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VUV photo processing of large cationic PAHs in astrophysical conditions: coupling a VUV source to the PIRENEA setup

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Anthony Bonnamy, Alexandre Marciniak, Gabi Wenzel, Sébastien Zamith, Sabela Quiroga, et al.. VUV photo processing of large cationic PAHs in astrophysical conditions: coupling a VUV source to the PIRENEA setup. GdR EMIE, Oct 2020, Ile d'Oléron, France. hal-03017838

HAL Id: hal-03017838

<https://hal.science/hal-03017838v1>

Submitted on 21 Nov 2020

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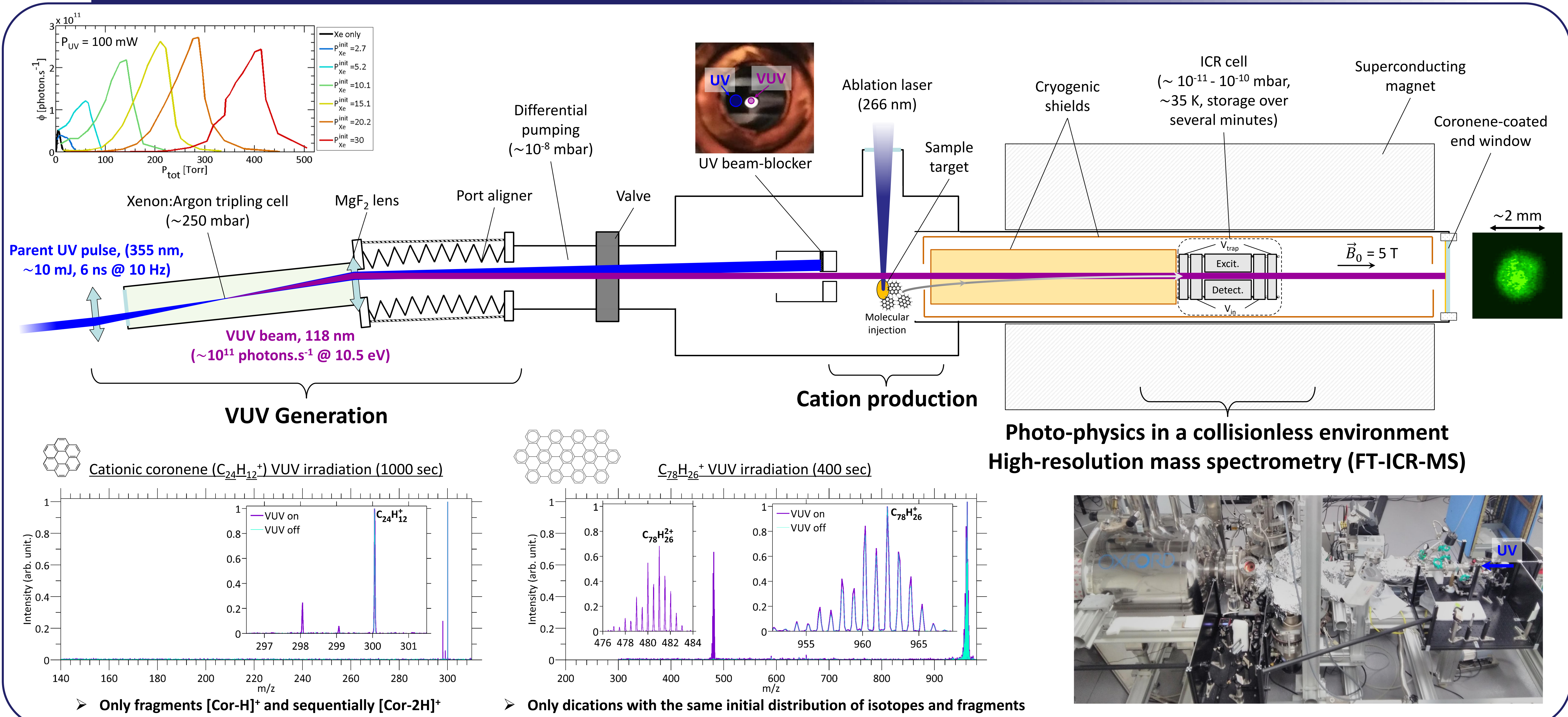
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Abstract

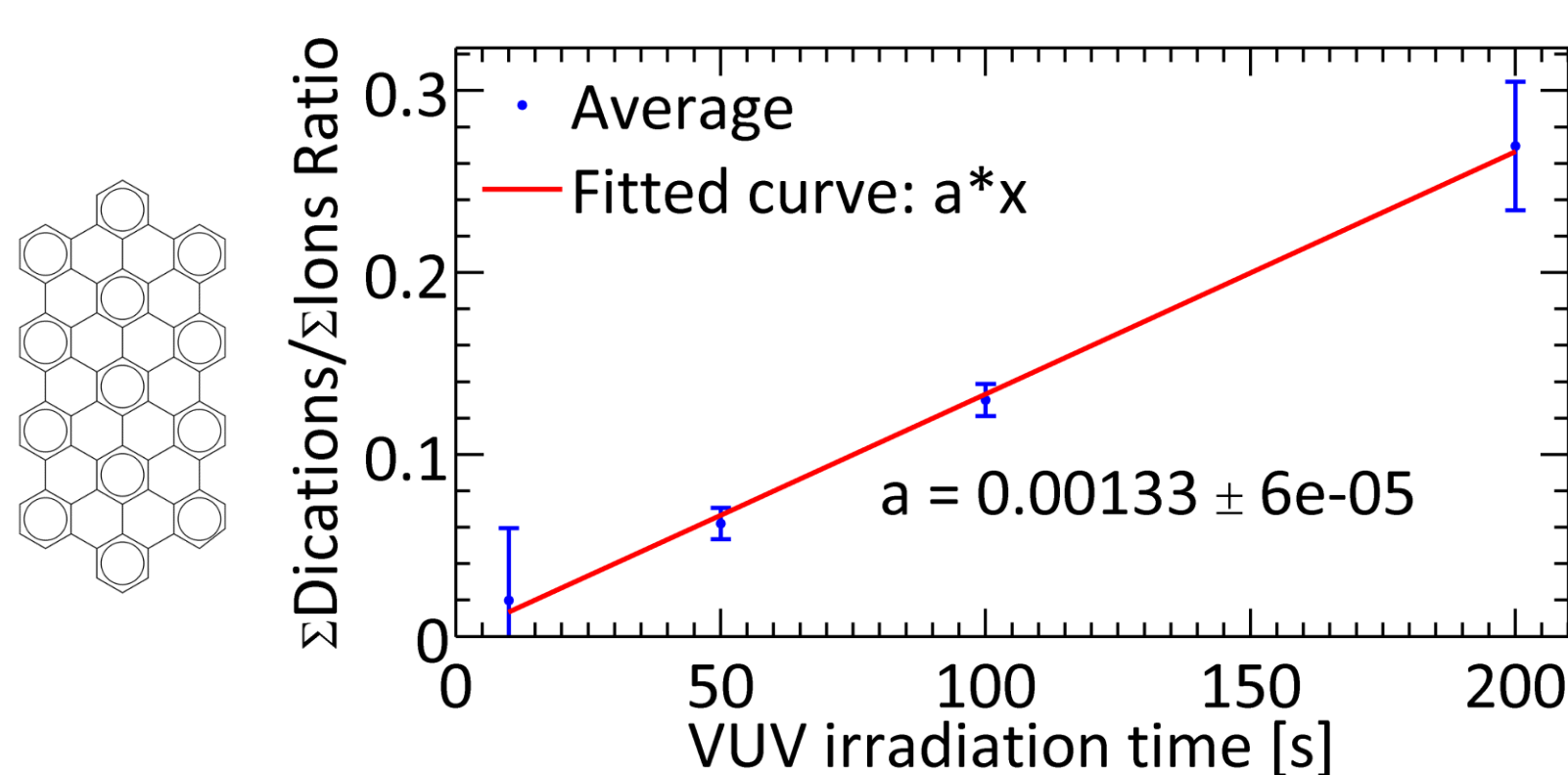
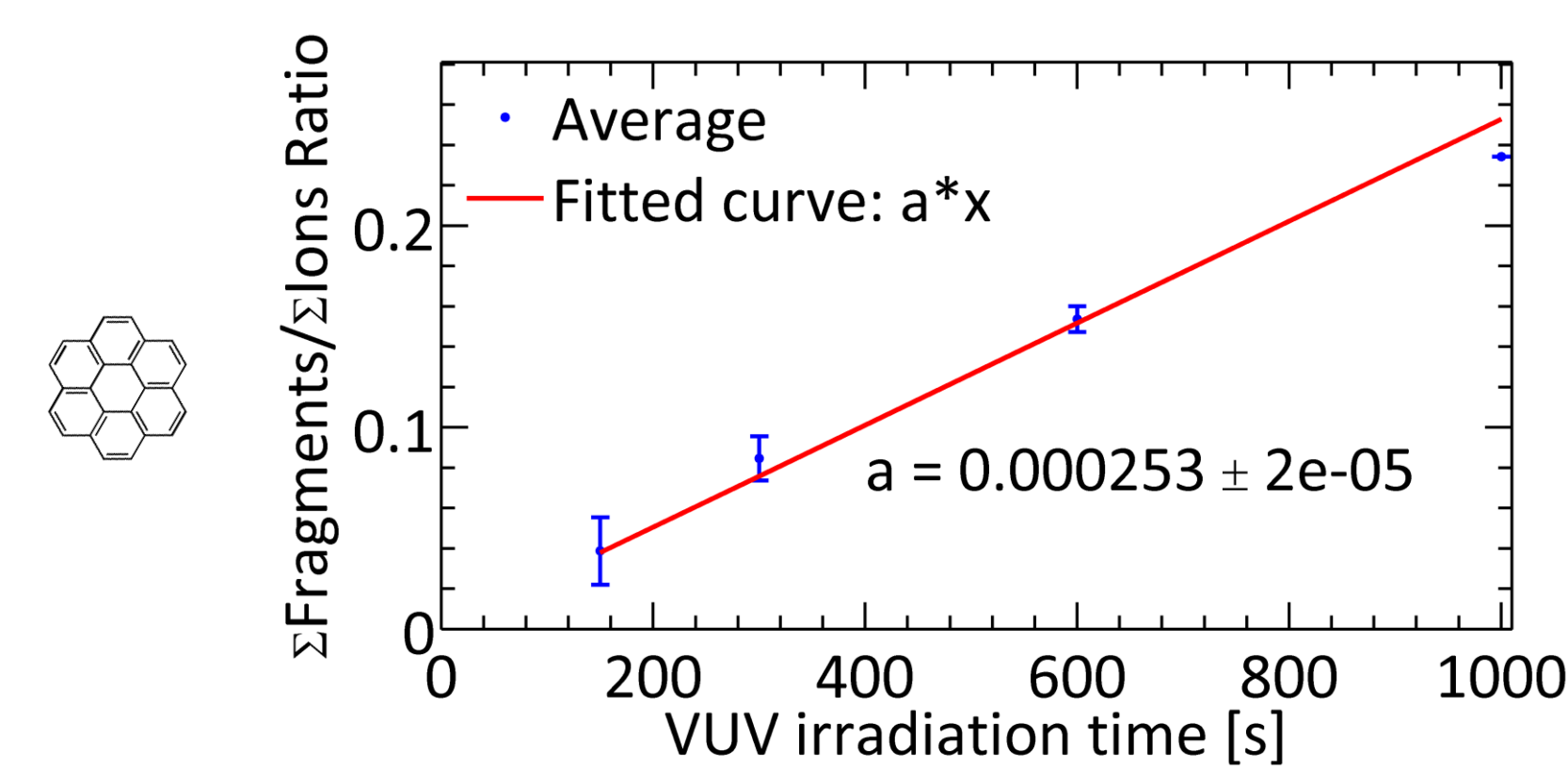
Studying the interaction of polycyclic aromatic hydrocarbons (PAHs) with UV and VUV light is crucial for the understanding of the physical and chemical evolution of the interstellar medium. Photo-processing by VUV irradiation leads to variation of the hydrogenation and ionization states of PAHs [1] and plays an important role in the heating of the gas [2]. Recent laboratory studies have shown that the VUV photoexcitation of large PAHs rather induces further ionization than fragmentation [3,4] and, more surprisingly, it can also induce non-statistical dissociation [5]. We have recently coupled a VUV source based on a Xe-Ar tripling cell to the PIRENEA (Piège à Ions pour la Recherche et l'Etude de Nouvelles Espèces Astrochimiques) setup which consists of a cryogenic (35 K) ion cyclotron resonance cell that is especially well suited to investigate ionization and dissociation on long timescales [1,5]. The produced VUV photons (10.5 eV) are sufficiently energetic to trigger dissociation in small/medium-size PAHs [6] and ionization in large PAH cations [4]. We present first measurements of VUV processing of several PAHs in a cryogenic and collisionless environment which is appropriate for interstellar conditions.

Experimental Method : VUV photo-processing of isolated PAH molecules



Preliminary results

Study as a function of the VUV irradiation time



Implications in VUV photo-processing of PAHs

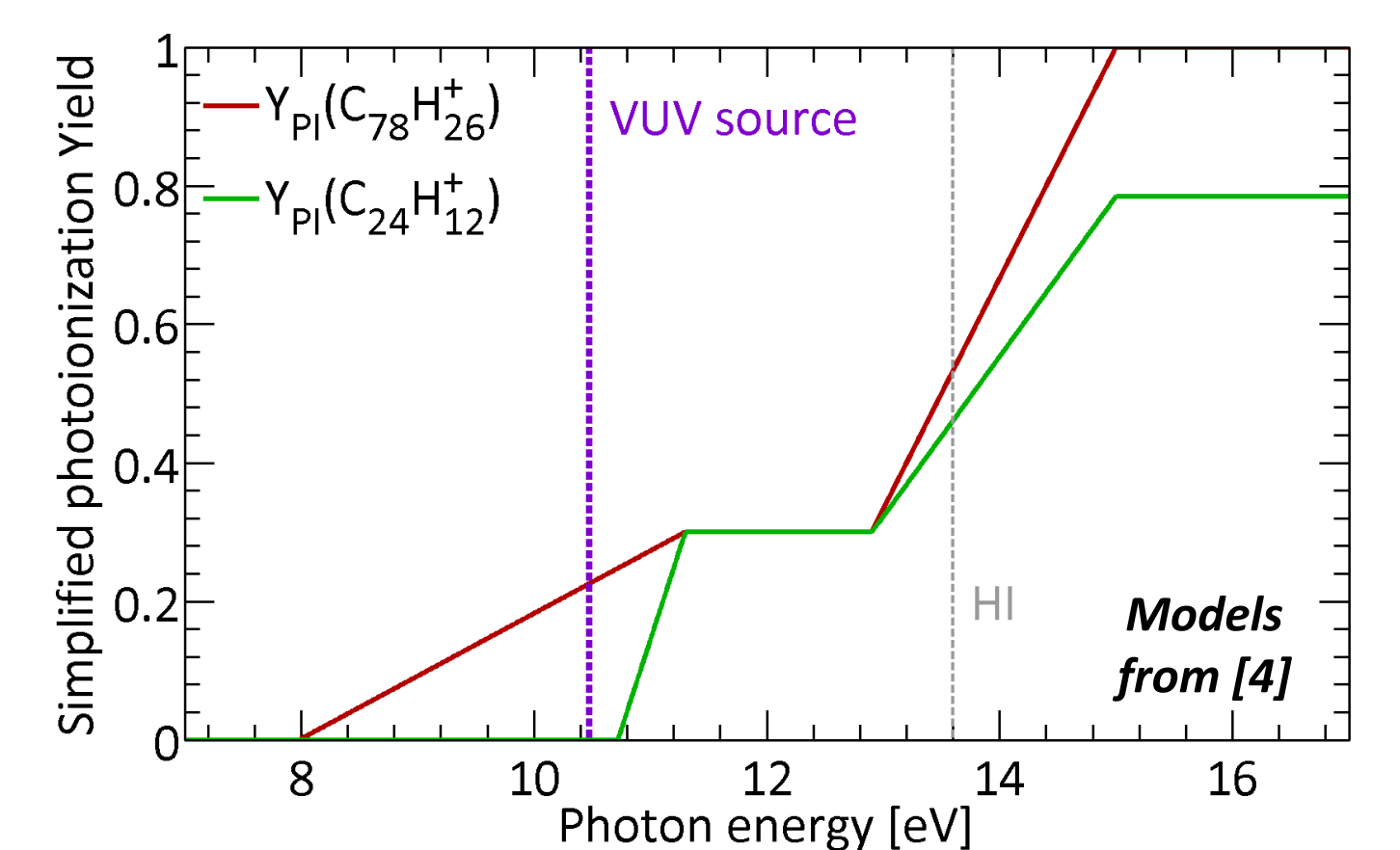
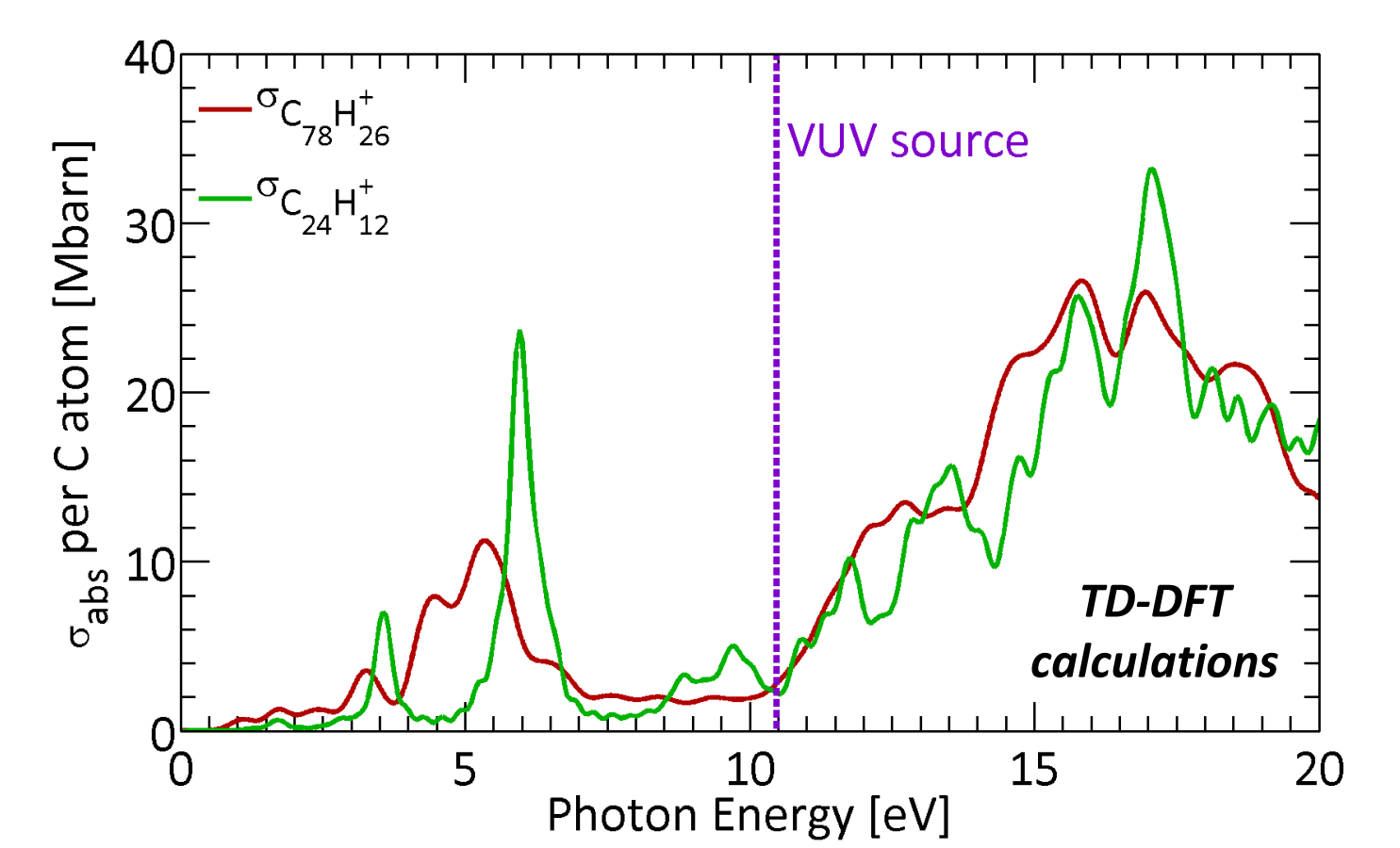
- The measured photo-products formation rate of C₇₈H₂₆⁺ is **5.25 times** larger than the one of C₂₄H₁₂⁺.
- The absolute VUV photo-absorption cross-section of C₇₈H₂₆⁺ is about **3.25 times** larger than the one of C₂₄H₁₂⁺ (ratio of C atom number).
- A simple model for the photo-ionization yield of large PAH has been derived from measurements in a previous study [4]: ~ 0.23 at 10.5 eV for C₇₈H₂₆⁺.

$$\text{Absorbed photons per second} = \begin{cases} \sigma_{\text{abs}}(\text{C}_{24}\text{H}_{12}^+) \times \Phi_{\text{VUV}} = \frac{a(\text{C}_{24}\text{H}_{12}^+)}{Y_{\text{diss.}}(\text{C}_{24}\text{H}_{12}^+)} \\ \sigma_{\text{abs}}(\text{C}_{78}\text{H}_{26}^+) \times \Phi_{\text{VUV}} = \frac{a(\text{C}_{78}\text{H}_{26}^+)}{Y_{\text{ion.}}(\text{C}_{78}\text{H}_{26}^+)} \end{cases}$$

if Φ_{VUV} is constant

$$\Rightarrow Y_{\text{diss.}}(\text{C}_{24}\text{H}_{12}^+) \approx \frac{a(\text{C}_{24}\text{H}_{12}^+)}{a(\text{C}_{78}\text{H}_{26}^+)} \times \frac{\sigma_{\text{abs}}(\text{C}_{78}\text{H}_{26}^+)}{\sigma_{\text{abs}}(\text{C}_{24}\text{H}_{12}^+)} \times Y_{\text{ion.}}(\text{C}_{78}\text{H}_{26}^+) \approx 0.14$$

- The retrieved dissociation yield at a VUV energy close to the threshold is consistent with the results found by Zhen and coworkers [6].
- This shows that a large fraction of the 10.5 eV photons absorbed by C₂₄H₁₂⁺ are relaxed by radiative cooling.



Perspectives

- Calibration to determine robust values of the dissociation yield combining experiments on smaller PAHs.
- Molecular systems from strongly dissociative to intermediate case where dissociation and ionization are in competition.
- VUV photo-chemistry by molecular gas injection.

Bibliography

- [1] J. Montillaud, C. Joblin and D. Toublanc, A&A, 552, A15 (2013)
- [2] E. L. O. Bakes and A. G. G. M. Tielens, ApJ, 427, 822 (1994)
- [3] J. Zhen, P. Castellanos, D. M. Paardekooper et al., ApJL, 804:L7 (2015)
- [4] G. Wenzel, C. Joblin, A. Giuliani et al., A&A, 641, A98 (2020)
- [5] C. Joblin, G. Wenzel, S. Rodriguez Castillo et al., J. Phys. Conf. Ser., 1412, 062002 (2020)
- [6] J. Zhen, S. Rodriguez Castillo, C. Joblin et al., ApJ, 822:113 (2016)