Efficient stabilization of cyanonaphthalene by fast radiative cooling

Mark H. Stockett[1*], James N. Bull[2], Henrik Cederquist[1], Suvasthika Indrajith[1], MingChao Ji[1], José E. Navarro Navarrete[1], Henning T. Schmidt[1], Henning Zettergren[1] & Boxing Zhu[1]

[1]Department of Physics, Stockholm University, Stockholm, Sweden
[2]School of Chemistry, University of East Anglia, Norwich, United Kingdom
[*]Mark.Stockett@fysik.su.se

After decades of speculation and searching, astronomers have recently identified specific Polycyclic Aromatic Hydrocarbons (PAHs) in space. Remarkably, the observed abundance of cyanonaphthalene (CNN, $C_{10}H_7CN$) in the Taurus Molecular Cloud (TMC-1) is six orders of magnitude higher than can be explained by astrochemical modeling. Here, we report absolute unimolecular dissociation and radiative cooling rate coefficients of the 1-CNN isomer in its cationic form. These results are based on measurements of the time-dependent neutral product emission rate and Kinetic Energy Release distributions produced from an ensemble of internally excited 1-CNN$^+$ studied in an environment similar to that in interstellar clouds. We find that Recurrent Fluorescence – emission of optical photons from thermally populated electronic excited states – efficiently stabilizes 1-CNN$^+$, owing to the large enhancement of the electronic transition probability by vibronic coupling. Our results help explain the anomalous abundance of CNN in TMC-1 and indicate that small PAHs may be stable in molecular clouds and in the interstellar medium in general, challenging current understanding in astrochemistry.

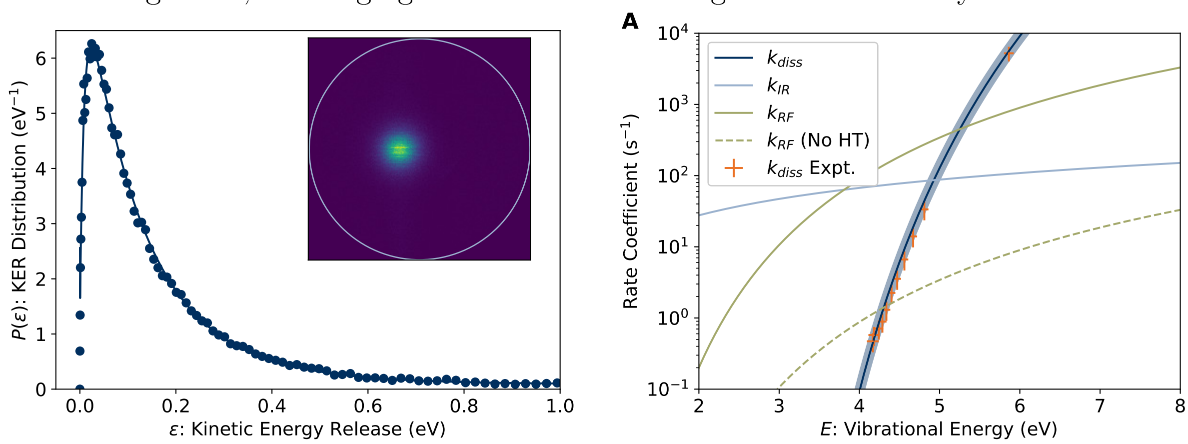

Figure 1: Left: Kinetic Energy Release distribution for 1-CNN$^+$ dissociating 120 μs after formation, determined from the inset detector image. Right: Unimolecular dissociation and radiative cooling rate coefficients for 1-CNN$^+$.

[1] M. H. Stockett *et al.* In preparation.