LABORATORY NEEDS OF CURRENT AND FUTURE SPACE SPECTROSCOPIC ASTROPHYSICS MISSIONS

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Astrophysics bears a distinct relation to Robin Hood's robbing from the data rich and giving to the poor, in this case, observers. The basic data obtained from laboratory investigation is essential to the understanding of the diverse cosmic environments with which observers and modelers have to deal.

The broad areas of investigation pioneered in the ultraviolet by the *International Ultraviolet Explorer* satellite (*IUE*) and certain to be the focus of the spectrographs on the *Hubble Space Telescope* and *FUSE/Lyman* are: 1. planetary atmospheres, magnetospheres and comets; 2. stellar atmospheres; and 3. H II regions and diffuse interstellar gas. The last of these is to be understood in both Galactic and extragalactic contexts. These illustrate the diversity of the required data, and also highlight the existing *lacunae* in the available data sets. I shall touch briefly in this note on each of them.

1. Planetary atmospheres: Here the need is for vibrational and electronic transition probabilities and oscillator strengths of molecular species ranging from diatoms to very complex species. In addition, van der Waals broadening coefficients are needed in order to properly calculate the atmospheric structures. Earth orbital reconnaissance over timescales of decades, a product of *IUE* and a promise of both *HST* and *Lyman*, will be essential in unraveling the long-term behavior of global atmospheric systems in the Jovian planets. Recent work on H_3^+ in the Jovian atmosphere (Drossart *et al.* 1989) has provided an important tool for the imaging and spectroscopy of auroral regions of planetary atmospheres. Accurate identification of energy levels and oscillator strengths should allow for the determination of the spectrum of precipitating magnetospheric particles.

Ultraviolet observations of cometary comas and of planetary magnetospheres have emphasized the need for additional data on S_2 and related sulfurous ionic species (Festou and Feldman 1989) as well as the need for accurate transition probabilities and wavelengths for OH and even neutral atomic lines. High resolution (R>20000) observations will permit the analysis of both dynamics and thermal conditions in the comas and also some of the plasma properties of planetary magnetospheres, especially the Io torus.

2. Stellar Atmospheres and Winds: The only information we have about the chemical evolution of the Galaxy over the full span of its history comes from the analysis of stellar atmospheric spectra. Here the need is most accurate in the heavy elements. Neutral and ionized spectra for the iron peak and beyond are still very incomplete, leading both to numerous unidentified lines and possible confusion in the identification and abundance determination of trace species of nucleosynthetic importance (see Leckrone *et al.* 1991 for a striking example in the spectrum of the chemically peculiar star χ Lupi). The site of r-process nucleosynthesis is still an unsettled matter, and the sorting out of s- *vs.* r-process elemental abundances in stars, from Ba and S stars through the chemically peculiar main sequence stars, is an important clue. Therefore, the rare earths are very important

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although the lack of detailed laboratory analysis of many of these species still hampers serious progress in this field. Light ions are most important for understanding nucleosynthesis both cosmologically and in intermediate and low mass stars in very advanced evolutionary stages. Available instruments can not routinely obtain R>80000 in the $\lambda\lambda$1200-3000Å region, seriously pushing the incompleteness of available laboratory identifications.

Non-LTE analyses of stellar chromospheres and atmospheres require model atoms of increasing complexity and therefore collision strengths, transition probabilities, and state identifications and energies of species ranging from CNO through the heavy elements like Hg are needed. Isotopic shifts and hyperfine structure analyses are needed for several heavy species, notably the rare earths. Some of these data have recently become available through the NIST analyses of Pt (Reader *et al.* 1990) but other analyses are required. The Opacity Project has gone a long way toward making available collision strengths for light ions, but laboratory work on heavy species are also needed. Also needed are excited state identifications for molecules, notably oxides and nitrogen-bearing molecules. Identification of lines of highly ionized metals, like Fe V - VII are important for hot subdwarf and Wolf-Rayet stellar atmospheres. Fe II is still the dominant uncertainty in modeling novae and other massive ejecta from stars, like luminous blue variables and supernovae. The analysis of silicon (Artru *et al.* 1987) has been an important tool in the modeling of chemically peculiar stars and also provides a sterling example of how such work, done with an eye to the needs of the observers, can dramatically assist the understanding of complex problems.

3. Interstellar Medium: This is a broad field, spanning the widest range of density and excitation conditions and probably the one that most benefits from extremely precise laboratory analysis. Accurate wavelengths and oscillator strengths of resonance transitions for neutral through doubly ionized species are essential. Accurate energy levels and band strengths for CO, CN, OH, and H_2 are still extremely important and need improving. These probe the cold clouds and peripheral portions of molecular clouds (see Cardelli *et al.* 1991, Smith *et al.* 1991). Neutral and singly ionized atoms, not just CNO but also heavy elements, are in need of accurate wavelengths and oscillator strengths. Here the need is broad, because these are the dominant probes of the diffuse interstellar medium. Coronal ions, especially Mg V-VII through Ne IV-V, and also intercombination and forbidden lines of the iron peak coronal species, are all needed for the analysis of H II regions.

A more complete account of this talk will be found in the proceedings of the *Joint Commission Discussion*, to be published by Springer- Verlag.

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