonance lines of simple, low Z ions confirm the estimated accuracy of these calculations, but the situation is much worse for complicated ions and for excitation to higher levels. Both laboratory and solar observations show factor-of-two errors in the relative excitation rates to the 3s, 3p and 3d levels of Li-like and Be-like ions. The iron ions Fe VIII - Fe XVI are especially important in the 40 - 200 Å range, while the Ne-like through Li-like iron ions produce the strong complex near 1 keV.

When the collision strengths become better than 10%, it will be necessary to pay more careful attention to many other processes. Density sensitivity of the dielectronic recombination rates, cascades from more highly excited levels, recombination to excited states as a contributor to emission line excitation, resonance scattering, and non-Maxwellian velocity distributions are probably each important in some situations.

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