OBSERVATION OF ORTHO-PARA H$_3^+$ SELECTION RULES IN PLASMA CHEMISTRY. A TIME DEPENDENT STUDY IN A HOLLOW CATHODE DISCHARGE.

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During the past two Columbus meetings, we reported our observation of a nonthermal ortho-to-para distribution of H$_3^+$ in hydrogen plasmas, where we found selection rules on nuclear spin modifications to hold in a chain of plasma chemical reactions. The solution of rate equations incorporating nuclear spin branching ratios gave an ortho-to-para ratio of H$_3^+$ in good agreement with experiments. However, our observations were limited to steady-state plasma conditions, and no direct information relative to the kinetics of the plasma could be derived.

For this reason, a new time dependent experiment has been carried out in a hydrogen plasma. Our study consisted of monitoring the evolution of ortho- and para-H$_3^+$ absorptions during and after a short pulse discharging normal H$_2$ or para-H$_2$ confined in a hollow cathode. Deviations from thermal conditions were found stronger than those observed in the steady-state work, and the study of the H$_3^+$ absorption signals allowed a more detailed analysis of the chemical processes occurring during the thermalization of the o-H$_3^+$ and p-H$_3^+$ in the cell. An experimental value for the ratio of rate constants of the proton hop (H$_2$ + H$_3^+$ → H$_3$H$^+$ + H$_2$) and the hydrogen exchange (H$_2$ + H$_3^+$ → H$_3$H$^+$ + H$^+$) reactions has been obtained to explain the ortho-to-para H$_3^+$ ratios observed in the pulsed plasma.