State-to-state molecular collisions: progresses and prospects

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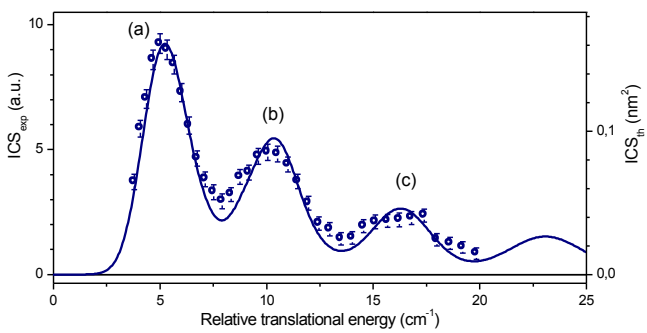
The Herschel satellite, the ALMA interferometer and the NOEMA telescope open new windows of observation for wavelengths ranging from far infrared to sub-millimeter with spatial and spectral resolutions previously unmatched. To make the most of these observations, an accurate knowledge of the collisional excitation rate coefficients of the interstellar molecules by the most abundant species (H, He, H_2) is needed. Indeed, accurate determination of molecular abundances relies on accurate collisional data. We present here the most recent advances in this area made by the French community.

First, we present the latest results for collisions between radicals (O_2, CN, C_2H), ions (HCO^+, N_2H^+) and H_2 [1-3]. For these systems, we will also expose detailed comparison between theoretical and experimental results showing the very good accuracy of the new data. Then, we will show the latest results obtained by the Hydrides ANR project on collisional excitation and chemistry of interstellar hydrides (OH, OH^+, CH, CH^+, NH, HCl) [4-5]. After this, we will also discuss the theoretical advances that have been made recently to take into account the excitation of bending modes of interstellar molecules (HCN, C_3) [6] but also to obtain reliable data for the collisional excitation of complex molecules (COM) [7].

Finally, we will show that the use of these new rate coefficients compared to the use of previous published ones significantly changes molecular abundances in molecular clouds.



$O_2(N_j=1_0)$+p-H_2 → $O_2(N_j=1_1)$+p-H_2 cross section: Experiments (open circles); theory (solid line)

Références :

[1] Lique, F. *et al*, A&A **567**, A22 (2014)

[2] Kalugina, Y. *et al*., J. Chem. Phys. **139**, 074301 (2013)

[3] Najar, F. *et al.,* Chem. Phys. Lett, in press

[4] Gomez-Carrasco, S. *et al.,* ApJ, in press

[5] Lanza, M. *et al.,* MNRAS **443**, 3351 (2014)

[6] Stoecklin, T. *et al*., J. Chem. Phys. **139**, 124317 (2013)

[7] Faure, A. *et al.,* ApJ **783**, 72 (2014)