A study of N_2H^+ dominated afterglow plasma using cavity ring-down spectroscopy

P. Dohnal[1], Á. Kálosi[1], Š. Roučka[1], R. Plašil[1], J. Glosík[1]

[1] *Department of Surface and Plasma Science, Faculty of Mathematics and Physics, Charles University in Prague, V Holešovičkách 2, 18000 Prague, Czech Republic*

The first results of experimental study on recombination of N_2H^+ ions with electrons are presented. A stationary afterglow setup equipped with cavity ring-down spectrometer as a main diagnostics tool was used to probe the time evolutions of several rotational states of the vibrational ground state of N_2H^+ ion in discharge and afterglow plasma. A particular attention was given to ascertain that kinetic and rotational temperature of the ions in afterglow is close to the buffer gas temperature. A possibility of helium or H_2 assisted three body recombination channel was taken in to account during the data evaluation. The obtained results will be compared to experimental data from other groups and to the theoretical calculations.

1. Introduction

N_2H^+ was one of the first molecular ions detected in interstellar space [1]. It was observed towards cold dark clouds and protostellar cores and can serve as a probe for determination of physical conditions therein. Especially as a tracer for N_2, that is difficult for direct astronomical observation [2].

The recombination of N_2H^+ molecular ions with electrons was also studied by many groups in different types of experiments [3,4,5]. These results differ by more than order of magnitude.

2. Experiment

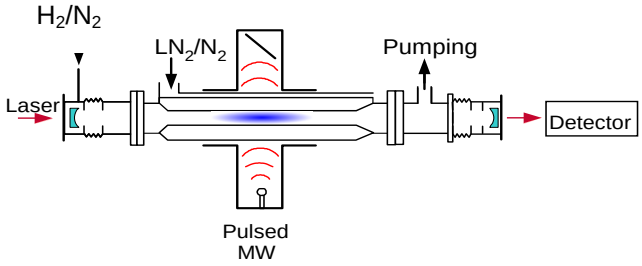

Fig 1. Stationary afterglow with the CRDS absorption spectrometer: SA-CRDS (not to scale). In the middle part of the fused silica discharge tube a discharge is periodically ignited in the microwave resonator (MW, 2.5 GHz, 4–15W). A gas mixture (H_2/N_2 in the figure) is used to form a plasma containing the desired ionic composition. The discharge tube is cooled by liquid nitrogen (LN_2) or by precooled nitrogen vapours.

A stationary afterglow apparatus equipped with cavity ring-down spectrometer (SA-CRDS, for details on the current apparatus and diagnostic technique see reference [6] and Fig. 1) was employed in the experiments. The N_2H^+ ions were produced in a pulsed discharge in a gas mixture of $He/H_2/N_2$ or H_2/N_2. We were able to follow the time evolutions of number densities of different quantum states of studied ions in discharge and afterglow plasma. The kinetic temperature of the ions was determined from the Doppler broadening of the absorption lines while the rotational temperature was calculated from the relative populations of different states of particular ion.

3. Conclusions

Several overtone transitions of N_2H^+ molecular ion in the near infrared spectral region were probed and we have measured the kinetic and rotational temperature of these ions and their evolution in discharge and afterglow plasma. The first results on recombination of N_2H^+ ions with electron will be presented at the conference.

4. Acknowledgement

This work was partly supported by Czech Science Foundation projects GACR 17-08803S and GACR 15-15077S.

5. References

[1] P. Thaddeus et al., Astrophys. J. **201** (1975) L25.

[2] E. Herbst et al., Astrophys. J. **215** (1977) 503-510.

[3] T. Amano et al., J. Chem. Phys. **92** (1990) 6492.

[4] V. Poterya et al., J. Phys. Chem. A **109** (2005) 7181.

[5] E. Vigren et al., Astrophys. J. **757** (2012) 34.

[6] P. Dohnal et al., J. Chem. Phys. **136** (2012) 244304.