

# **Supporting Information:**

## **Velocity Map Imaging Spectroscopy of $\text{C}_2\text{H}^-$ and $\text{C}_2\text{D}^-$ : a benchmark study of vibronic coupling interactions**

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# 1 C<sub>2</sub>H<sup>−</sup> Spectral Assignments

Spectral assignments for all peaks resolved in the photoelectron spectra of C<sub>2</sub>H<sup>−</sup> from this work are presented in Table S1. Peaks are labelled with respect to the photoelectron spectrum of C<sub>2</sub>H<sup>−</sup> at 300 nm in Figure S1. The experimental binding energy of each transition is given, alongside the anisotropy parameter sign (+/−), the corresponding vibronic symmetry, and the calculated energy from Ref.S1. Assignments are given as  $\tilde{X}(v_1, v_2, v_3)\tilde{A}(v_1, v_2, v_3)$  where any superscripts represent hot-band transitions.

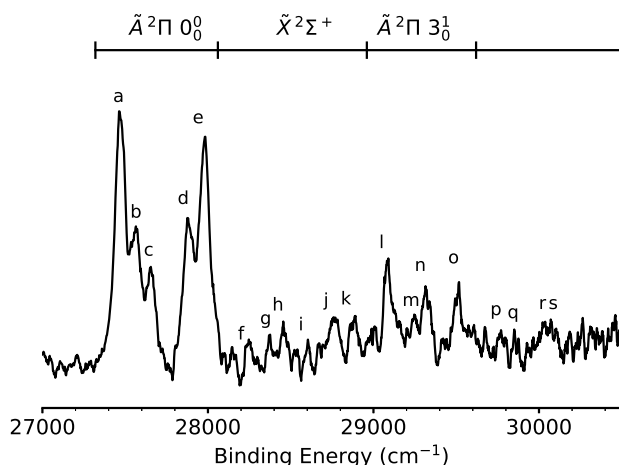


Figure S1: Photoelectron spectrum of C<sub>2</sub>H<sup>−</sup> at 300 nm, showing the alphabetic labelling of peaks used in this work.

# 2 C<sub>2</sub>D<sup>−</sup> Spectral Assignments

Spectral assignments for all peaks resolved in C<sub>2</sub>D<sup>−</sup> from this work are presented in Table S2. Peaks are labelled with respect to the photoelectron spectrum of C<sub>2</sub>D<sup>−</sup> at 355 nm in Figure S2. The experimental binding energy of each transition is given, alongside the anisotropy parameter sign (+/−), the corresponding vibronic symmetry, and the calculated energy from Ref. S1.

Table S1: Peak positions ( $\text{cm}^{-1}$ ), and assignments for the  $\text{C}_2\text{H}^-$  photoelectron spectra from this work. The sign of the anisotropy parameter is shown for each transition, along with it's vibronic symmetry, and the calculated position from Ref.<sup>S1</sup>.

Peak	eBE ( $\text{cm}^{-1}$ )	$v$ ( $\text{cm}^{-1}$ )	$\beta$	Symmetry	$v_{\text{calc}}^a$	Assignment
	23 591	-231	+	$\Sigma^+$		$\tilde{X}(0, 2^2, 0)$
	23 685	-137	+	$\Sigma^+$		$\tilde{X}(0, 1^1, 0)$
	23 823	0	+	$\Sigma^+$	0	$\tilde{X}(0, 0, 0)$
	24 184	361	−	$\Pi$	371	$\tilde{X}(0, 1, 0)$
	24 630	807	+	$\Sigma^+$	794	$\tilde{X}(0, 2, 0)$
	25 663	1840	+	$\Sigma^+$	1838	$\tilde{X}(0, 0, 1)$
	25 916	2093	−	$\Pi$	2096	$\tilde{X}(0, 1, 1)$
	25 993	2170	−	$\Pi$	2166	$\tilde{X}(0, 5, 0)$
	26 362	2539	+	$\Sigma^+$	2536	$\tilde{X}(0, 2, 1)$
	26 757	2934	−	$\Pi$	2933	$\tilde{X}(0, 3, 1)$
	26 929	3106	−	$\Pi$	3104	$\tilde{X}(0, 7, 0)$
	27 175	3352	+	$\Sigma^+$	3371	$\tilde{X}(0, 4, 1)$
a	27 430	3607	−	$\Pi$	3604	$\tilde{X}(0, 1, 2)\tilde{X}(1, 1, 0)\tilde{A}(0, 0, 0)$
b	27 515	3692	−	$\Pi$	3690	$\tilde{X}(1, 1, 0)\tilde{X}(0, 1, 2)\tilde{A}(0, 0, 0)$
c	27 612	3788	−	$\Pi$	3790	$\tilde{X}(0, 5, 1)\tilde{A}(0, 0, 0)$
d	27 851	4028	−	$\Pi$	4011	$\tilde{X}(0, 9, 0)\tilde{X}(0, 5, 1)\tilde{A}(0, 0, 0)$
e	27 941	4118	−	$\Pi$	4093	$\tilde{X}(0, 9, 0)\tilde{A}(0, 0, 0)$
f	28 200	4377	+	$\Sigma^+$	4375	$\tilde{X}(0, 6, 1)$
g	28 349	4526	+	$\Sigma^+$	4524	$\tilde{X}(0, 10, 0)$
h	28 423	4600	−	$\Pi$	4593	$\tilde{X}(0, 3, 2)\tilde{A}(0, 0, 0)$
i	28 562	4739	−	$\Pi$	4702	$\tilde{X}(0, 7, 1)\tilde{A}(0, 1, 0)$
j	28 714	4891	−	$\Pi$	4879	$\tilde{X}(0, 7, 1)$
k	28 834	5011	−	$\Pi$	5004	$\tilde{X}(0, 11, 0)$
l	29 049	5226	−	$\Pi$	5222	$\tilde{X}(0, 1, 3)\tilde{A}(0, 0, 1)$
m	29 227	5404	+	$\Sigma^+$	5406	$\tilde{X}(0, 12, 0)\tilde{A}(0, 1, 0)$
n	29 283	5460	−	$\Pi$	5445	$\tilde{X}(0, 5, 2)\tilde{A}(0, 0, 1)$
o	29 465	5642	−	$\Pi$	5630	$\tilde{X}(0, 9, 1)\tilde{A}(0, 0, 1)$
p	29 740	5917	−	$\Pi$	5914	$\tilde{X}(0, 13, 0)$
q	29 844	6021	+	$\Sigma^+$	6054	$\tilde{X}(0, 6, 2)\tilde{X}(0, 2, 3)$
r	30 021	6198	−	$\Pi$	6200	$\tilde{X}(0, 3, 3)\tilde{A}(0, 2, 0)$
s	30 086	6263	−	$\Pi$	6266	$\tilde{X}(1, 7, 0)$

<sup>a</sup> from calculations of Ref. S1

Table S2: Peak positions ( $\text{cm}^{-1}$ ) and assignments for the  $\text{C}_2\text{D}^-$  photoelectron spectra from this work. The sign of the anisotropy parameter is shown for each transition, along with it's vibronic symmerty, and calculated position from Ref.<sup>S1</sup>.

Peak	eBE ( $\text{cm}^{-1}$ )	$v$ ( $\text{cm}^{-1}$ )	$\beta$	Symmetry	$v_{\text{calc}}^a$	Assignment
	23 751	-197	+	$\Sigma^+$		$\tilde{X}(0, 2^2, 0)$
	23829	-120	+	$\Sigma^+$		$\tilde{X}(0, 2^1, 0)$
	23 949	0	+	$\Sigma^+$	0	$\tilde{X}(0, 0, 0)$
	24 227	278	—	$\Pi$	287	$\tilde{X}(0, 1, 0)$
	24 577	629	+	$\Sigma^+$	615	$\tilde{X}(0, 2, 0)$
	24 906	957	—	$\Pi$	953	$\tilde{X}(0, 3, 0)$
	25 506	1557	+			
	25 688	1740	+	$\Sigma^+$	1744	$\tilde{X}(0, 0, 1)$
	25 901	1952	—	$\Pi$	1962	$\tilde{X}(0, 1, 1)$
	26 245	2297	+	$\Sigma^+$	2302	$\tilde{X}(0, 2, 1)$
	26 556	2607	—	$\Pi$	2612	$\tilde{X}(0, 3, 1)$
	26 747	2798	—	$\Pi$	2796	$\tilde{X}(1, 1, 0)$
a	27 253	3304	—	$\Pi$	3309	$\tilde{X}(0, 5, 1)$
b	27 369	3420	—	$\Pi$	3426	$\tilde{X}(1, 3, 0)$
c	27 450	3501	—	$\Pi$	3511	$\tilde{X}(0, 1, 2)$
d	27 552	3603	—			
e	27 793	3844	—	$\Pi$	3838	$\tilde{A}(0, 0, 0)$
f	27 906	3957	+	$\Sigma^+$	3967	$\tilde{X}(0, 2, 2)$

<sup>a</sup> from calculations of Ref. S1

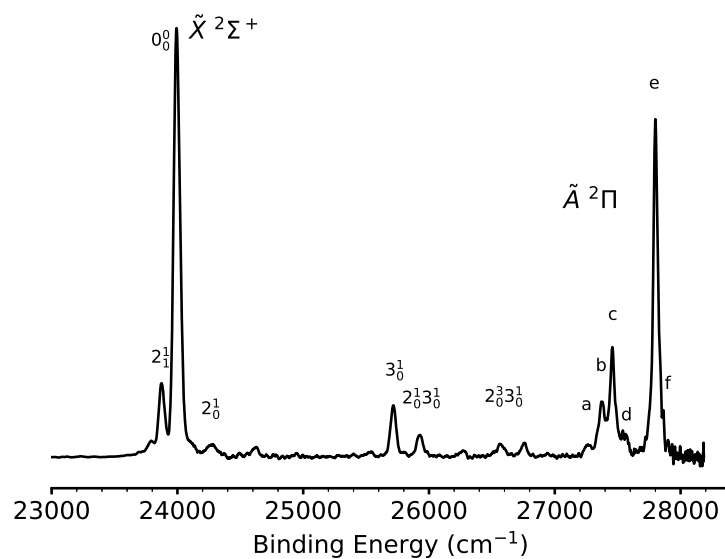


Figure S2: Photoelectron spectrum of  $\text{C}_2\text{D}^-$  at 266 nm, showing the alphabetic labelling of peaks used in this work.

## References

- (S1) Tarroni, R.; Carter, S. Theoretical calculation of vibronic levels of  $\text{C}_2\text{H}$  and  $\text{C}_2\text{D}$  to 10,000  $\text{cm}^{-1}$ . *The Journal of Chemical Physics* **2003**, *119*, 12878–12889.