Atomic Oscillator Strengths in the Vacuum Ultraviolet

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Abstract

Transitions in singly-ionized and doubly-ionized iron-group elements give rise to prominent emission lines from a wide variety of astrophysical objects. Some of the most important lines are formed when the upper energy level is excited by radiation from hydrogen at 1216 Å(Ly-α), giving strong fluorescence lines from the vacuum ultraviolet to the infrared. These emission lines are important diagnostics of astrophysical plasmas, but laboratory oscillator strengths are unavailable.

The established way to measure accurate oscillator strengths for atomic lines combines the measurement of a lifetime of an upper energy level with a separate measurement of the branching fractions of all the lines emitted from that level. This technique relies on being able to observe *all* the spectral lines emitted by the upper level, which range down to Ly-α or below for many fluorescence lines. Methods of measuring branching fractions using Fourier transform spectroscopy are limited to wavelengths above about 1400 Å and cannot observe all the spectral lines required.

We have developed techniques to measure branching fractions in the vacuum ultraviolet using our 10.7 m normal incidence grating spectrograph. For this we use phosphor image plates as replacements for the photographic plates previously used on this instrument. Image plates are sensitive to wavelengths from the X-ray region to 2200 Å, and have a linear intensity response with a dynamic range of at least 10^{4}. We have recorded spectra of iron-neon hollow cathode and Penning discharges, using a deuterium standard lamp for radiometric calibration. Our measurements of Fe II branching ratios around 1600 Å agree with previously-published measurements to within 8 %. The reproducibility of our D_2 standard lamp spectra at shorter wavelengths is 4 % , enabling us to measure branching ratios down to 1150 Å. We are also investigating methods of radiometric calibration below 1150 Å using hollow cathode standard lamps. This will enable us to measure branching ratios down to 800 Å or below – a region with many resonance lines of doubly-ionized spectra and critical for the analysis of data from the Far Ultraviolet Spectroscopic Explorer.

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