Measurement of Lifetimes and f-Values in Multiply-Charged Positive Ions

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Measurements will continue to be made of lifetimes of metastable levels in singly- and multiply charged ions (MCI) which have significant density and can contribute to the optical absorptions, emissions and energy balance in the ISM, stellar atmospheres, etc. These ion charge states are important for interpretation of data obtained from GHRS/HST, EUVE, STIS/HST, and the planned FUSE missions. Accurate column densities of abundant species found in the ISM are limited by the presence of strong electric dipole transitions with equivalent widths (EW) that lie on the saturated part of the curve of growth. Hence reliable column densities require metastable state measurements with small f-values, where EW's are on the linear part of the curve. Intensity ratios between forbidden and allowed transitions are density and temperature sensitive, and critically depend on the lifetimes of the metastable or intersystem line. However, calculated and measured lifetimes in some cases can differ by a factor of three. The vast majority of transition rates required are presently being calculated by theory alone,which if unchecked by benchmark experiments can lead to orders of magnitude error in the estimation of electron densities and temperatures from diagnostic line ratios. MCI metastable lifetime measurements reported here use the JPL CAPRICE electron-cyclotron resonance ion source (ECRIS) which provides microampere currents of charge states such as C II-VII, S II-VII, Ne II-VI, and Mg II-VI. Metastable ions are injected into a Kingdon ion trap and stored for times longer than the metastable lifetimes (.001 to 1 second). Decay channels include intercombination, electric quadrupole E2, magnetic dipole M1 and double photon decay 2E transitions. The UV photon emission are detected by (a) interference filter and phototube using a UV grade quartz optical system and (b) for transitions shorter than 180 nm, a cesium-iodide coated microchannel plate enhanced for UV performance. The JPL ion trap, constructed in collaboration with Texas A & M University[1] is on a dedicated beam line. The measured lifetimes for C II at 232.5 nm, N II at 215.5 nm and Ar III at 519 nm will be presented. Results are in good agreement with other experiments and theoretical calculations. Additional series of measurements will be made of the astrophysically relevant species N III at 174 nm, Ne V at 113.4 nm, and S III at 171.3 nm. The accuracy is at the 5-10% level.

References:

(1) L. Yang and D.A. Church, Phys. Rev. Lett. 70, 3860 (1993).

Acknowledgments:

J. Greenwood acknowledges support through a NASA-NRC fellowship. This work was carried out at JPL/Caltech, and supported by NASA.