

Electron-ion recombination and ion-neutral interactions play a pivotal role in the chemical evolution of molecules in the Interstellar Medium (ISM). Physical conditions under which these processes undergo in the ISM include a wide range of temperatures and particle number densities. This work contributes to the experimental study of named low temperature phenomena in the range of 30 K to 300 K focusing on the reactions of hydrogen-containing light molecules. The employed experimental techniques are based on a combination of a Stationary Afterglow (SA) instrument with a Continuous Wave Cavity Ring-down Spectrometer (cw-CRDS). The main contributions of this work can be split into three topics. (1) The proton and deuteron containing isotopic system of  $\text{H}_3^+$  ions. The isotopic fractionation process in collisions with hydrogen and deuterium gas was investigated in low temperature discharges, nominal ion temperatures of 80 K to 140 K, to deduce relative ion densities in the experiments. These are necessary for afterglow studies of isotopic effects in electron-ion recombination of the studied ions. (2) Vibrational spectroscopy of  $\text{N}_2\text{H}^+$  ions focusing on first overtone ( $2\nu_1$  band) transitions and ion thermometry, the first step towards studies of electron-ion recombination. (3) The role of *para/ortho* spin modifications in the reactive collision system of  $\text{H}_3^+ + \text{H}_2$ . The *para*- $\text{H}_3^+$  fraction in afterglow plasmas was investigated as a function of the *para*- $\text{H}_2$  fraction in experiments with *para*-enriched hydrogen gas in the nominal temperature range of 30 K to 60 K.