Thermal radiative cooling of carbon cluster cations C_N^+, N =8-27

K.Hansen[1,2], S.Iida[3], P.Ferrari[4], W.Hu[1], R.Zhang[1], T.Azuma[5], H.Shiromaru[3]

[1]Department of Physics, Tianjin University, China
[2]Key Laboratory of Theoretical Physics of Gansu Province, Lanzhou University, China
[3]Tokyo Metropolitan University, Japan
[4]Department of Physics and Astronomy, KU Leuven, Belgium
[5]Atomic, Molecular and Optical Physics Laboratory, RIKEN, Japan

klavshansen@tju.edu.cn, *hansen@lzu.edu.cn*

Emission of thermal radiation from molecules have until recently been considered an exclusively vibrational effect. Measurements in both time-of-flight mass spectrometers and storage rings have now demonstrated a number of cases of a very efficient radiative cooling of clusters and molecules by emission of NIR and visible photons from thermally excited electronic states of carbon-containing systems and metallic clusters. The emission rate constants exceed typical IR rates by large factors, in some cases by more than four orders of magnitude. In a few cases the emitted photons have been detected [1].

The effect has direct consequences for our understanding of the molecular universe. In the interstellar medium high energy photons may be absorbed and re-emitted strongly redshifted as thermal photons. An important consequence is that emitting species will be significantly more resilient to XUV radiation than non-emitting species. This provides an efficient mechanism for selection of the fittest molecules. The high quantum efficiencies, expected to be significantly above unity, will also provide a long-sought source of diffuse and spectrally broad red photons in the interstellar medium.

Here we report measurements of radiative cooling rates of C_N^+ clusters, with N=8-27, in a storage ring [2,3]. The values are on the order of 10^4 s^{-1}. This translates into an efficient radiative stabilization after absorption of photons of energies between 10 eV and 14 eV for the species measured.

[1] Y.Ebara *et al.*, Phys. Rev. Lett. **117** (2016) 133004
[2] S. Iida *et al.*, MNRAS, DOI: 10.1093/mnras/stac1349
[3] F.-Q. Chen *et al.*, Phys. Chem. Chem. Phys. **21** (2019) 1587-1596