Time-resolved FTIR study of high-L Rydberg states of Li, Ca, Mg and Sr atoms

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Laser Induced Plasma Spectroscopy (LIPS) consists of analyzing the light spectrum emitted from plasma created on the sample surface by laser pulses. LIPS has many practical advantages over the conventional methods of chemical analysis of elements and is consequently being considered for a growing number of applications [1].
Here is shortly reported a study focused on time-resolved spectra arising from 193 nm pulsed laser ablation of metal halide targets in a 10^{-3} Torr vacuum. We report IR spectra of several metal atoms in the 1200–7500 cm^{-1} region. For the measurement of the time resolved Fourier-transform infrared spectroscopy (FTIR) spectra the synchronous continuous scanning method was used. After each ArF laser trigger point several data points was sampled while the interferometer's mirror moved continuously. To couple this method with a laser ablation as a source of the registered emission requires a special instrumental approach [2].
The infrared emission spectra of Li, Mg and Ca resulting from the laser ablation of targets performed as metal plates or alkali metal halides (LiI, $MgCl_2$, MgF_2, CaF_2 and SrF_2) tablets in a vacuum was recorded using time-resolved FTIR in the 1200–1600, 1800–3600, 4100–5000 and 5200–7500 cm^{-1} ranges with a resolution of 0.02 cm^{-1}. We report 4 new lines of Li, 26 of Ca, 3 of Mg, 19 of Sr. The measured Ca and Mg lines are in agreement with the solar spectra recorded in Atmospheric Chemistry Experiment (ACE).
The line classification is performed using relative line strengths expressed in terms of transition dipole matrix elements calculated with the help of the single-channel quantum defect theory (QDT)[3]. We show the results for the transition probabilities and oscillator strengths for transitions between the reported atomic metal states. For the classification of the observed IR lines, an important role is played by the f-, g- and h-states including those discovered in the present measurements. For all the elements considered, the most intensive emission line in the 1200–1600 cm^{-1} region correspond to the 5g–6h transitions.
The investigation of atomic emission in our LIBS experiment is complicated by nonequilibrium and nonstationary conditions of the plasma for the excited states. In particular, the emission intensities of the spectral lines show a complex dependence on the time delay after the ArF laser pulse shot. These curves are examples of a complex dynamics of the excited state population which is only scarcely available for these states. So the use of the time-resolved scheme is essential in our experiment.
This study gives first laboratory observation evidence (uncertainty 0.01–0.03 cm-1) for 12 levels of Ca and 9 of Mg, some of which were previously observed in solar spectra. Ten levels Sr are reported for the first time.

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