Formation of CaO in laser plasma studied by emission and fluorescence spectroscopy

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Laser-induced plasma is a universal plasma source for spectral diagnostics of processes under extreme conditions. Due to possibility to freely vary laser energy, ambient pressure, compositions of the ablation target and surrounding environment plasma parameters can also be varied within a wide range. Typical temperatures (0.2-4 eV) and electron number densities (10^{15}-10^{19} cm^{-3}) along the plasma evolution allow observation of both atomic emission and emission of small, predominantly diatomic, molecules. In spite of spatial inhomogeneity of laser plasma (which also can be considered as a benefit for laboratory modeling), its certain symmetry opens up space for spatially resolved studies. Laser-induced fluorescence in plasma appears to be one of the most promising tools for spatially resolved plasma diagnostics. All these unique properties of laser plasma, combined with research interest in combustion processes during the meteor events in the Earth's atmosphere, led us to the study of Ca and CaO distribution in laser plasma under low ambient pressure.

We measured emission spectra of atomic calcium and calcium monoxide varying delay after laser pulse and ambient pressure from 0.16 Torr to atmospheric. Plasma temperature and electron number density were calculated where possible. By comparison of experimental spectra and spectra of Benešov bolide at different heights we showed that the emitting bolide wake is formed under 7-10 times higher pressure than the one at the corresponding altitude. The obtained data lead us to suggestion that the formation of CaO in plasma occurs primarily using oxygen from atmosphere. Therefore, abundance of CaO should have a strong dependency on the pressure of the surrounding media.

Also, we performed plasma elemental imaging (resolution of 200µm along each of 2 axes) by the means of Ca and CaO fluorescence in laser plasma. Ca atomic lines Ca I 428.30 nm and Ca I 430.52 nm and bands of CaO red system were used for this purpose. The estimated spatial distribution of Ca atoms and CaO molecules in laser plasma proves our suggestion that CaO is formed both in laser plasma and in the meteor wake primarily using oxygen from ambient air on the periphery of the cloud and this process almost does not involve oxygen from the ablated material ($CaCO_3$).

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