3 Conclusion

The main goal of this doctoral thesis is to investigate the possibility of synthesis of simply organic molecules from inorganic gases such $CO,CO_2,N_2,NH_3,CH_4,H_2O,H_2$, using the large laser sparks. The laser sparks provide a unique way to mimic the chemical effects of high-energy-density events in planetary atmospheres (cometary impact, lightning) matching the natural energy-density, its spatio-temporal evolution and plasma-volume scaling of such events in a fully-controlled laboratory environment.

Laser induced dielectric breakdown was induced by $\leq$1 kJ laser pulses in molecular gases and mixtures related to various planetary atmospheres. We believe that the single-shot experiments realized at the high-power laser facility simulate more realistically high-energy-density atmospheric events than similar experiments conducted with electrical discharges or experiments using low-energy pulses from high-repetition-rate lasers.

In our case three different gaseous mixtures were used for these purposes; the strongly-reduced mixture NH_3-CH_4-H_2-H_2O, medium-reduced mixture CO-N_2-H_2O and mildly-reduced mixture CO_2-N_2-H_2O. For all kind of my experiments the emission spectra were measured in different spectral regions. The molecular bands of CN and C_2 radicals dominates in the visible spectra taken from the stationary cell, whereas, only atomic and ionic lines were observed in the visible spectra measured in the gas puff experiment.. Strong XUV/x-ray emission was also detected from plasmas generated in the gas puff. . Many lines of multiply-charged C, N, and O ions were identified in soft x-ray spectra collected by a transmission grating spectrometer.

The results are generally summarized below:

- The liquid phase from the irradiated mixture was investigated using HPLC/MS technique. The analytical method was optimized for five simple amino acids. The analysis of CO_2-N_2-H_2O mixture showed the presence of alanine, glycine, serine, and asparagine. Only alanine was identified among the products formed due to LIDB in the CO-N_2-H_2O mixture. These results demonstrate the possibility of the synthesis of

small organic compounds, specifically amino acids from the simply inorganic gases and water.

- Fourier transform (FT) absorption spectroscopy in the IR region was used for analysis of chemical changes of the composition the CO-rich gas mixture due to LIDB. . The gas phase was studied before and after the large laser sparks action. CO and a small amount of CO_2 and H_2O were in the original mixture. Only CO_2, C_2H_2, and water were identified in the mixture after ten laser sparks (E_p~85J). This result demonstrates that large laser sparks in gaseous mixtures cause substantial changes of its composition. The gas phase analysis shows the formation of a simple organic compound (acetylene).
- Unstable species were investigated using optical emission spectroscopy. C_2 and CN molecular bands dominated in all our LIDB spectra. The relative vibrational intensities of these radicals were used for estimation of vibrational and rotational temperature. The strong H_α and H_β lines, which appeared in the NH_3-CH_4-H_2-H_2O mixture, allow the determination of the excitation temperature of the system. The results indicate that all investigated systems were in the local thermodynamic equilibrium.
- Experiments with the gas puff give the unique ability to look through the vacuum and weakly absorbing gases (here He) to observe the short-wavelength emission of LIDB plasma. No molecular species were identified in the optical spectra. This fact indicates that the presence of cold surrounding gas is necessary for their formation. The soft x-ray spectra showed the presence of multiply-charged C,N and O up to H-like type.