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Radiative cooling dynamics of anthracene cations stored in DESIREE studied via the time evolution of 2-photon-absorption induced dissociation rate

J Bernard^{1*}, M C Ji^{2†}, S Martin¹, G Wenzel³, A Al-Mogeeth¹, M H Stockett², H T Schmidt², H Zettergren² and C Joblin³

¹Institut lumière matière (ILM), UMR5306 Université Lyon 1-CNRS, Université de Lyon 69622 Villeurbanne, France

²Department of Physics, Stockholm University, Roslagstullsbacken 21, SE-106 91, Stockholm, Sweden

³Institut de Recherche en Astrophysique et Planétologie (IRAP), Université de Toulouse (UPS), CNRS, CNES, 9 Av. du Colonel Roche, 31028 Toulouse Cedex 4, France

Synopsis Anthracene cations ($C_{14}H_{10}^+$) have been stored in the cryogenic (13 K) electrostatic storage ring DESIREE in Stockholm to study their radiative cooling dynamics on a long time scale up to 2 s. By monitoring the laser-induced delayed dissociation curves during the storage, the evolution of the dissociation rate was obtained. Its decrease as a function of time is closely related to the time evolution of the internal energy distribution of the stored anthracene cations and consequently to the energy loss due to radiative cooling, including both Poincaré and infrared fluorescences.

Measurements of radiative cooling rates of Polycyclic Aromatic Hydrocarbons (PAHs) in isolated conditions are essential to characterize the photostability of interstellar PAHs[1]. Previous studies using a compact electrostatic ion storage ring (Mini-Ring) have demonstrated that recurrent fluorescence, also denoted as Poincaré fluorescence, is an efficient radiative cooling mechanism in the time range up to 10 ms[2]. In the present work, we have extended these previous studies to a much longer time range (up to 2 s) by storing anthracene cations in the cryogenic (13 K) electrostatic storage ring DESIREE in Stockholm. On this long time scale, we could investigate the contribution to the radiative cooling due to slow infrared emission via vibrational transitions.

As in the previous study, the cations were produced in the ion source with a broad distribution of internal energies and injected in the ring. Delayed dissociation decay curves were then recorded after laser irradiation of the stored ion bunch every 100 ms with a pulsed nanosecond tuneable laser set at 350 nm. Dissociation rates were derived from the exponential fits to these decay curves as a function of storage time (Figure 1). In the time range 0.1 to 1 s, this rate is found to decrease almost linearly with storage time; whereas, after 1 s, the dissociation rate remains rather constant with time. Since dissociation

rates are known to vary rapidly with the internal energy, Figure 1 can be used to further estimate the time evolution of the internal energy (or temperature) of the anthracene cations due to radiative emission. A Monte Carlo kinetics code [3] was used to simulate the radiative cooling of the ions and rationalise these results.

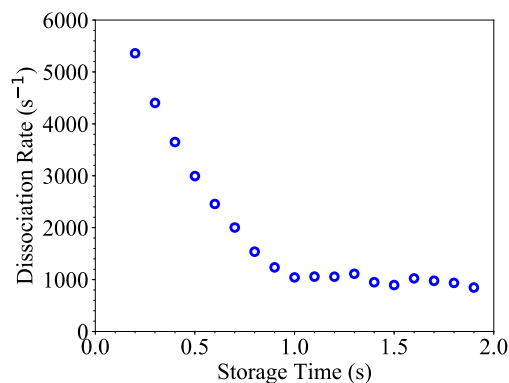


Figure 1. Time evolution of the dissociation rate of anthracene cations induced by two-photon absorption at 350 nm.

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* E-mail: jerome.bernard@univ-lyon1.fr

† E-mail: mingchao.ji@fysik.su.se

