Atomic Data and Stellar Chemical Compositions

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Abundance distributions in stars are the living records of Big Bang and Galactic nucleosynthesis. New spectrographs for 8-meter class ground-based telescopes and the Hubble Space Telescope provide data of very high resolution and signal-to-noise for stars ranging over three orders of magnitude in metallicity. NASA missions exploring wavelength regions inaccessible from the ground (e.g., FUSE, Kuiper Airborne Observatory) produce excellent spectroscopic data on nebulae surrounding evolved stars that are in the process of returning newly minted elements to the interstellar medium. Analyses of these spectra should yield a reconstruction of the origin and evolution with time of all major element groups in the Periodic Table. Indeed, rapid progress has been made in our understanding of the trends with metallicity and scatter at a given metallicity for the very light elements Li, Be, and B (e.g., [1],[3]), and the very heavy neutron-capture elements, especially those with atomic numbers greater than 55 (e.g., [4]).

But large abundance uncertainties remain for many of these elements and even for the apparently well-understood elements of the iron peak. Much of the difficulty must be attributed to lack of accurate atomic data (transition probabilities, hyperfine and/or isotopic splitting constants, partition functions) for the transitions that are accessible in stellar spectra. We will review recent successes in campaigns to upgrade the atomic data for the first three ionization stages of many rare-earth elements, and show the application of these new data to solar and stellar abundances. Illustrative examples will also be given of attempts to extract abundances of crucial elements for nucleosynthesis studies (e.g., B, Ge, Pt, Au) from complex UV stellar spectra, and to discover previously unidentified features of elements that should be present in planetary nebulae (e.g., [2]). These examples demonstrate the need for further development of comprehensive sets of accurate atomic parameters (particularly transition probabilities) for many species to be applied to spectroscopy of stars and nebulae.

References:

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