Fluorescence in the Outer Atmospheres of Red Giant Stars

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The outer atmosphere of a cool red giant star is an ideal locale for the operation of line fluorescence processes. Low plasma densities imply low rates of collisional de-excitation and thus allow radiative decay of levels populated by selective radiative pumping. There are many strong sources of line radiation (i.e. possible pumps) and numerous possible upward transitions from highly populated low-lying levels of abundant elements such as Fe II, thus providing many chance coincidences between potential pumps and lines to be pumped. These conditions ensure that many of the chromospheric emission features observed in the UV spectrum of such a star are affected by fluorescence. Many of the observed emission features originate from energy levels populated solely by radiative fluorescent excitation, including strong lines of S I, O I, CO, Ni II, Si I, Fe I and Fe II, as well as weaker lines from Cr II and Co II. Important pumps active in these atmospheres include hydrogen Lyman alpha, and individual lines of O I, C I, Si II, Fe II, and Mg II. In the case of Fe II, there are many additional features arising from upper levels whose populations, although primarily maintained by collisions, are also significantly affected by radiative fluorescent excitation. In fact, there may be virtually no level in Fe II not affected to one degree or another by direct decays or cascades down from levels populated by fluorescence, driven either by Lyman alpha or, in some cases, by lines of Fe II itself ("self-fluorescence").

Neither the spectrum itself nor the structure of the atmosphere can be properly understood without properly accounting for these fluorescent processes. Furthermore, detailed modeling of the processes has potential for providing critical information on the structure (density, temperature, velocity) of these outer atmospheres, including a determination of whether they consist of hot and cool layers or are multi-component atmospheres within which cool and hot plasmas co-exist at similar heights above the photosphere.

I summarize in this paper the processes active in these atmospheres. Grotrian diagrams which illustrate selected processes are presented; in particular, a grandiose Fe II diagram showing all levels of importance to the UV spectrum, and illustrating the impact of fluorescent excitation on virtually all of these levels is shown. A preliminary model of the Fe II ion, being prepared for use with MULTI and PANDORA is discussed.

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