Possible utilization of laser-induced plasma for astrophysical applications (No 898)

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The properties of laser plasma arising from the breakdown of high-power pulsed laser radiation in volume of gas or on the surface of a solid target significantly change during the plasma decay. Typical plasma temperature decreases from 3-4 eV to 0.2 eV and electron density falls from 1019 to 1015 cm-3. Depending on the pressure and composition of the ambient atmosphere ions (multiple and single charged), atoms and molecules can be observed in a plasma. Such properties and behavior of laser-induced plasma are promising for its application for simulation of optical radiation from various astronomical plasmas and for study of spectral lines profiles. Registration and further interpretation of emission from meteor events in Earth's atmosphere is important for the study of the impact processes and estimation of elemental composition of meteors and other celestial bodies. Quantitative elemental analysis can be realized by fitting of a meteor plasma spectrum by synthetic data. Profiles of emission lines are typically disturbed due to Stark effect, and, therefore, Stark broadening parameters are essential for correct spectra fitting and lack of them results in errors of element abundances calculation. Laser-induced plasma provides important advantages (absence of electrode material, relatively high electron number density) for determination of Stark parameters in the range of temperature from 5000 to 30000 K that is close to the typical temperature of meteor ablation. Another weak point in interpretation of spectra of ablated cosmic bodies is overlapping of molecular bands of monoxides. Simulated spectra have large discrepancies with experimental spectra at high vibrational levels due to big uncertainties of the known spectroscopic parameters. Moreover, it does not seem possible to calculate reliable values of the Einstein coefficients for some molecules (e.g. FeO, CaO). By virtue of the foregoing, we focused on determination of Stark shifts and widths of a number of singly ionized oxygen and nitrogen lines in air laser plasma and on obtaining spectra of CaO orange system under different values of atmospheric pressure.

For plasma diagnostics and Stark parameters measurements we suggested a novel approach to evaluate the "quality" of a line by thermodynamic spectra modeling (homogeneous LTE plasma, line broadening and self-absorption). We used the synthetic spectrum approximated the experimental data to exclude the self-absorbed lines and the lines disturbed by interfering ones. The selected nitrogen lines with well-known parameters were used for temperature and electron number density calculation. We measured both Stark shifts and widths for 10 oxygen and nitrogen ionic lines (8 ones have not been previously calculated or measured and the rest values are in a good agreement with previous experimental and theoretical data).

For imitation of optical emission from meteor ablation we developed a vacuum chamber with possibility

to input two orthogonal laser beams and to collect emitted radiation rather by optical fiber or lens condenser. We obtained spectra of the orange system of CaO molecule at pressures corresponding to the altitudes for the recorded spectra of Benešov Benešov bolide wake. Laboratory spectra were measured at delays of 20-30 ?s after laser pulse, and the plasma temperature was evaluated by Saha-Boltzmann plot with the use of Ca I and Ca II lines. It was shown that the profile of orange band of CaO in laser-induced plasma is in good agreement with those for Benešov bolide, especially at low altitudes. This indicates the adequacy of the suggested imitation of meteor ablation plasma by laser-induced one.