Determination of Radiative Parameters for the V I and V II Spectra: TR-LIF Measurements and HFR+CPOL Calculations

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The determination of elemental abundances and their patterns in stellar atmospheres has recently challenged the accuracy of the oscillator strengths used in the stellar spectrum modelling. Actually, recent studies [1–2] showed that an accuracy of the order of ∼0.05 dex in differential abundances (and therefore also in log gf) is needed to detect the effect of planet formation in the stellar atmospheres. These effects are marked by a ∼20% depletion of refractory elements with respect to the volatile elements. Vanadium ($Z = 23$) is a refractory elements that belongs to the iron group. Due to its complex electronic structure related to an open 3d subshell and a relatively high cosmic abundance, many lines of V I and V II are observed in solar and stellar spectra. The experimental oscillator strengths are essential to achieve the level of accuracy currently needed in elemental abundance determination. A reliable method for obtaining experimental oscillator strengths is through the combination of measured radiative lifetimes with accurate branching fractions.

In this work, radiative lifetimes of 79 levels of V I and of 27 levels of V II have been measured using time-resolved laser-induced fluorescence (TR-LIF) spectroscopy (see, e.g. Ref. [3]) in laser-produced plasma. The lifetime values range between 3.2 ns and 494 ns and their uncertainties are within ±10%. A good agreement was obtained with previous data. In order to obtain the branching fractions, the Hartree-Fock atomic structure package of R.D. Cowan [4] have been used in which a core-polarization potential and a correction to the dipole transition operator have been incorporated giving rise to the HFR+CPOL method [5]. The calculated branching fractions were then combined with the available experimental lifetimes to determine semi-empirical oscillator strengths for E1 transitions in V I and V II.

References

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