Lifetime measurements in singly and doubly ionized rare earths by time-resolved laser spectroscopy

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The lanthanides ($57 < Z < 71$) have recently attracted the interest of the astrophysicists because they are now currently identified on the high resolution astrophysical spectra (ground-based or Hubble Space Telescope spectra) and because they frequently lead to large overabundances in some stars when compared to the solar photospheric results.

Radiative lifetimes of excited states of rare earth ions (Yb III, Er II, Er III, Tm III, ...), some of them characterized by values ranging between 1 and 2 ns, have been measured using time-resolved laser-induced fluorescence. The experiment was carried out in Sweden at the Lund Laser Center. These measurements are extremely useful for testing the accuracy of the calculations recently performed in such complex ions or atoms.

To create tunable UV radiation with a narrow bandwidth and a short pulse duration, we used a multistage system. The frequency doubled output from a Q-switched, mode locked picosecond Nd:YAG laser, was used to pump a distributed feedback dye laser (DFDL) working in the 700-900 nm region. That pulse was subsequently amplified in a Ti:Sapphire crystal pumped by a second nanosecond Nd:YAG laser and frequency doubled or tripled with KDP or BBO crystals to get wavelengths in the 240-390 nm region. The $\approx$ 60 ps duration laser pulse of a few mJ was focused on the plume of rare earth ions generated by the 10-20 mJ pulse of a third Nd:YAG laser focused on a rotating target placed at the center of a vacuum chamber. The investigated states were selectively populated through different excitation schemes. The decay photons were observed with a monochromator acting as a wavelength selector and detected by a fast MCP photomultiplier. The signal was recorded by a Tektronix TDS684A 5GS/s oscilloscope and analysed online by a PC.

We will describe the experimental setup and discuss our new results in the context of recent calculations. More specifically, the measured lifetime values will be compared with theoretical HFR calculations obtained by taking configuration interaction and core-polarisation effects into account.