The **AtMoCiad** database

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Photoionization

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1.1.1 Total Cross Section

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$CO_2 + \lambda \rightarrow CO^+ + O^+ + 2e$

$CO_2 + \lambda \rightarrow {CO_2}^{2+} + 2e + \lambda$ Auger (O)

${CO_2}^{2+}$ Auger (O) K-Shell (Avakyan 1998) K-shell photoionization of CO_2, with excitation of the C, from the review work [1]. Claimed uncertainty of 20%. The rate for the double ionization (including the following dissociation, not studied) is 31%, letting 69% of Auger fluorescence. The energy of the Auger electron (ejected in the double ionization cases) is 467 eV. The reported values in [?] were in nm, following several boxes, including lines, and were adapted in eV for the database.

$CO_2 + \lambda \rightarrow C^+ + O_2 + e$

$CO_2 + \lambda \rightarrow CO^+ + O + e$

$CO_2 + \lambda \rightarrow {CO_2}^+ + e$

${CO_2}^+ + e$ (AMOP) Photoionization of CO_2 yielding $CO_2^+ + e$ from the review of AMOP. The uncertainty, not claimed by the review, is estimated at 30%. The data, in nm, have been directly adapted in eV.

$CO_2 + \lambda \rightarrow {CO_2}^{2+} + 2e + \lambda$ Auger (C)

${CO_2}^{2+}$ Auger (C) K-Shell (Avakyan 1998) K-shell photoionization of CO_2, with excitation of the C, from the review work [1]. Claimed uncertainty of 20%. The rate for the double ionization (including the following dissociation, not studied) is 74%, letting 26% of Auger fluorescence. The energy of the Auger electron (ejected in the double ionization cases) is 223 eV. The reported values in [?] were in nm, following several boxes, including lines, and were adapted in eV for the database.

Reference	Threshold	Range of energy	Uncertainty	Properties	Fig
Revi AMOP	0	5.45:12400	???%	U	Fig. 1.29 1.30
???? ? BDD	0	7.2:532	???%	U	Fig. 1.29 1.30
Revi Avakyan 98	0	12:8260	20%		Fig. 1.29 1.30
Adap AMOP+Avakyan	0	5.45:8260	20%	RU	Fig. 1.29 1.30

Table 1.1: Total cross section for λ impact on CO_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$CO_2 + \lambda \rightarrow CO^+ + O^+ + 2e$	???? ? BDD	39.200	39.200:-1	???%	U	Fig. 1.11 1.12
	???? ? BDD	39.200	39.200:-1	???%	U	Fig. 1.23 1.24
$CO_2 + \lambda \rightarrow {CO_2}^{2+} + 2e + \lambda$ Auger (O)	Revi Avakyan 98	539	830:610	20%		Fig. 1.21 1.22
$CO_2 + \lambda \rightarrow C^+ + O_2 + e$	Revi AMOP	23	23:-1	30%	RUE	Fig. 1.15 1.16
	???? ? BDD	27.9	27.9:-1	???%	U	Fig. 1.15 1.16
$CO_2 + \lambda \rightarrow CO^+ + O + e$	Revi AMOP	19.446	19.446:-1	30%	RUE	Fig. 1.23 1.24
	???? ? BDD	19.446	19.446:-1	???%	U	Fig. 1.23 1.24
$CO_2 + \lambda \rightarrow {CO_2}^+ + e$	Revi AMOP	13.733	13.79:12400	???%	U	Fig. 1.5 1.6
	???? ? BDD	13.733	13.733:-1	???%	U	Fig. 1.5 1.6
	Revi Avakyan 98	13.773	13.773:-1	20%		Fig. 1.5 1.6
	Adap AMOP+Avakyan	13.733	13.733:-1	20%	RUE	Fig. 1.5 1.6
$CO_2 + \lambda \rightarrow {CO_2}^{2+} + 2e + \lambda$ Auger (C)	Revi Avakyan 98	282	340:830	20%		Fig. 1.21 1.22
$CO_2 + \lambda \rightarrow {CO_2}^{2+} + 2e$ (non Auger)	Revi Avakyan 98	37.6	37.6:-1	20%		Fig. 1.19 1.20
	Adap ? BDD	37.600	37.600:-1	50%	U	Fig. 1.19 1.20
$CO_2 + \lambda \rightarrow O^+ + CO + e$	Revi AMOP	19.070	19.070:-1	30%	RUE	Fig. 1.11 1.12
	???? ? BDD	19.070	19.070:-1	???%	U	Fig. 1.11 1.12

Table 1.2: Ionization Cross section for λ impact on CO_2

CO_2 + $\lambda \rightarrow$ $CO_2{}^{2+}$ + 2e (non Auger)

CO_2 + $\lambda \rightarrow$ O^+ + CO + e

Dissociation Cross Sections

CO_2 + $\lambda \rightarrow$ CO + O

Excitation Cross Sections

CO_2 + $\lambda \rightarrow$ $O(^3S)$ + CO

CO_2 + $\lambda \rightarrow$ $CO_2{}^+(B)$ + e

CO_2 + $\lambda \rightarrow$ $CO(A^1\Pi)$ + O

CO_2 + $\lambda \rightarrow$ $CO_2{}^+(A)$ + e

CO_2 + $\lambda \rightarrow$ $O(^1S)$ + CO

CO_2 + $\lambda \rightarrow$ $CO_2{}^+(C)$ + e

CO_2 + $\lambda \rightarrow$ $O(^1D)$ + CO

CO_2 + $\lambda \rightarrow$ $CO(a^3\Pi)$ + O

1.1.3 Recommended data set

CO_2 + $\lambda \rightarrow$ $CO_2{}^+(C)$ + e

CO_2 + $\lambda \rightarrow$ $O(^3S)$ + CO

CO_2 + $\lambda \rightarrow$ $CO(a^3\Pi)$ + O

CO_2 + $\lambda \rightarrow$ $CO_2{}^+(B)$ + e

CO_2 + $\lambda \rightarrow$ C^+ + O_2 + e

CO_2 + $\lambda \rightarrow$ $CO_2{}^+$ + e + Auger (O)

CO_2 + $\lambda \rightarrow$ $CO(A^1\Pi)$ + O

CO_2 + $\lambda \rightarrow$ $CO_2{}^{2+}$ + 2e

CO_2 + $\lambda \rightarrow$ $CO_2{}^+(A)$ + e

CO_2 + $\lambda \rightarrow$ $O(^1S)$ + CO

CO_2 + $\lambda \rightarrow$ Total

CO_2 + $\lambda \rightarrow$ $CO_2{}^+$ + e

CO_2 + $\lambda \rightarrow$ CO_+ + O + e

CO_2 + $\lambda \rightarrow$ O^+ + Co + e

CO_2 + $\lambda \rightarrow$ $O(^1D)$ + CO

CO_2 + $\lambda \rightarrow$ $CO_2{}^+$ + e + Auger (C)

Legend for the properties

R : Recommended cross section for the processus. It is used in the main file. The selection of the recommended cross section is based on the quality of

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$CO_2 + \lambda \rightarrow CO + O$	Revi AMOP	16.440	16.440:-1	???%	U	Fig. 1.9 1.10
	???? ? BDD	16.440	16.440:-1	???%	U	Fig. 1.9 1.10

Table 1.3: Dissociation Cross section for λ impact on CO_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$CO_2 + \lambda \rightarrow O(^3S) + CO$	Meas Wu 1979	16.44	16.44:-1	30%	RUE	Fig. 1.27 1.28
$CO_2 + \lambda \rightarrow {CO_2}^+(B) + e$	Revi Avakyan 98	18.076	18.076:-1	20%		Fig. 1.1 1.2
	Meas Ukai 1992	18.076	18.076:-1	15%		Fig. 1.1 1.2
$CO_2 + \lambda \rightarrow CO(A^1\Pi) + O$	Meas Gentieu and Mentall 1972	13.390	13.390:-1	50%	E	Fig. 1.3 1.4
	Meas Gentieu and Mentall 1972	13.390	13.390:-1	50%	RE	Fig. 1.3 1.4
$CO_2 + \lambda \rightarrow {CO_2}^+(A) + e$	Revi Avakyan 98	17.316	17.316:-1	20%		Fig. 1.31 1.32
	Meas Ukai 1992	17.316	17.316:-1	15%		Fig. 1.31 1.32
$CO_2 + \lambda \rightarrow O(^1S) + CO$	Meas Lawrence 1972	9	9:-1	20%		Fig. 1.25 1.26
	Meas Lawrence 1972	9	9:-1	20%	UE	Fig. 1.25 1.26
	Meas Lawrence 1972+AMOP	9	9:-1	20%	RUE	Fig. 1.25 1.26
$CO_2 + \lambda \rightarrow {CO_2}^+(C) + e$	Revi Avakyan 98	19.395	19.395:-1	20%		Fig. 1.7 1.8
$CO_2 + \lambda \rightarrow O(^1D) + CO$	Revi AMOP	7	7:-1	???%	U	Fig. 1.13 1.14
	Adap Slanger 74	7	7:-1	20%		Fig. 1.13 1.14
	Adap Slanger 74	7	7:-1	20%	RUE	Fig. 1.13 1.14
$CO_2 + \lambda \rightarrow CO(a^3\Pi) + O$	Revi AMOP	11.420	11.420:-1	???%	U	Fig. 1.17 1.18
	Meas Lawrence 1972	11.420	11.420:-1	50%	U	Fig. 1.17 1.18
	Meas Lawrence 1972	11.420	11.420:-1	50%	RUE	Fig. 1.17 1.18

Table 1.4: Excitation Cross section for λ impact on CO_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$CO_2 + \lambda \rightarrow CO_2{}^+(C) + e$	Revi Avakyan 98	19.395	19.395:-1	20%		Fig. 1.33 1.34 1.
$CO_2 + \lambda \rightarrow O(^3S) + CO$	Meas Wu 1979	16.44	16.44:-1	30%	RUE	Fig. 1.33 1.34 1.
$CO_2 + \lambda \rightarrow CO(a^3\Pi) + O$	Meas Lawrence 1972	11.420	11.420:-1	50%	RUE	Fig. 1.33 1.34 1.
$CO_2 + \lambda \rightarrow CO_2{}^+(B) + e$	Meas Ukai 1992	18.076	18.076:-1	15%		Fig. 1.33 1.34 1.
$CO_2 + \lambda \rightarrow C^+ + O_2 + e$	Revi AMOP	23	23:-1	30%	RUE	Fig. 1.33 1.34 1.
$CO_2 + \lambda \rightarrow CO_2{}^+ + e +$ Auger (O)	Revi Avakyan 98	539	539:-1	20%		Fig. 1.33 1.34 1.
$CO_2 + \lambda \rightarrow CO(A^1\Pi) + O$	Meas Gentieu and Mentall 1972	13.390	13.390:-1	50%	RE	Fig. 1.33 1.34 1.
$CO_2 + \lambda \rightarrow CO_2{}^{2+} + 2e$	Adap ? BDD	37.600	37.600:-1	50%	U	Fig. 1.33 1.34 1.
$CO_2 + \lambda \rightarrow CO_2{}^+(A) + e$	Meas Ukai 1992	17.316	17.316:-1	15%		Fig. 1.33 1.34 1.
$CO_2 + \lambda \rightarrow O(^1S) + CO$	Meas Lawrence 1972+AMOP	9	9:-1	20%	RUE	Fig. 1.33 1.34 1.
$CO_2 + \lambda \rightarrow$ Total	Adap AMOP+Avakyan	0	0:-1	20%	RU	Fig. 1.33 1.34 1.
$CO_2 + \lambda \rightarrow CO_2{}^+ + e$	Adap AMOP+Avakyan	13.733	13.733:-1	20%	RUE	Fig. 1.33 1.34 1.
$CO_2 + \lambda \rightarrow CO_+ + O + e$	Revi AMOP	19.446	19.446:-1	30%	RUE	Fig. 1.33 1.34 1.
$CO_2 + \lambda \rightarrow O^+ + Co + e$	Revi AMOP	19.070	19.070:-1	30%	RUE	Fig. 1.33 1.34 1.
$CO_2 + \lambda \rightarrow O(^1D) + CO$	Adap Slanger 74	7	7:-1	20%	RUE	Fig. 1.33 1.34 1.
$CO_2 + \lambda \rightarrow CO_2{}^+ + e +$ Auger (C)	Revi Avakyan 98	282	282:-1	20%		Fig. 1.33 1.34 1.

Table 1.5: Recommended Cross section for λ impact on CO_2

the data (e.g. errorbars, comparison with other experiments), the possibility of extrapolation, and the origin of the work, coupled with the consistency (sum of recommended cross sections Total cross section)

U : Estimated uncertainty: sometimes, the uncertainty is not given, because of theoretical work... The authors of the database have to estimate the uncertainty, but the quality of that estimation can be questionable. Moreover, when data from different sources have been adapted (e.g. for extrapolation), the uncertainty can be modified...

E : Validated for extrapolation: the extrapolation of these cross sections is plausible. For example, when an analytic function has been applied...

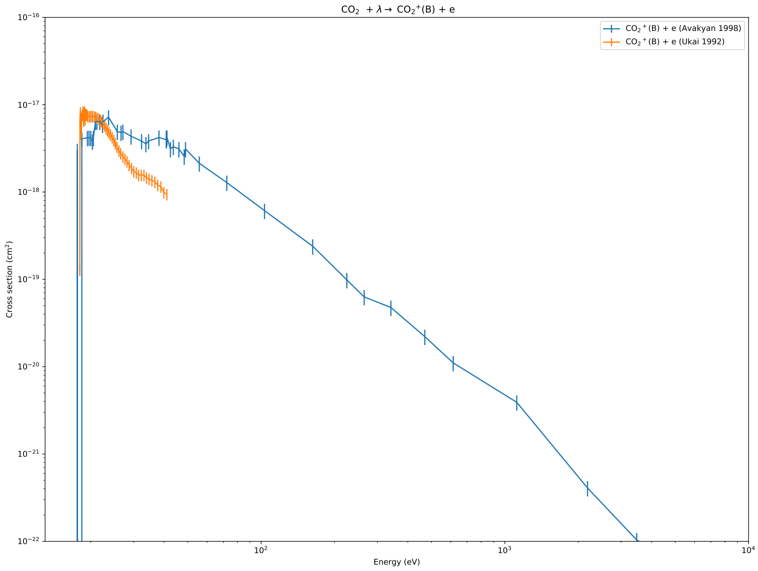

Figure 1.1: Cross sections for $CO_2 + \lambda \rightarrow {CO_2}^+(B) + e$

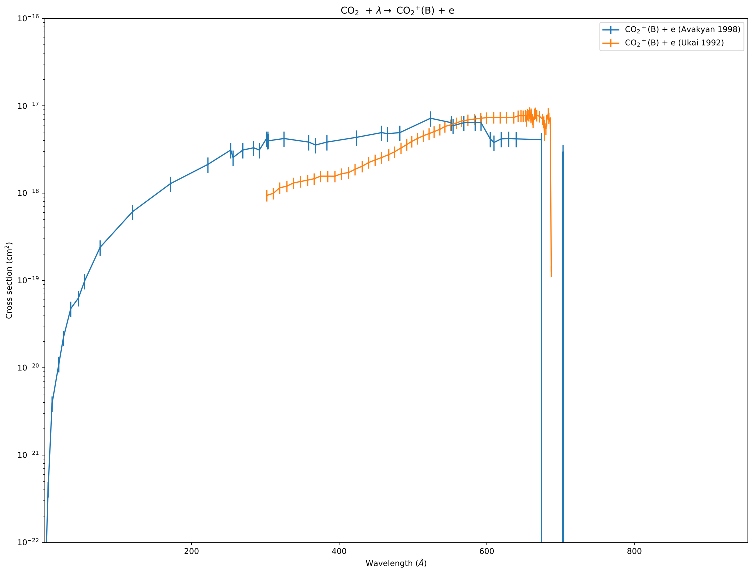

Figure 1.2: Cross sections for $CO_2 + \lambda \rightarrow {CO_2}^+(B) + e$ (wavelength version)

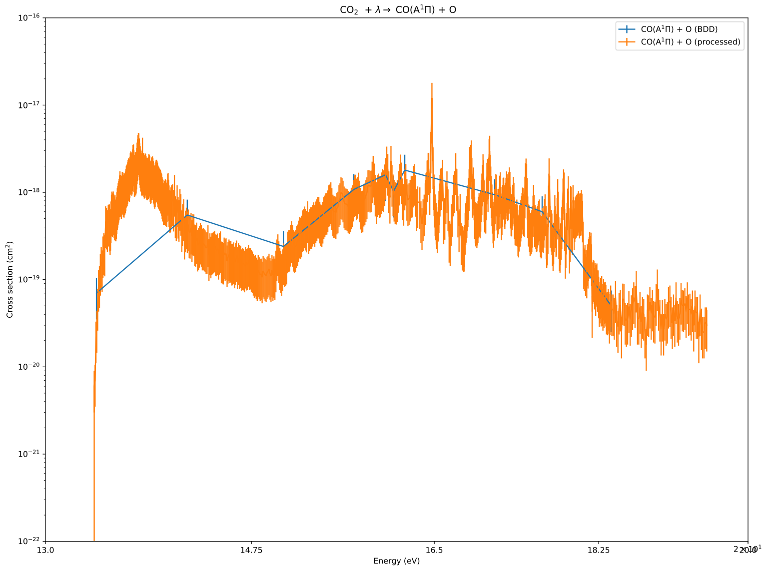

Figure 1.3: Cross sections for $CO_2 + \lambda \rightarrow CO(A^1\Pi) + O$

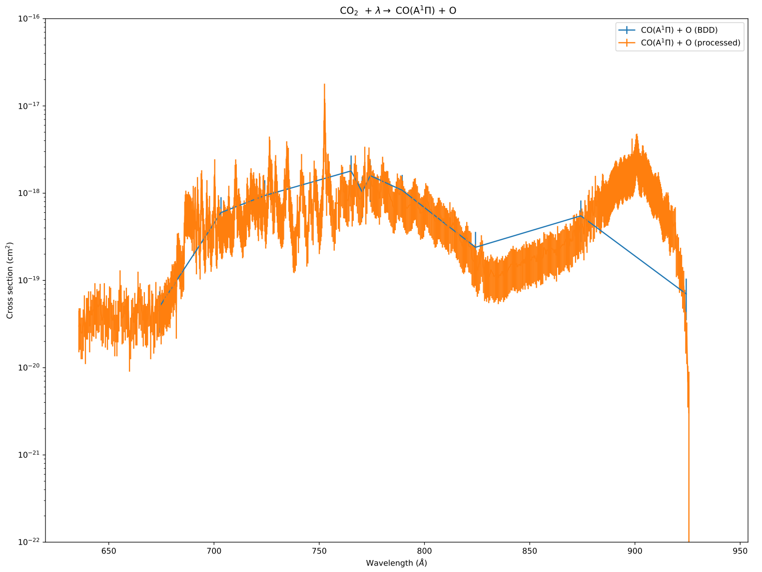

Figure 1.4: Cross sections for $CO_2 + \lambda \rightarrow CO(A^1\Pi) + O$ (wavelength version)

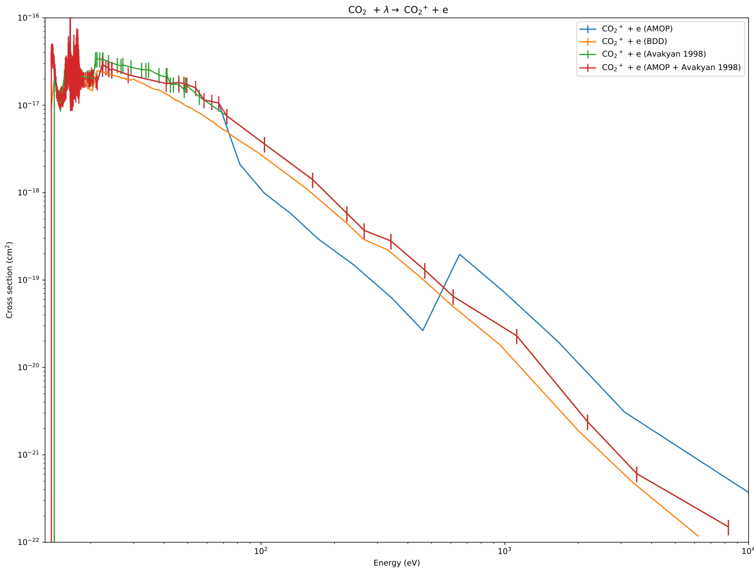

Figure 1.5: Cross sections for $CO_2 + \lambda \rightarrow {CO_2}^+ + e$

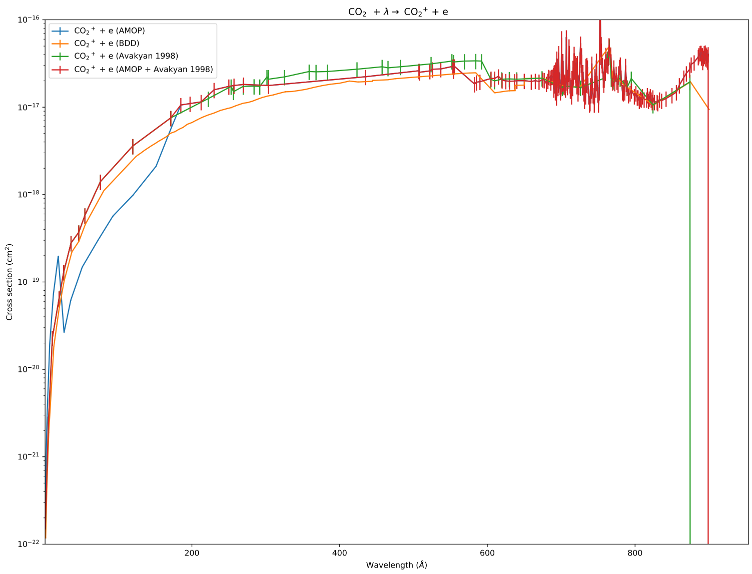

Figure 1.6: Cross sections for $CO_2 + \lambda \rightarrow {CO_2}^+ + e$ (wavelength version)

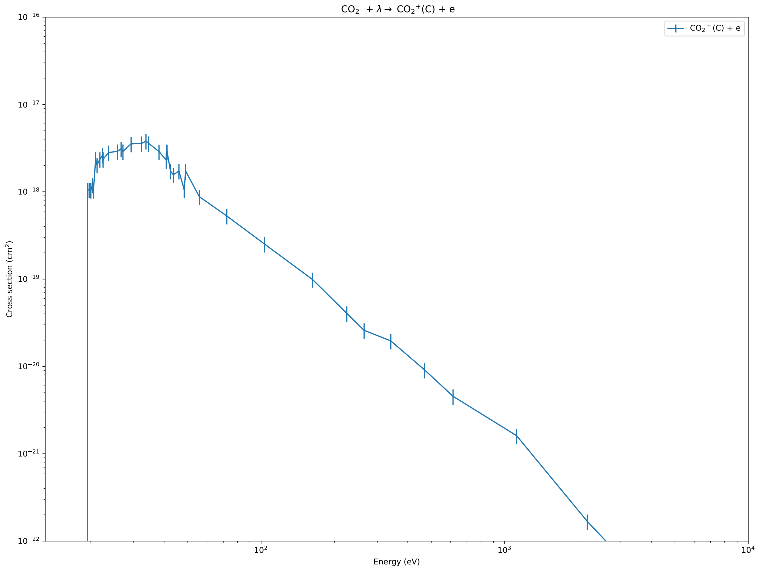

Figure 1.7: Cross sections for $CO_2 + \lambda \rightarrow {CO_2}^+(C) + e$

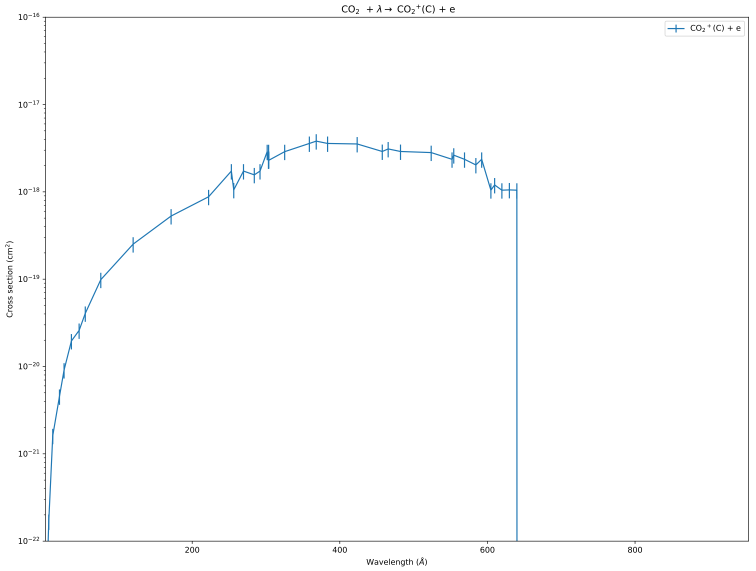

Figure 1.8: Cross sections for $CO_2 + \lambda \rightarrow {CO_2}^+(C) + e$ (wavelength version)

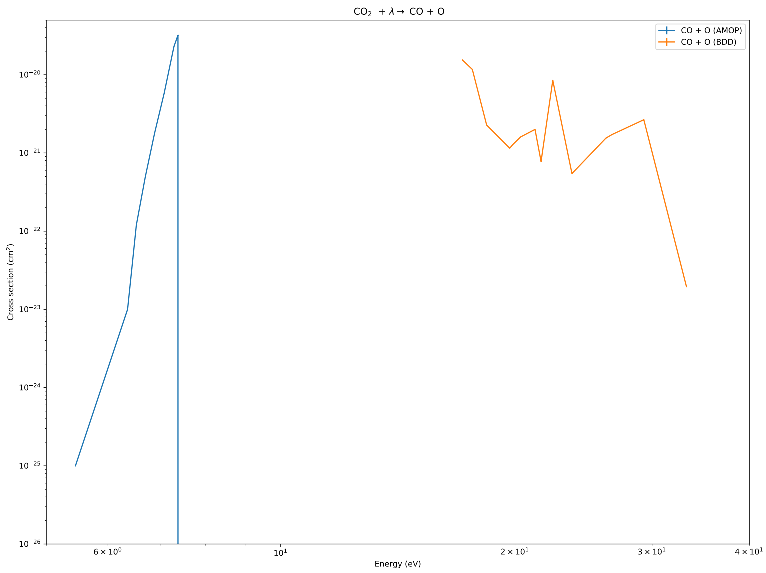

Figure 1.9: Cross sections for $CO_2 + \lambda \rightarrow CO + O$

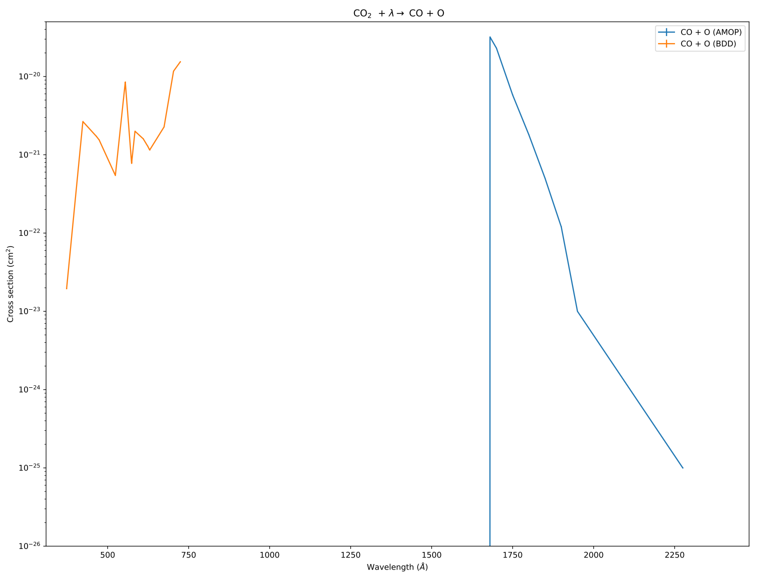

Figure 1.10: Cross sections for $CO_2 + \lambda \rightarrow CO + O$ (wavelength version)

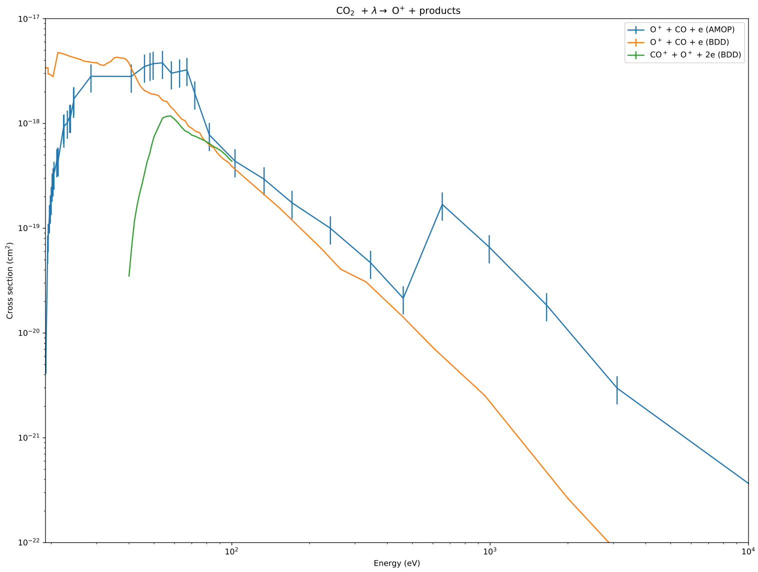

Figure 1.11: Cross sections for $CO_2 + \lambda \rightarrow O^+$ + products

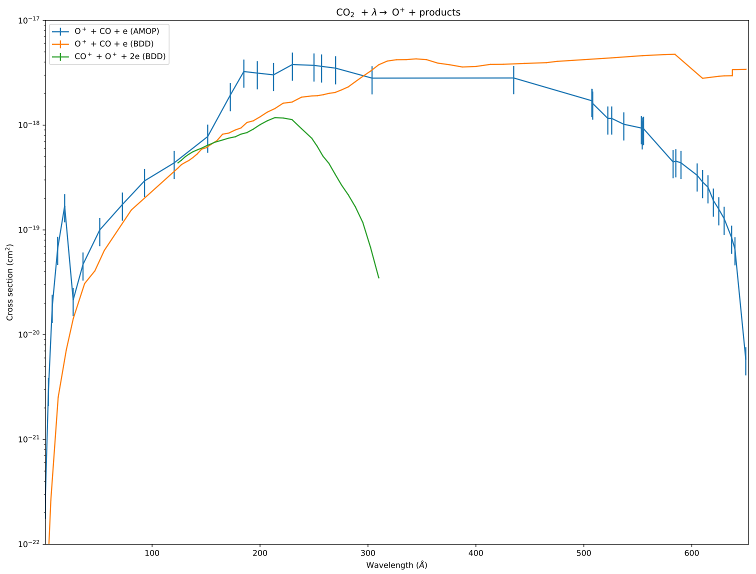

Figure 1.12: Cross sections for $CO_2 + \lambda \rightarrow O^+$ + products (wavelength version)

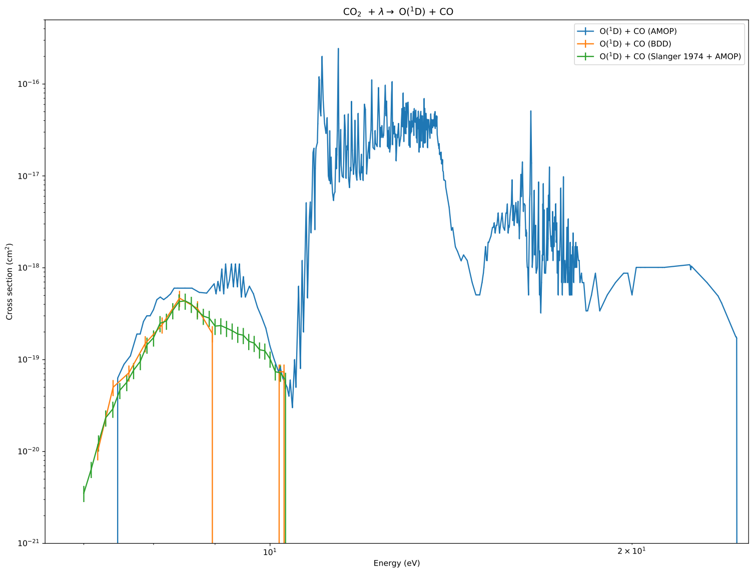

Figure 1.13: Cross sections for $CO_2 + \lambda \rightarrow O(^1D) + CO$

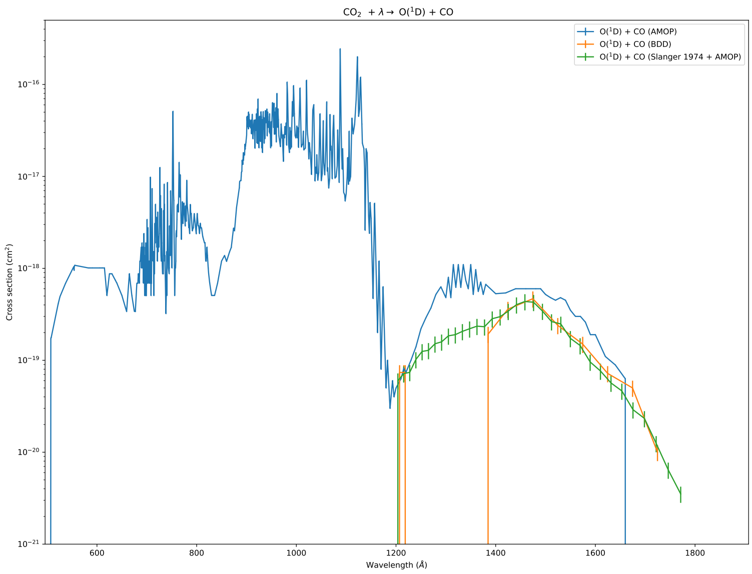

Figure 1.14: Cross sections for $CO_2 + \lambda \rightarrow O(^1D) + CO$ (wavelength version)

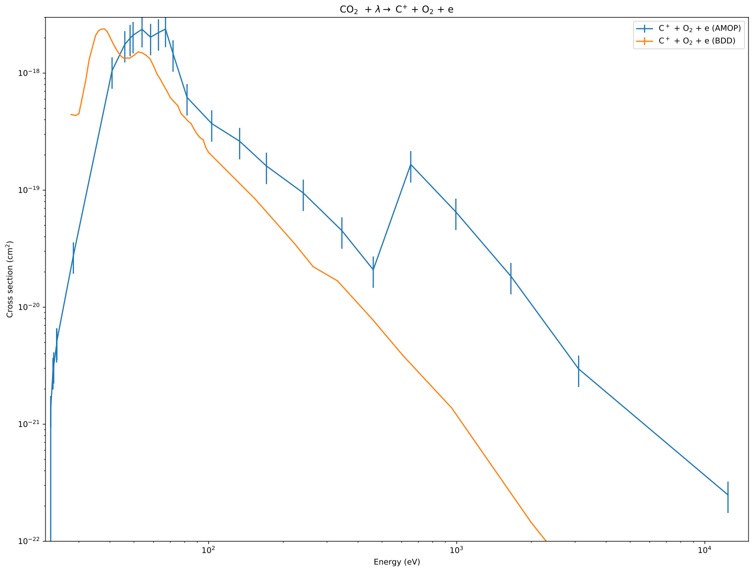

Figure 1.15: Cross sections for $CO_2 + \lambda \rightarrow C^+ + O_2 + e$

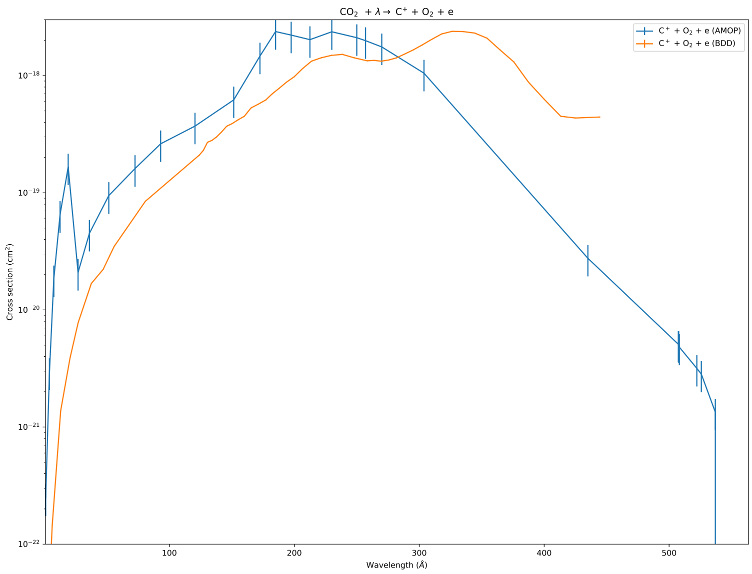

Figure 1.16: Cross sections for $CO_2 + \lambda \rightarrow C^+ + O_2 + e$ (wavelength version)

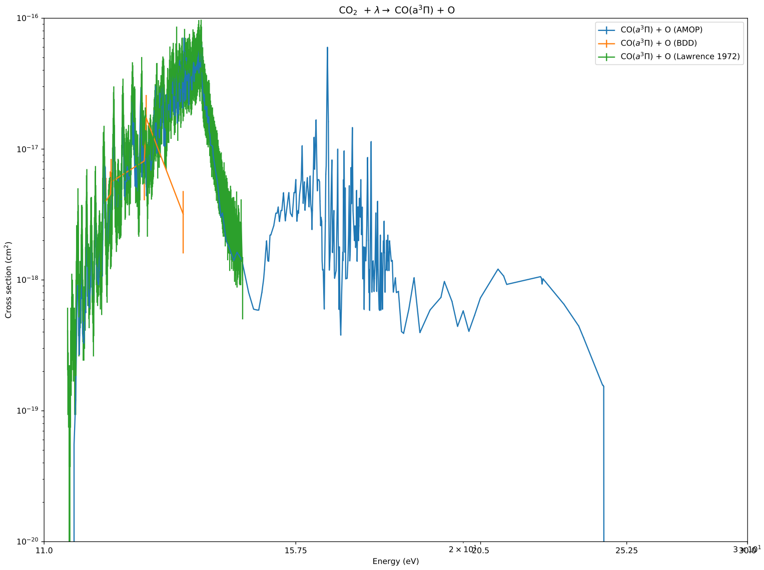

Figure 1.17: Cross sections for $CO_2 + \lambda \rightarrow CO(a^3\Pi) + O$

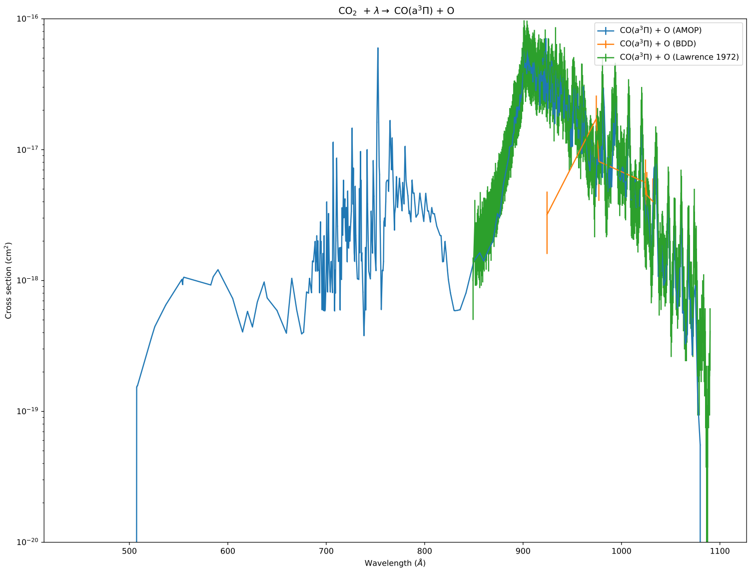

Figure 1.18: Cross sections for $CO_2 + \lambda \rightarrow CO(a^3\Pi) + O$ (wavelength version)

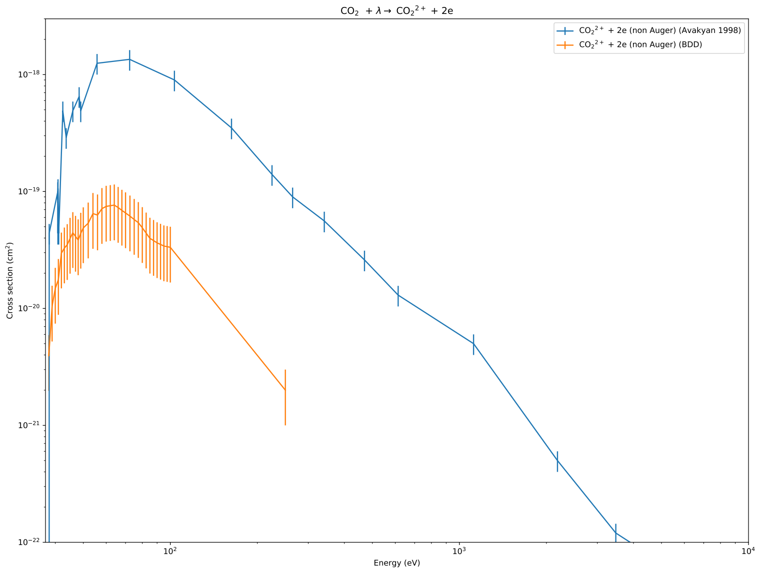

Figure 1.19: Cross sections for $CO_2 + \lambda \rightarrow {CO_2}^{2+} + 2e$

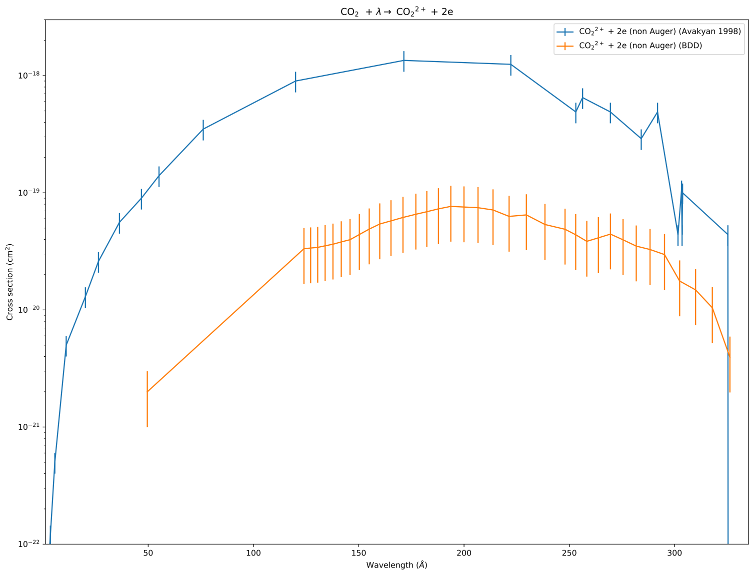

Figure 1.20: Cross sections for $CO_2 + \lambda \rightarrow {CO_2}^{2+} + 2e$ (wavelength version)

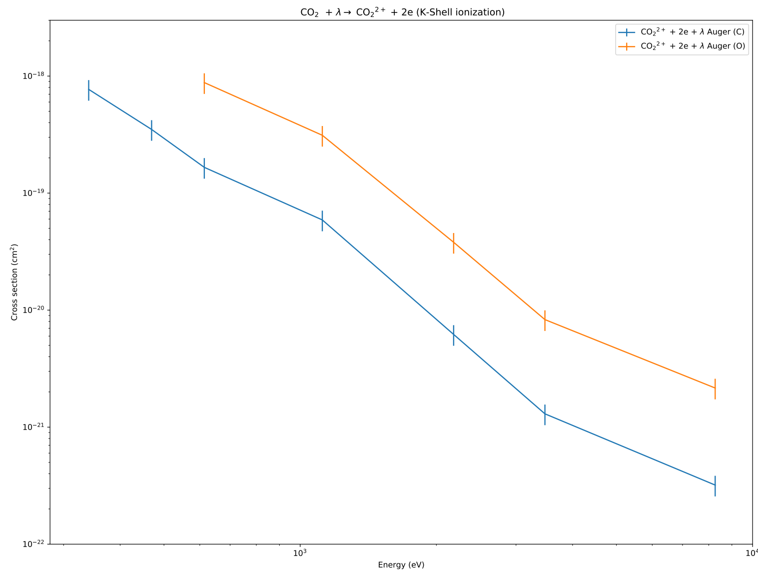

Figure 1.21: Cross sections for $CO_2 + \lambda \rightarrow {CO_2}^{2+} + 2e$ (K-Shell ionization)

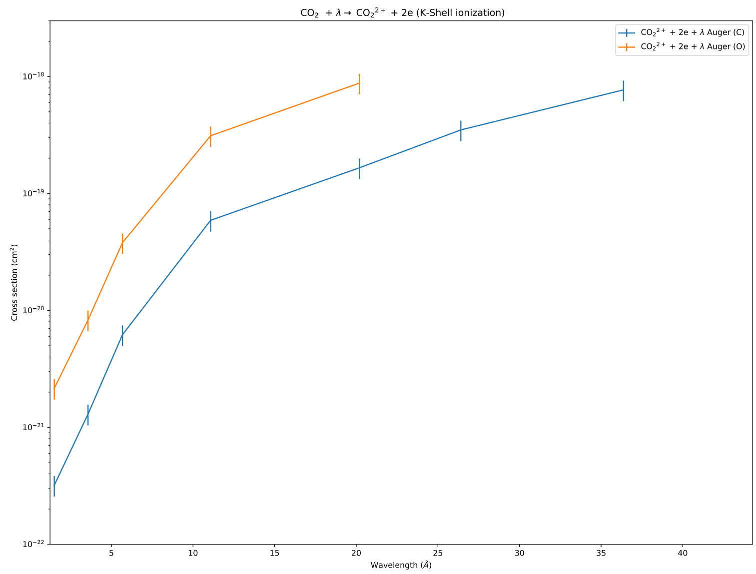

Figure 1.22: Cross sections for $CO_2 + \lambda \rightarrow {CO_2}^{2+} + 2e$ (K-Shell ionization) (wavelength version)

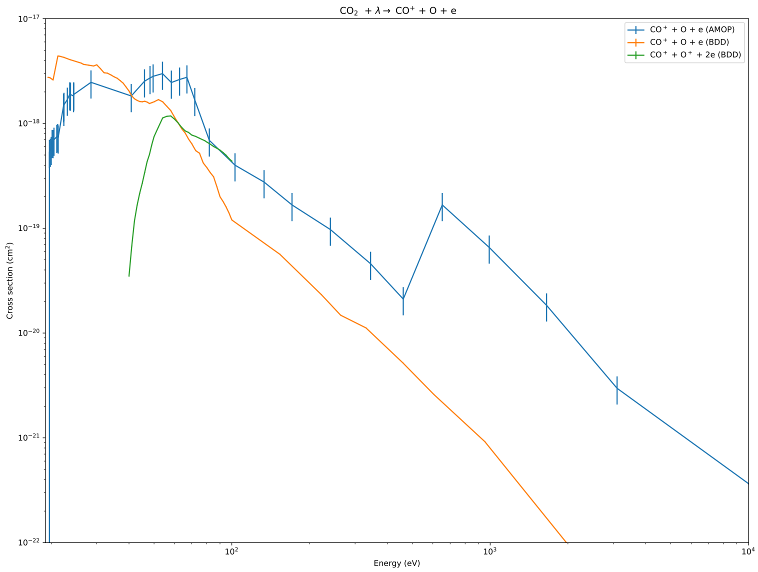

Figure 1.23: Cross sections for $CO_2 + \lambda \rightarrow CO^+ + O + e$

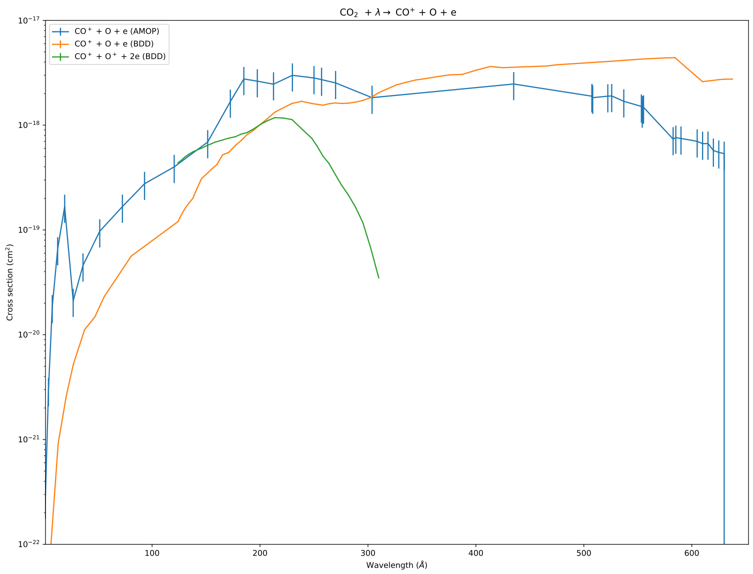

Figure 1.24: Cross sections for $CO_2 + \lambda \rightarrow CO^+ + O + e$ (wavelength version)

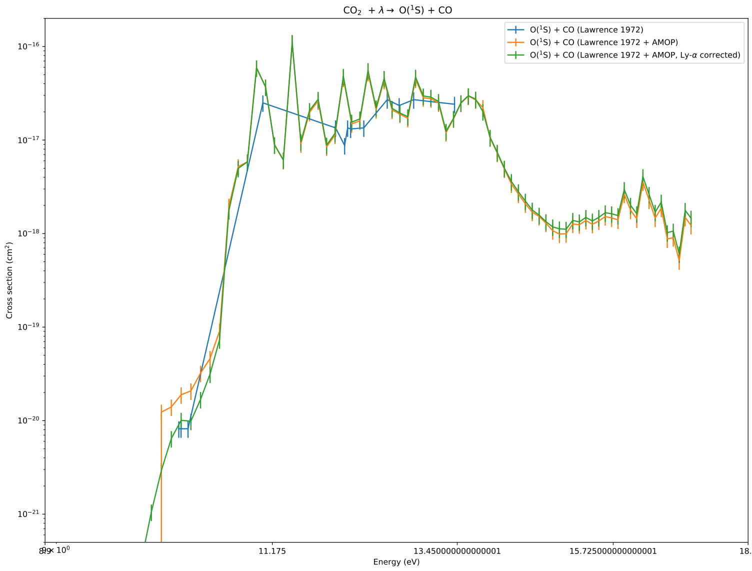

Figure 1.25: Cross sections for $CO_2 + \lambda \rightarrow O(^1S) + CO$

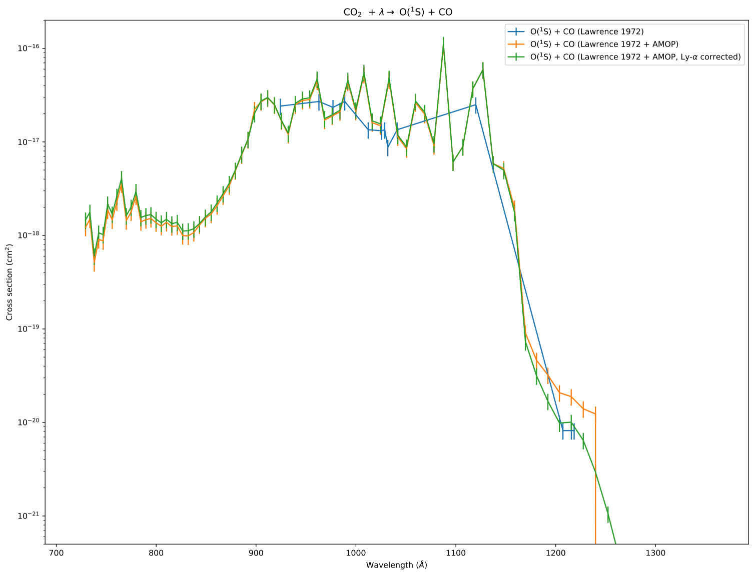

Figure 1.26: Cross sections for $CO_2 + \lambda \rightarrow O(^1S) + CO$ (wavelength version)

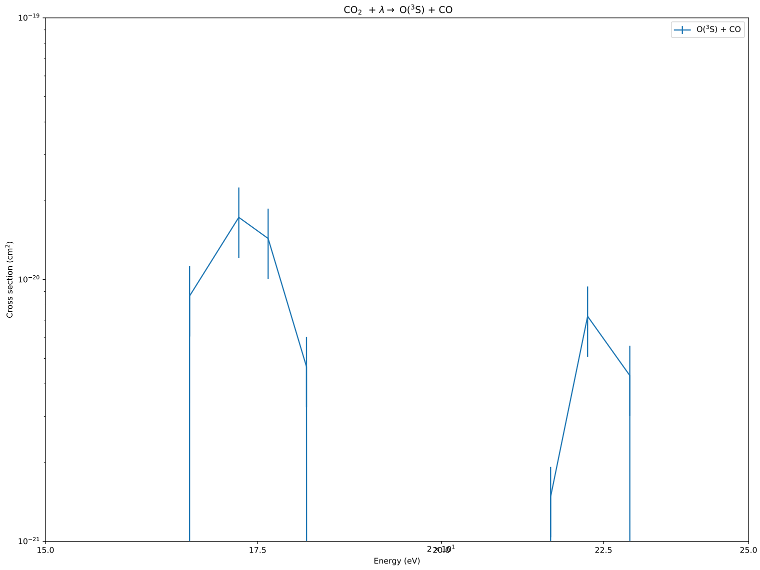

Figure 1.27: Cross sections for $CO_2 + \lambda \rightarrow O(^3S) + CO$

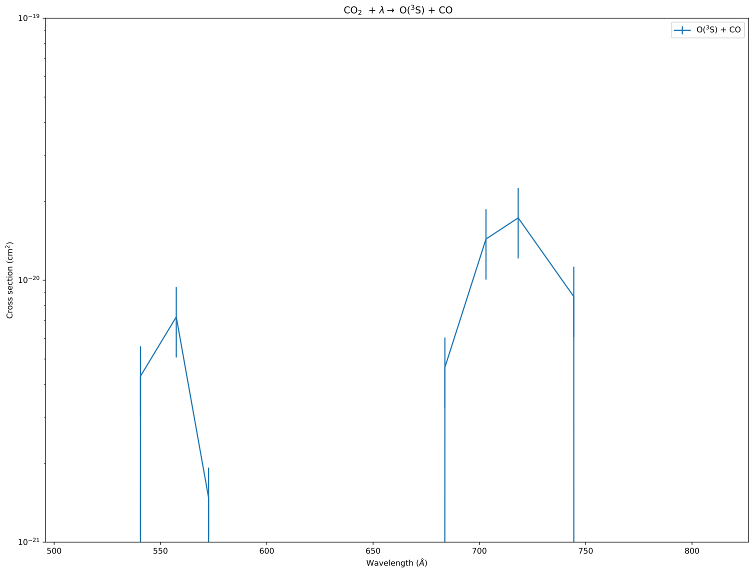

Figure 1.28: Cross sections for $CO_2 + \lambda \rightarrow O(^3S) + CO$ (wavelength version)

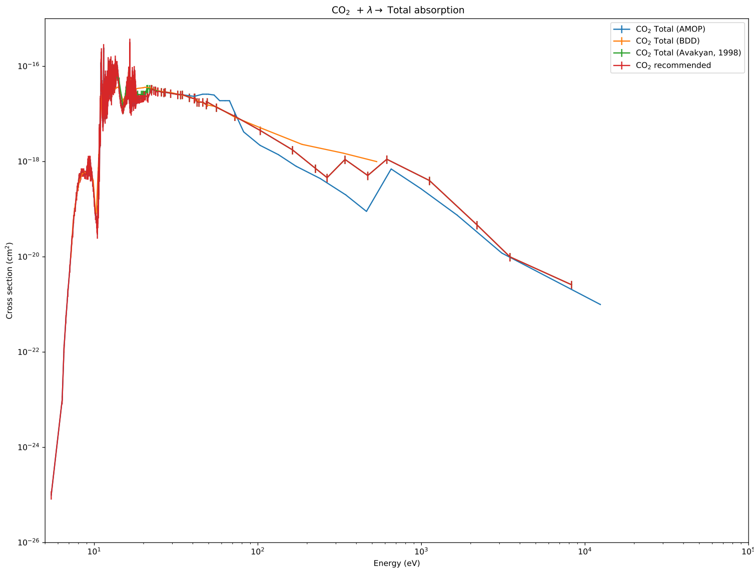

Figure 1.29: Cross sections for $CO_2 + \lambda \rightarrow$ Total absorption

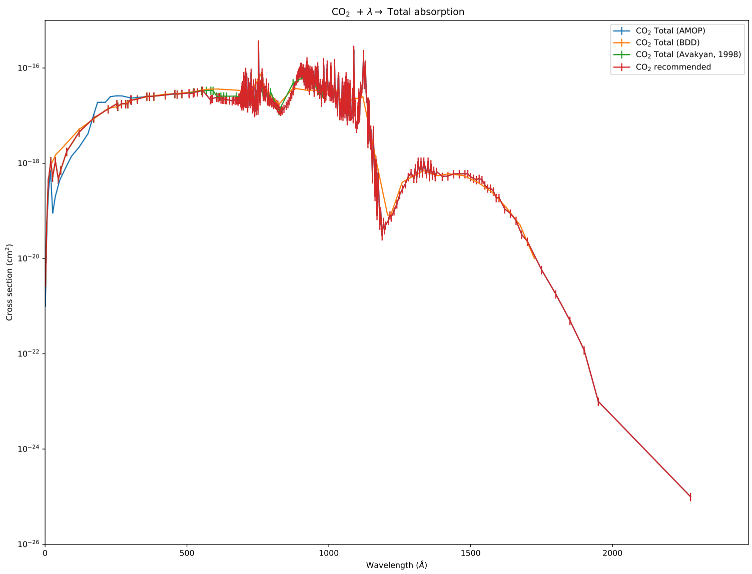

Figure 1.30: Cross sections for $CO_2 + \lambda \rightarrow$ Total absorption (wavelength version)

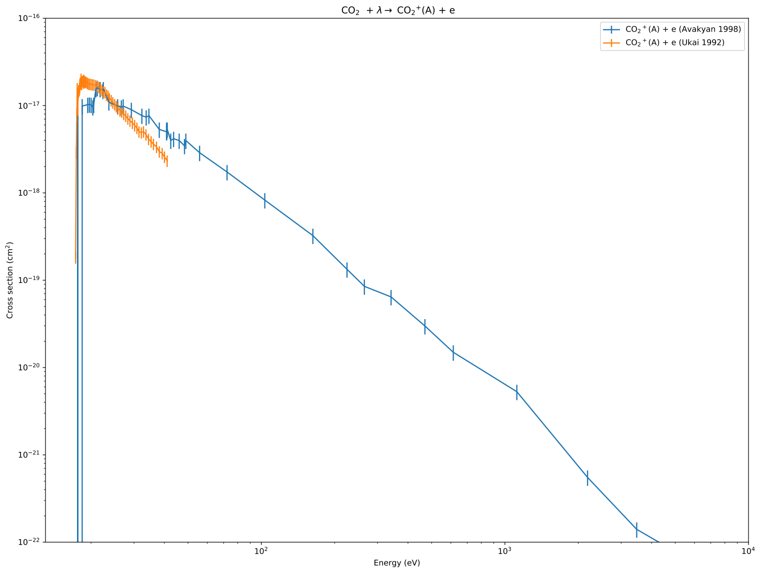

Figure 1.31: Cross sections for $CO_2 + \lambda \rightarrow {CO_2}^+(A) + e$

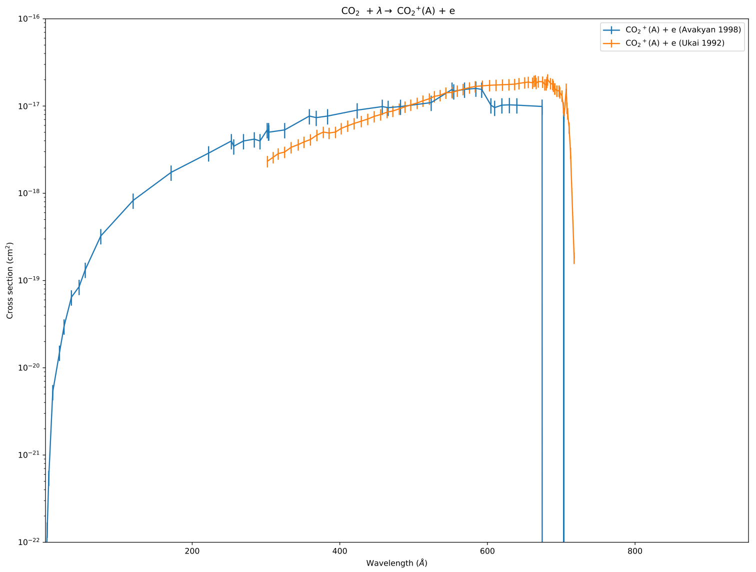

Figure 1.32: Cross sections for $CO_2 + \lambda \rightarrow {CO_2}^+(A) + e$ (wavelength version)

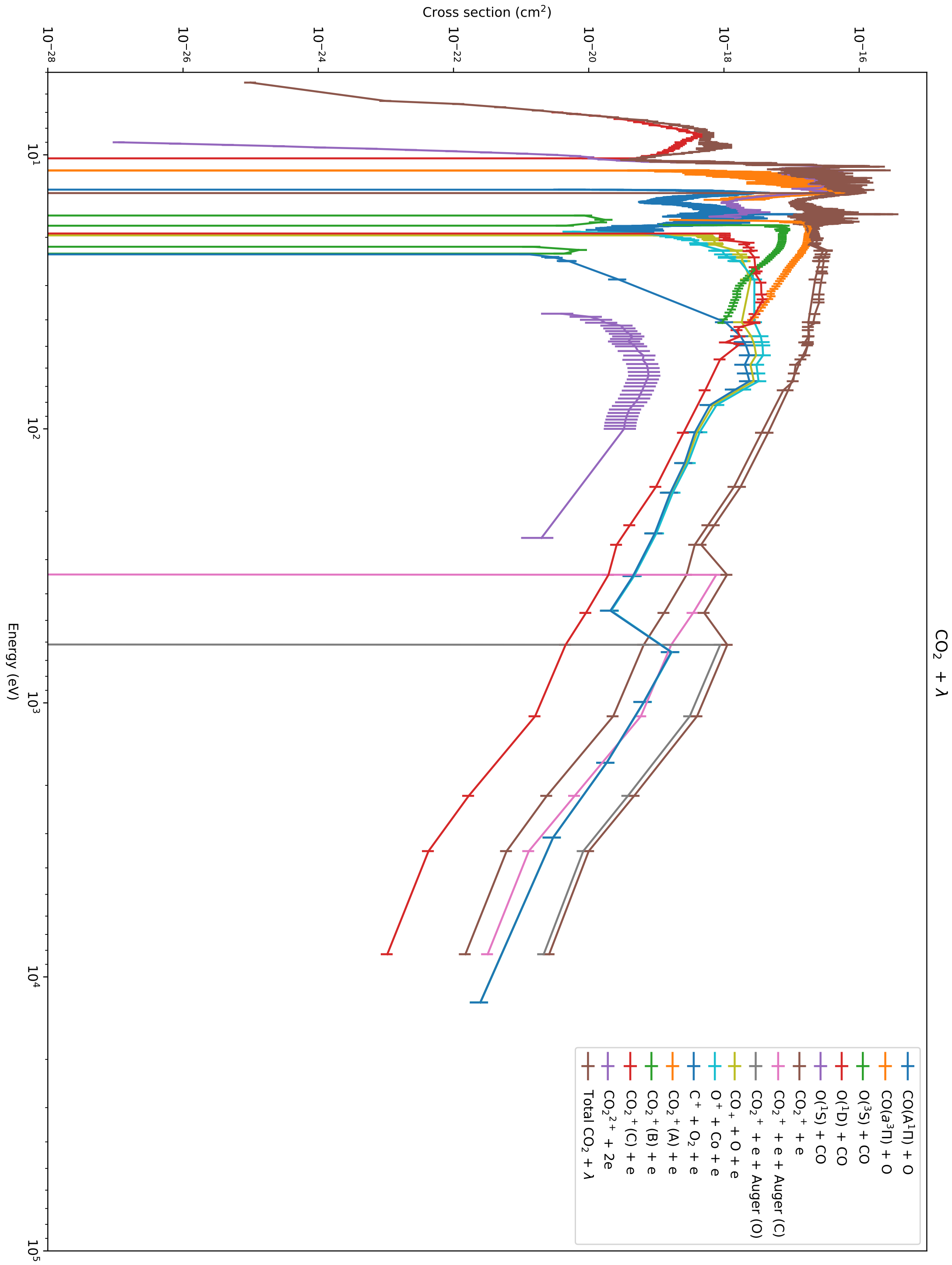

Figure 1.33: Cross sections for $CO_2 + \lambda$

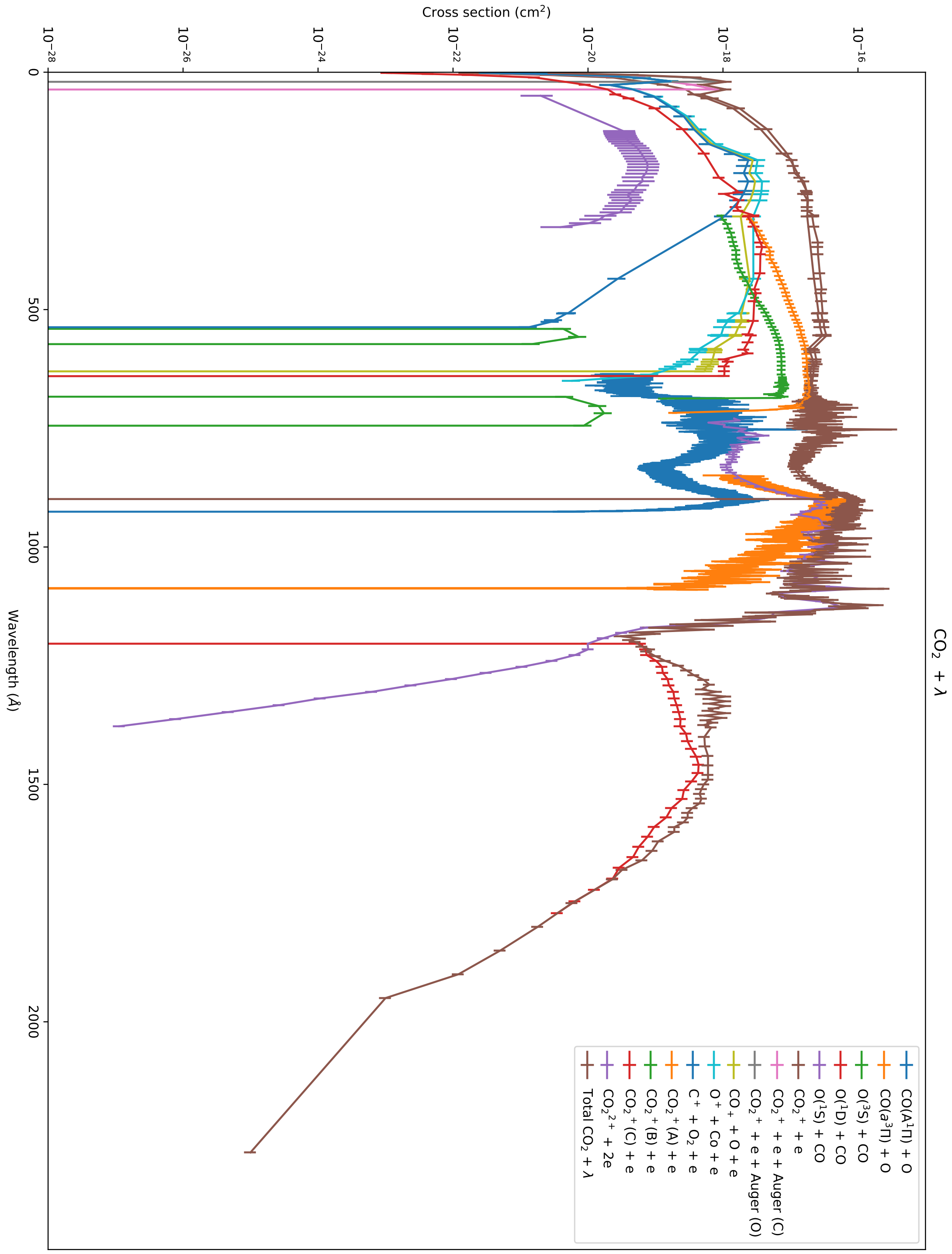

Figure 1.34: Cross sections for $CO_2 + \lambda$ (wavelength version)

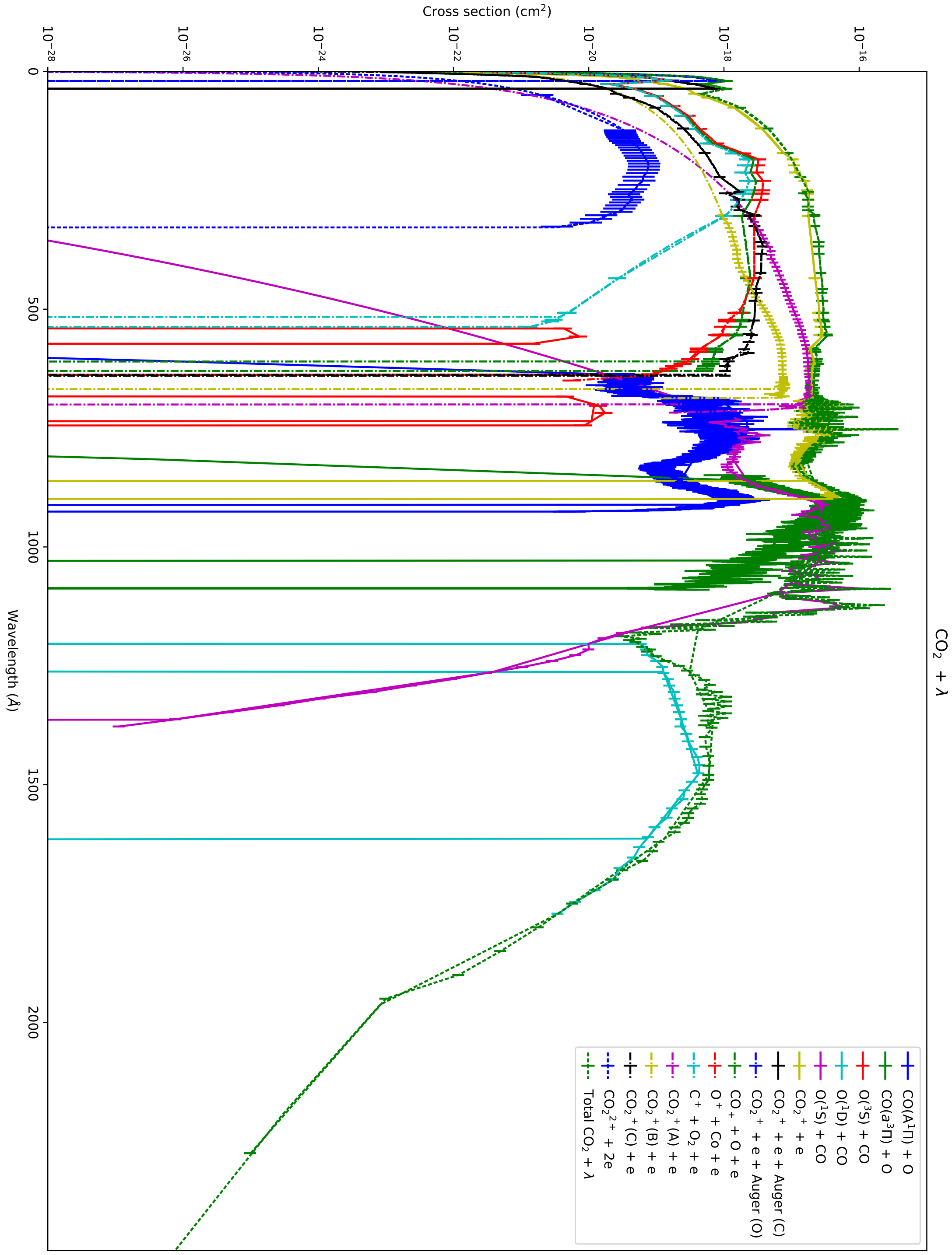

Figure 1.35: Cross sections for $CO_2 + \lambda$ (with extrapolation version)

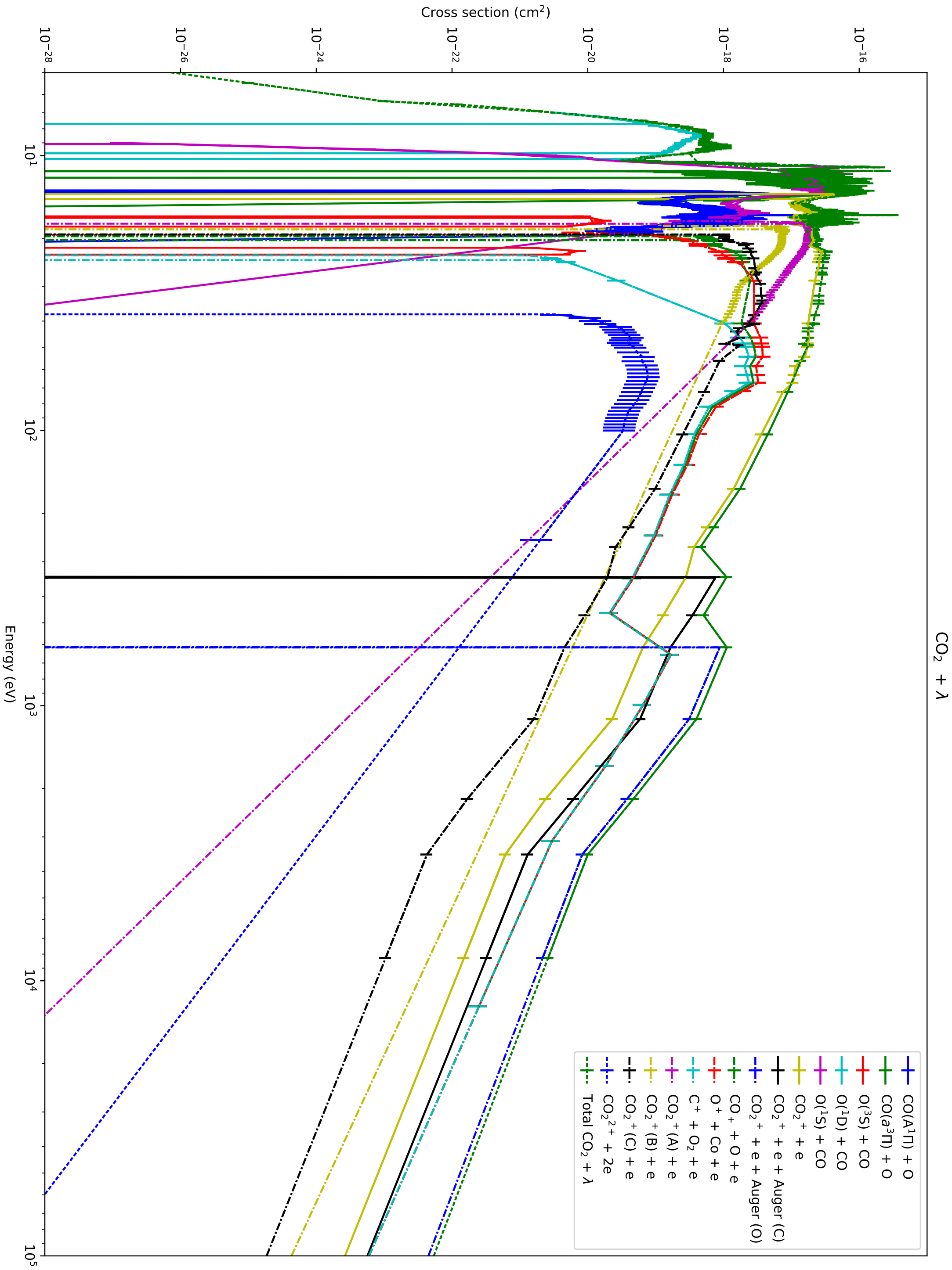

Figure 1.36: Cross sections for CO_2 + λ (wavelength with extrapolation version)

1.2 Cross section of ph impact with O

1.2.1 Total Cross Section

1.2.2 Inelastic Cross Sections

Ionization Cross Sections

$O + \lambda \rightarrow O^{2+}, O^{+} + e + \lambda$, Auger(X)

$O + \lambda \rightarrow O^{2+} + 2e$

$O + \lambda \rightarrow O^{+} + e$

1.2.3 Recommended data set

$O + \lambda \rightarrow O^{2+}, O^{+} + e + \lambda$, Auger(X)

$O + \lambda \rightarrow$ Total

$O + \lambda \rightarrow O^{+}(^4P^*) + e$

$O + \lambda \rightarrow O^{+}(^2P) + e$

$O + \lambda \rightarrow O^{+}(ABS^*) + e$

$O + \lambda \rightarrow O^{+}(^4S) + e$

$O + \lambda \rightarrow O^{2+} + 2e$

$O + \lambda \rightarrow O^{+}(^2P^*) + e$

$O + \lambda \rightarrow O^{+}(^2D) + e$

Legend for the properties

R : Recommended cross section for the processus. It is used in the main file. The selection of the recommended cross section is based on the quality of the data (e.g. errorbars, comparison with other experiments), the possibility of extrapolation, and the origin of the work, coupled with the consistency (sum of recommended cross sections Total cross section)

U : Estimated uncertainty: sometimes, the uncertainty is not given, because of theoretical work... The authors of the database have to estimate the uncertainty, but the quality of that estimation can be questionable. Moreover, when data from different sources have been adapted (e.g. for extrapolation), the uncertainty can be modified...

Reference	Threshold	Range of energy	Uncertainty	Properties	Fig
Revi Avakyan 98	0	0:-1	20%		Fig. 1.43 1.44
???? ? BDD	0	0:-1	???%	U	Fig. 1.43 1.44
Revi AMOP	0	0:-1	???%	U	Fig. 1.43 1.44

Table 1.6: Total cross section for λ impact on O

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$O + \lambda \rightarrow O^{2+}, O^{+} + e + \lambda$, Auger(X)	Revi Avakyan 98	539	539:-1	20%	R	Fig. 1.37 1.38
	???? ?? Avakyan 98	532	532:-1	???%	U	Fig. 1.37 1.38
$O + \lambda \rightarrow O^{2+} + 2e$	Revi Avakyan 98	48.74	48.74:-1	20%	R	Fig. 1.39 1.40
	???? ? BDD	48.74	48.74:-1	???%	U	Fig. 1.39 1.40
$O + \lambda \rightarrow O^{+} + e$	Revi Avakyan 98	13.618	13.618:-1	20%	R	Fig. 1.41 1.42
	???? ? BDD	13.61	13.61:-1	???%	U	Fig. 1.41 1.42

Table 1.7: Ionization Cross section for λ impact on O

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$O + \lambda \rightarrow O^{2+}, O^{+} + e + \lambda$, Auger(X)	Revi Avakyan 98	539	539:-1	20%	R	Fig. 1.45 1.46 1.47 1.48
$O + \lambda \rightarrow$ Total	Revi Avakyan 98	0	0:-1	20%		Fig. 1.45 1.46 1.47 1.48
$O + \lambda \rightarrow O^{+}(^{4}P^{*}) + e$	Revi Avakyan 98	28.48	28.48:-1	20%		Fig. 1.45 1.46 1.47 1.48
$O + \lambda \rightarrow O^{+}(^{2}P) + e$	Revi Avakyan 98	18.635	18.635:-1	20%		Fig. 1.45 1.46 1.47 1.48
$O + \lambda \rightarrow O^{+}(ABS^{*}) + e$	Revi Avakyan 98	13.618	13.618:-1	20%		Fig. 1.45 1.46 1.47 1.48
$O + \lambda \rightarrow O^{+}(^{4}S) + e$	Revi Avakyan 98	13.618	13.618:-1	20%		Fig. 1.45 1.46 1.47 1.48
$O + \lambda \rightarrow O^{2+} + 2e$	Revi Avakyan 98	48.74	48.74:-1	20%		Fig. 1.45 1.46 1.47 1.48
$O + \lambda \rightarrow O^{+}(^{2}P^{*}) + e$	Revi Avakyan 98	39.98	39.98:-1	20%		Fig. 1.45 1.46 1.47 1.48
$O + \lambda \rightarrow O^{+}(^{2}D) + e$	Revi Avakyan 98	16.941	16.941:-1	20%		Fig. 1.45 1.46 1.47 1.48

Table 1.8: Recommended Cross section for λ impact on O

E : Validated for extrapolation: the extrapolation of these cross sections is plausible. For example, when an analytic function has been applied...

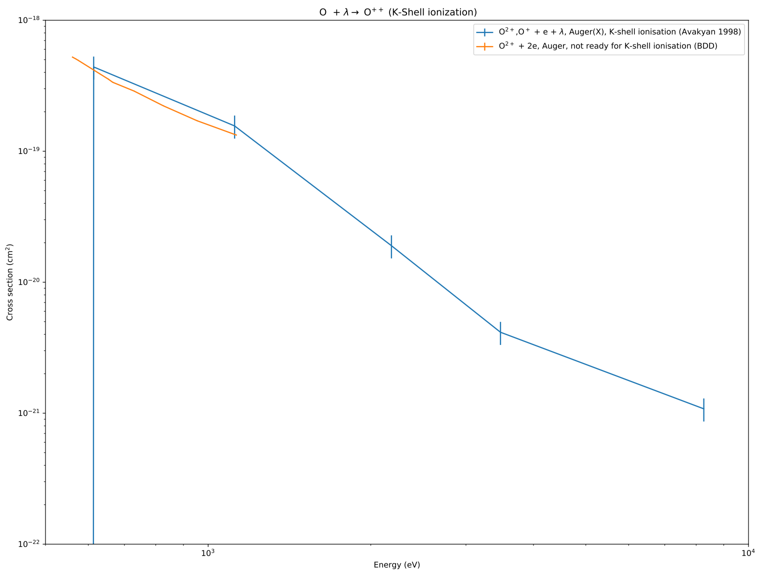

Figure 1.37: Cross sections for O + $\lambda \rightarrow$ O^{++} (K-Shell ionization)

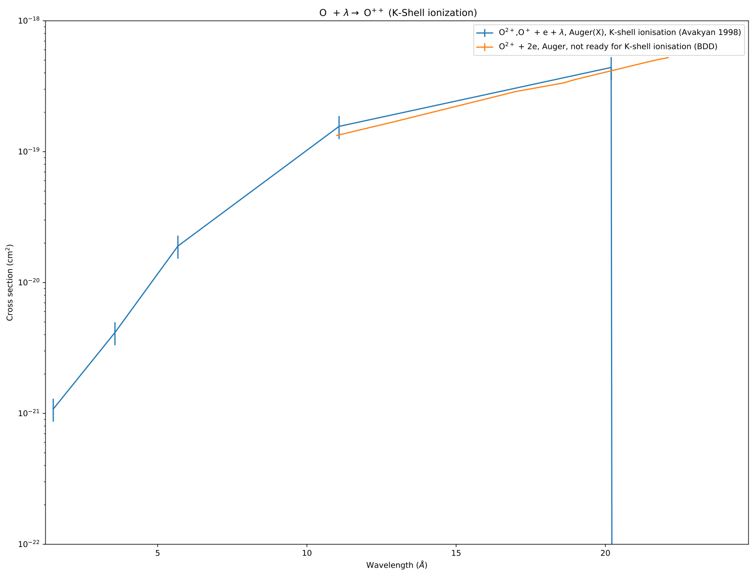

Figure 1.38: Cross sections for O + $\lambda \rightarrow$ O^{++} (K-Shell ionization) (wavelength version)

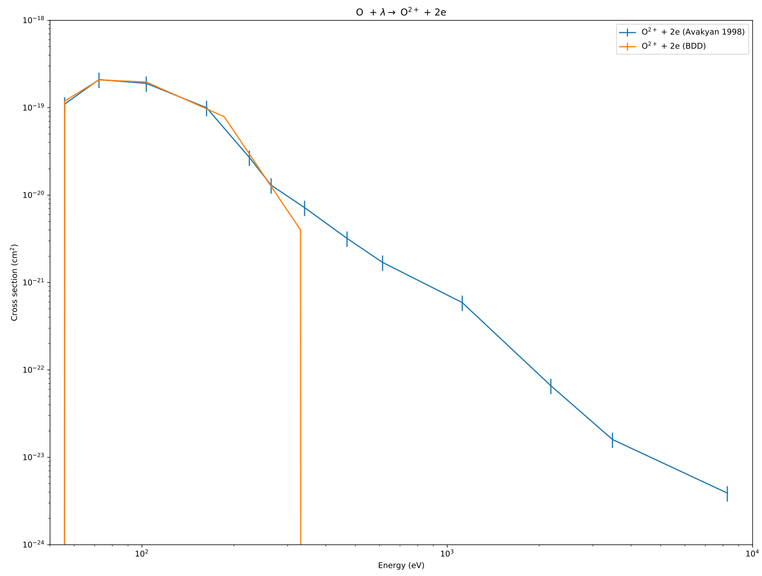

Figure 1.39: Cross sections for O + $\lambda \rightarrow$ O^{2+} + 2e

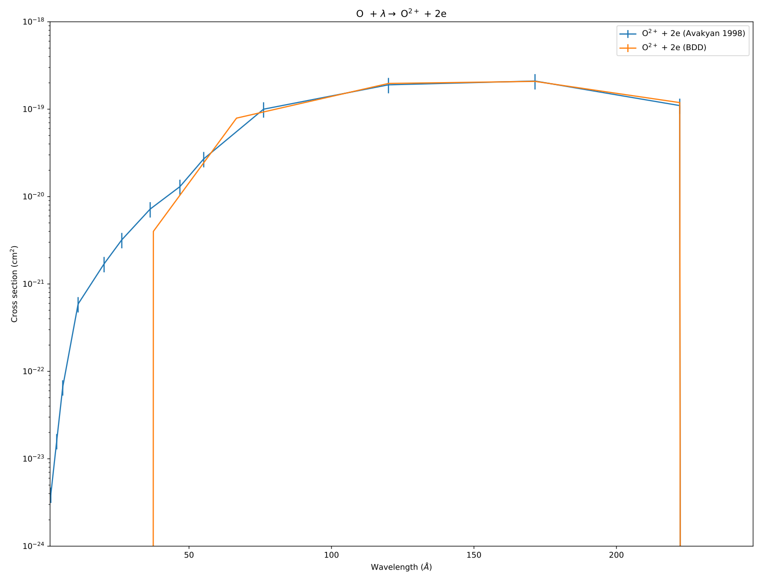

Figure 1.40: Cross sections for O + $\lambda \rightarrow$ O^{2+} + 2e (wavelength version)

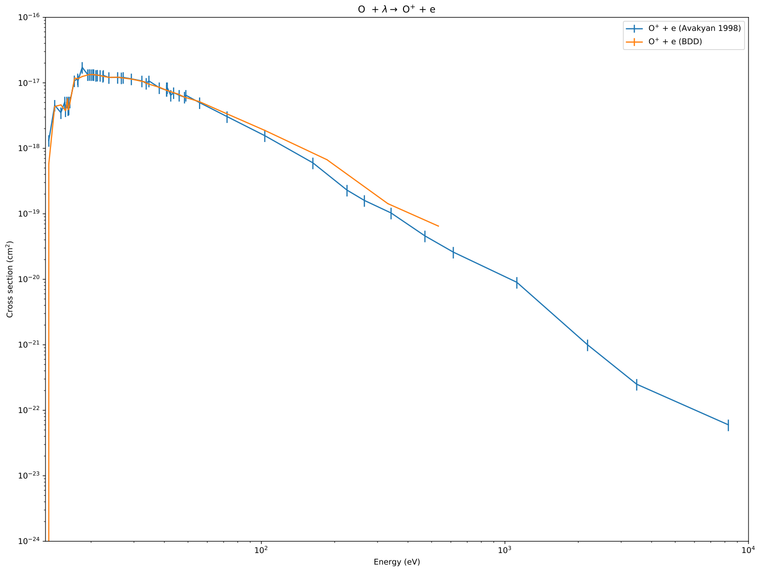

Figure 1.41: Cross sections for O + $\lambda \rightarrow$ O^+ + e

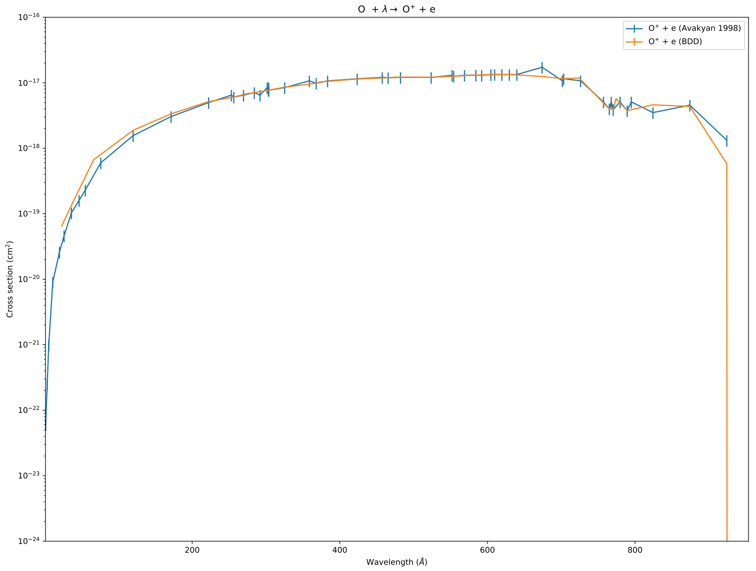

Figure 1.42: Cross sections for O + $\lambda \rightarrow$ O^+ + e (wavelength version)

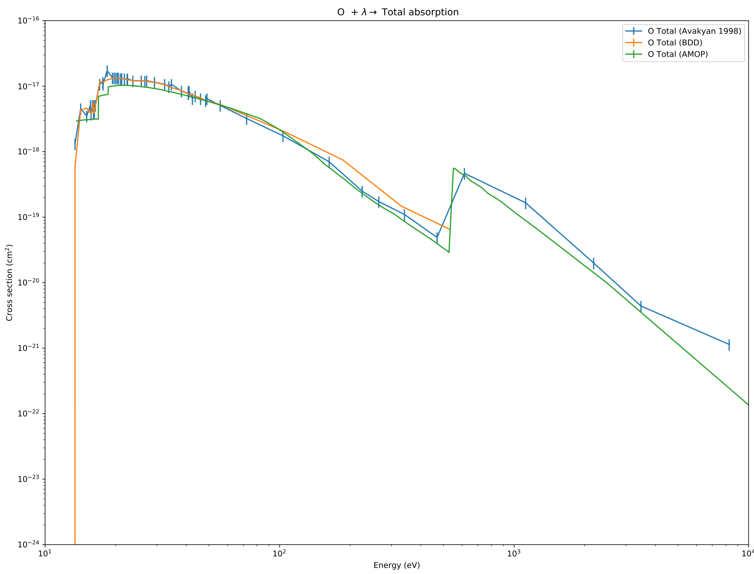

Figure 1.43: Cross sections for O + $\lambda \rightarrow$ Total absorption

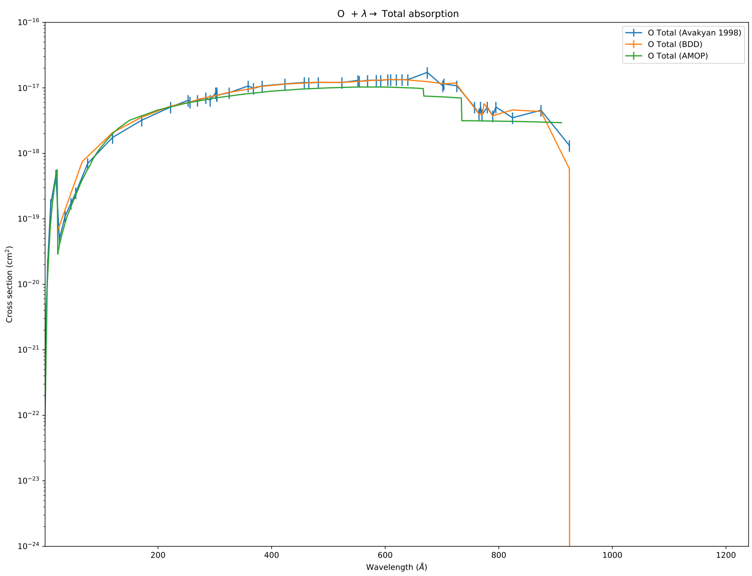

Figure 1.44: Cross sections for O + $\lambda \rightarrow$ Total absorption (wavelength version)

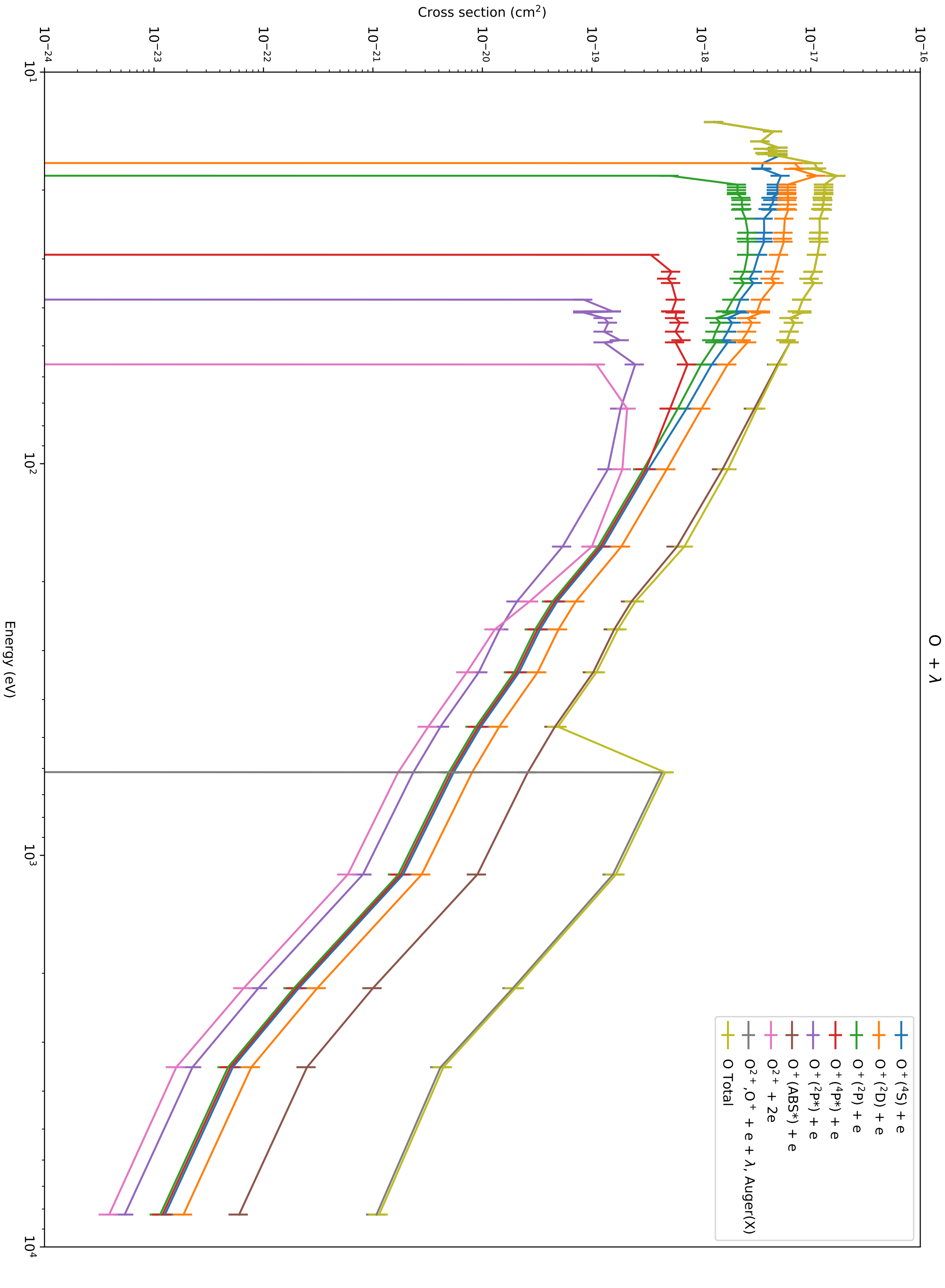

Figure 1.45: Cross sections for O + λ

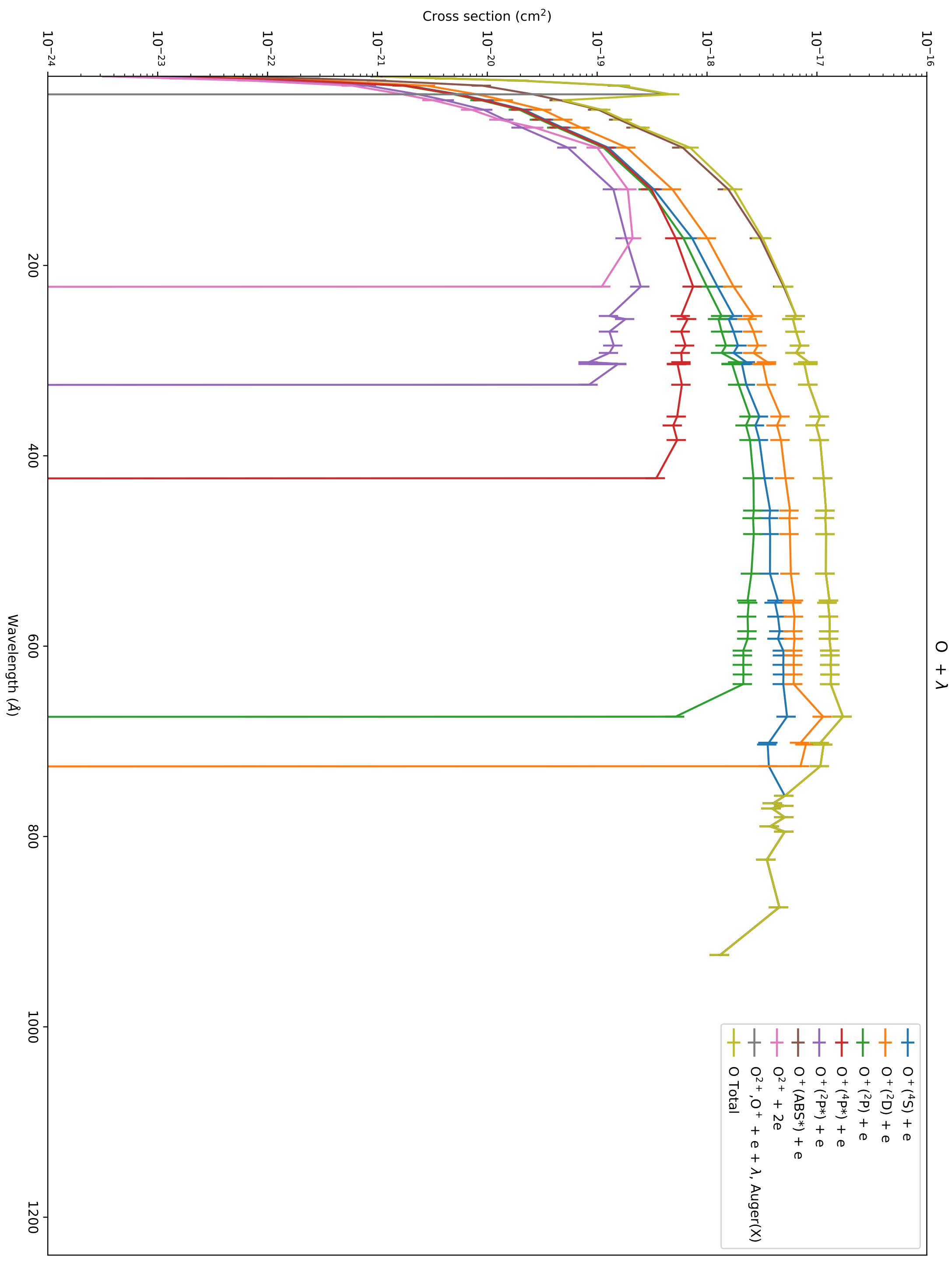

Figure 1.46: Cross sections for O + λ (wavelength version)

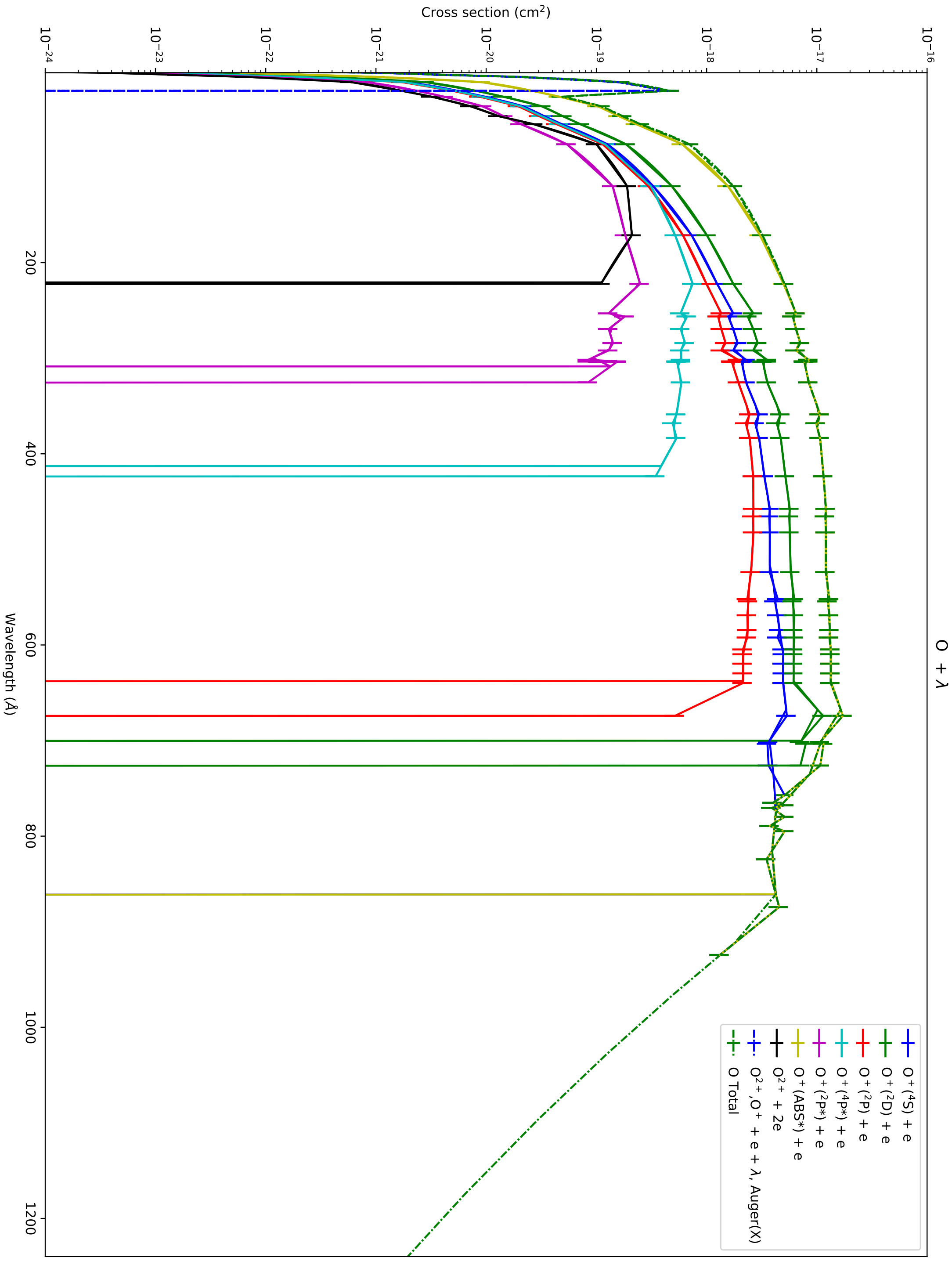

Figure 1.47: Cross sections for O + λ (with extrapolation version)

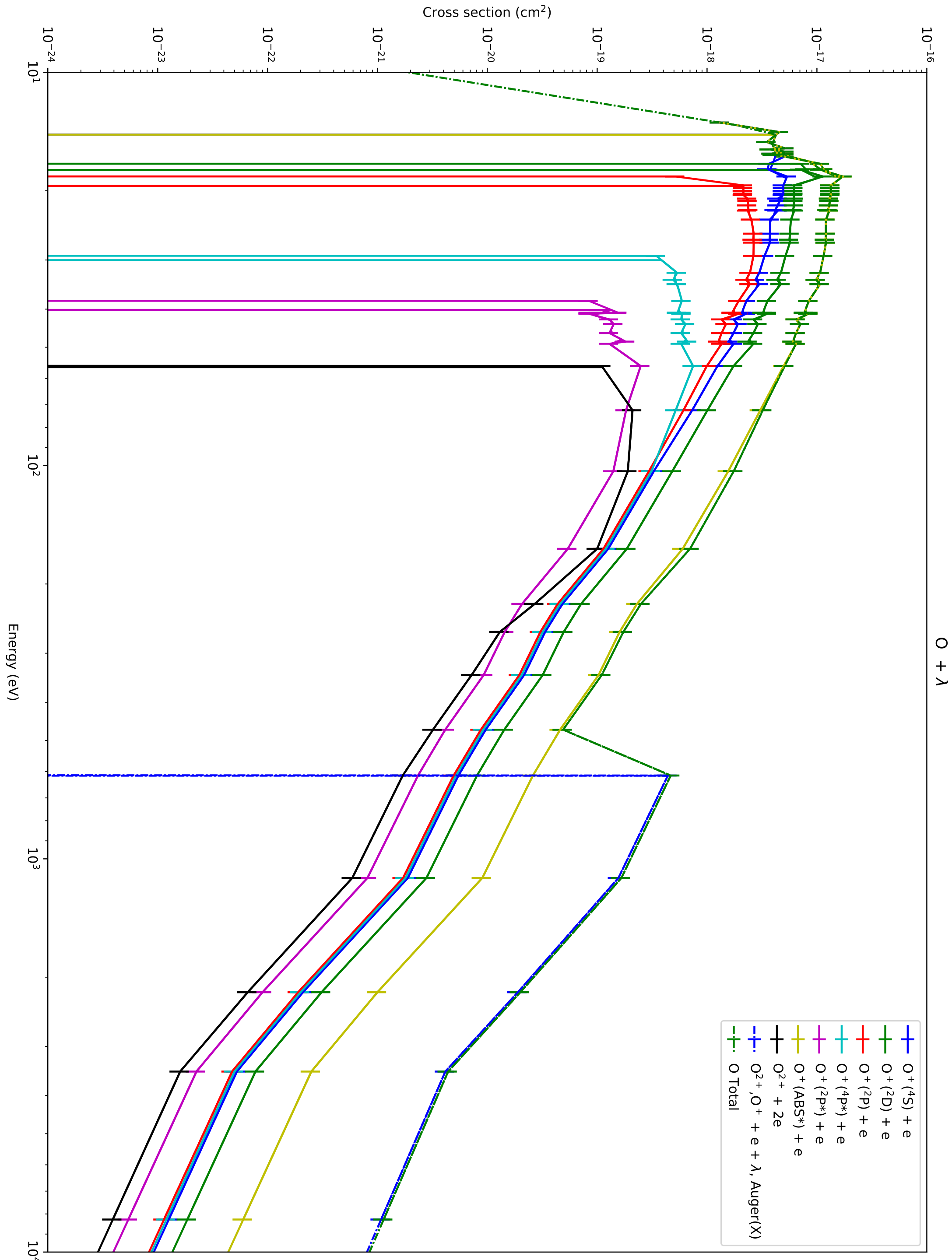

Figure 1.48: Cross sections for O + λ (wavelength with extrapolation version)

Reference	Threshold	Range of energy	Uncertainty	Properties	Fig
Revi Avakyan 98	0	0:-1	20%		Fig. 1.57 1.58
???? ? BDD	0	0:-1	???%	U	Fig. 1.57 1.58
Revi AMOP	0	0:-1	???%	U	Fig. 1.57 1.58
Adap AMOP + Avakyan	0	0:-1	20%	RU	Fig. 1.57 1.58

Table 1.9: Total cross section for λ impact on O_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$O_2 + \lambda \rightarrow {O_2}^+ + e$	Revi Avakyan 98	12.071	12.071:-1	20%		Fig. 1.53-1.54
	???? ? BDD	12.8	12.8:-1	???%	U	Fig. 1.53-1.54
	Revi AMOP	12.8	12.8:-1	???%	U	Fig. 1.53-1.54
	Adap AMOP+BDD+Avakyan	12.8	12.8:-1	20%		Fig. 1.53-1.54
$O_2 + \lambda \rightarrow O^+ + O + e$	???? ? BDD	18.73	18.73:-1	???%	U	Fig. 1.49-1.50
	Revi AMOP	18.73	18.73:-1	20%	RU	Fig. 1.49-1.50

Table 1.10: Ionization Cross section for λ impact on O_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$O_2 + \lambda \rightarrow O(^1S) + O$	Adap ? BDD	11	11:-1	20%		Fig. 1.55 1.56
$O_2 + \lambda \rightarrow O(^1D) + O$	Adap BDD	7	7:-1	20%		Fig. 1.51 1.52

Table 1.11: Excitation Cross section for λ impact on O_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$O_2 + \lambda \rightarrow {O_2}^{2+}, {O_2}^{+} + e + \lambda$ Auger	Revi Avakyan 98	539	539:-1	20%	R	Fig. 1.59 1.60 1.6
$O_2 + \lambda \rightarrow {O_2}^{+}(b^4) + e$	Revi Avakyan 98	18.171	18.171:-1	20%		Fig. 1.59 1.60 1.6
$O_2 + \lambda \rightarrow {O_2}^{+}({}^{2,4}\Sigma_g) + e$	Revi Avakyan 98	40	40:-1	20%		Fig. 1.59 1.60 1.6
$O_2 + \lambda \rightarrow {O_2}^{+}(B^2) + e$	Revi Avakyan 98	20.296	20.296:-1	20%		Fig. 1.59 1.60 1.6
$O_2 + \lambda \rightarrow {O_2}^{+} + e$	Adap AMOP+BDD+Avakyan	12.8	12.8:-1	20%		Fig. 1.59 1.60 1.6
$O_2 + \lambda \rightarrow {O_2}^{+}({}^2\Pi) + e$	Revi Avakyan 98	22.8	22.8:-1	20%		Fig. 1.59 1.60 1.6
$O_2 + \lambda \rightarrow {O_2}^{+}(a^4A^2) + e$	Revi Avakyan 98	16.10	16.10:-1	20%		Fig. 1.59 1.60 1.6
$O_2 + \lambda \rightarrow O({}^1S) + O$	Adap ? BDD	11	11:-1	20%		Fig. 1.59 1.60 1.6
$O_2 + \lambda \rightarrow {O_2}^{+}(33\ eV) + e$	Revi Avakyan 98	33	33:-1	20%		Fig. 1.59 1.60 1.6
$O_2 + \lambda \rightarrow {O_2}^{2+} + 2e$	???? Rees+Bratio?	36.13	36.13:-1	50%	RU	Fig. 1.59 1.60 1.6
$O_2 + \lambda \rightarrow O({}^1D) + O$	Adap BDD	7	7:-1	20%		Fig. 1.59 1.60 1.6
$O_2 + \lambda \rightarrow {O_2}^{+}({}^2\Sigma_u) + e$	Revi Avakyan 98	28	28:-1	20%		Fig. 1.59 1.60 1.6
$O_2 + \lambda \rightarrow {O_2}^{+}(c^4\Sigma) + e$	Revi Avakyan 98	24.6	24.6:-1	20%		Fig. 1.59 1.60 1.6
$O_2 + \lambda \rightarrow$ Total	Adap AMOP + Avakyan	0	0:-1	20%	RU	Fig. 1.59 1.60 1.6
$O_2 + \lambda \rightarrow O^{+} + O + e$	Revi AMOP	18.73	18.73:-1	20%	RU	Fig. 1.59 1.60 1.6

Table 1.12: Recommended Cross section for λ impact on O_2

1.3 Cross section of ph impact with O_2

1.3.1 Total Cross Section

1.3.2 Inelastic Cross Sections

Ionization Cross Sections

$\mathbf{O_2 + \lambda \rightarrow O_2{}^+ + e}$

$\mathbf{O_2 + \lambda \rightarrow O^+ + O + e}$

Excitation Cross Sections

$\mathbf{O_2 + \lambda \rightarrow O(^1S) + O}$

$\mathbf{O_2 + \lambda \rightarrow O(^1D) + O}$

1.3.3 Recommended data set

$\mathbf{O_2 + \lambda \rightarrow O_2{}^{2+}, O_2{}^+ + e + \lambda}$ **Auger**

$\mathbf{O_2 + \lambda \rightarrow O_2{}^+(}b^4\mathbf{) + e}$

$\mathbf{O_2 + \lambda \rightarrow O_2{}^+(}^{2,4}\Sigma_g\mathbf{) + e}$

$\mathbf{O_2 + \lambda \rightarrow O_2{}^+(B^2) + e}$

$\mathbf{O_2 + \lambda \rightarrow O_2{}^+ + e}$

$\mathbf{O_2 + \lambda \rightarrow O_2{}^+(}^2\Pi\mathbf{) + e}$

$\mathbf{O_2 + \lambda \rightarrow O_2{}^+(}a^4\mathbf{A^2) + e}$

$\mathbf{O_2 + \lambda \rightarrow O(^1S) + O}$

$\mathbf{O_2 + \lambda \rightarrow O_2{}^+(33\ eV) + e}$

$\mathbf{O_2 + \lambda \rightarrow O_2{}^{2+} + 2e}$

$\mathbf{O_2 + \lambda \rightarrow O(^1D) + O}$

$\mathbf{O_2 + \lambda \rightarrow O_2{}^+(}^2\Sigma_u\mathbf{) + e}$

$\mathbf{O_2 + \lambda \rightarrow O_2{}^+(}c^4\Sigma\mathbf{) + e}$

$\mathbf{O_2 + \lambda \rightarrow}$ **Total**

$\mathbf{O_2 + \lambda \rightarrow O^+ + O + e}$

Legend for the properties

R : Recommended cross section for the processus. It is used in the main file. The selection of the recommended cross section is based on the quality of

the data (e.g. errorbars, comparison with other experiments), the possibility of extrapolation, and the origin of the work, coupled with the consistency (sum of recommended cross sections Total cross section)

U : Estimated uncertainty: sometimes, the uncertainty is not given, because of theoretical work... The authors of the database have to estimate the uncertainty, but the quality of that estimation can be questionable. Moreover, when data from different sources have been adapted (e.g. for extrapolation), the uncertainty can be modified...

E : Validated for extrapolation: the extrapolation of these cross sections is plausible. For example, when an analytic function has been applied...

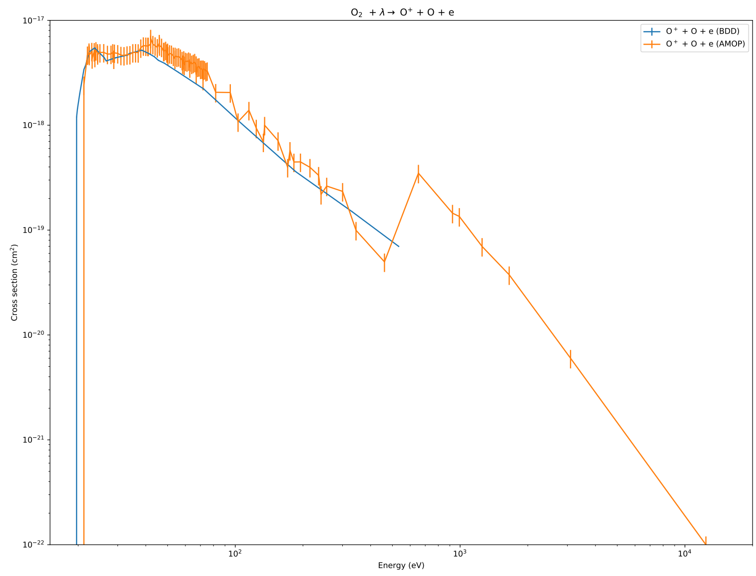

Figure 1.49: Cross sections for $O_2 + \lambda \rightarrow O^+ + O + e$

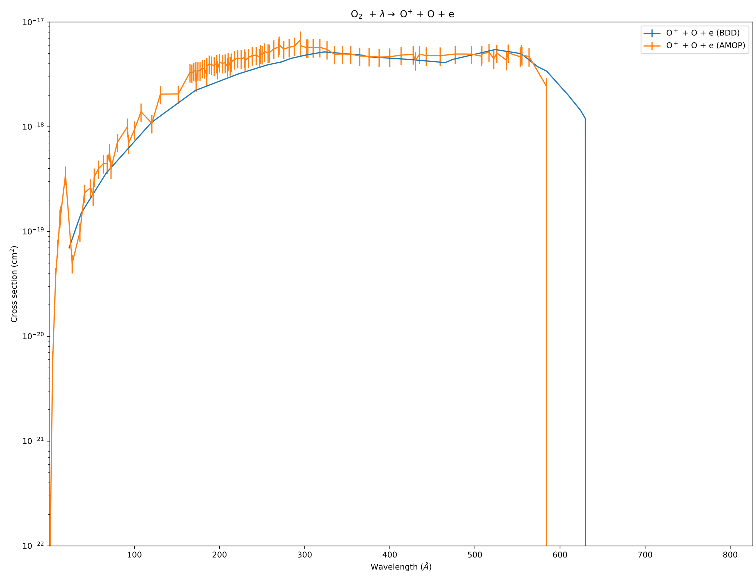

Figure 1.50: Cross sections for $O_2 + \lambda \rightarrow O^+ + O + e$ (wavelength version)

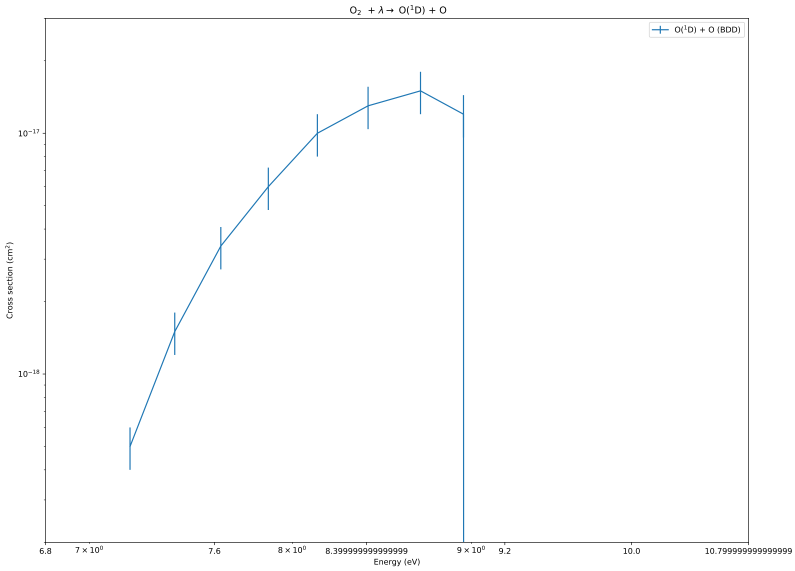

Figure 1.51: Cross sections for $O_2 + \lambda \rightarrow O(^1D) + O$

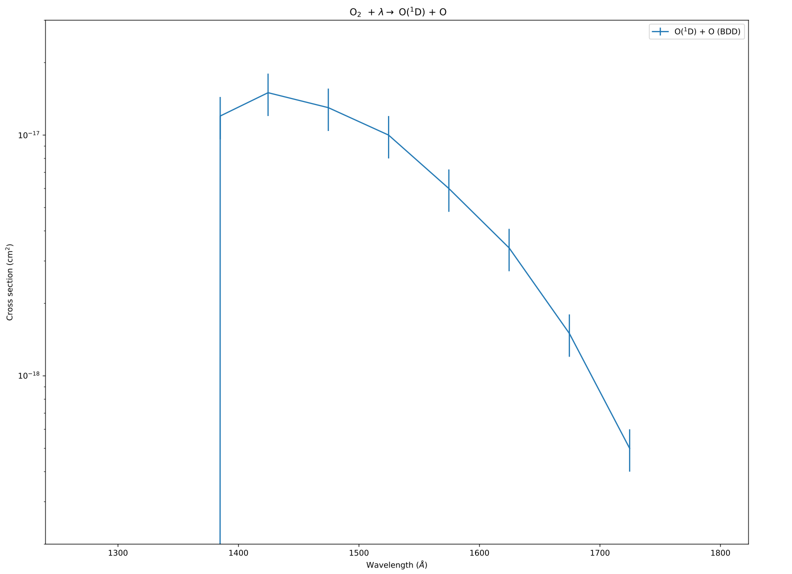

Figure 1.52: Cross sections for $O_2 + \lambda \rightarrow O(^1D) + O$ (wavelength version)

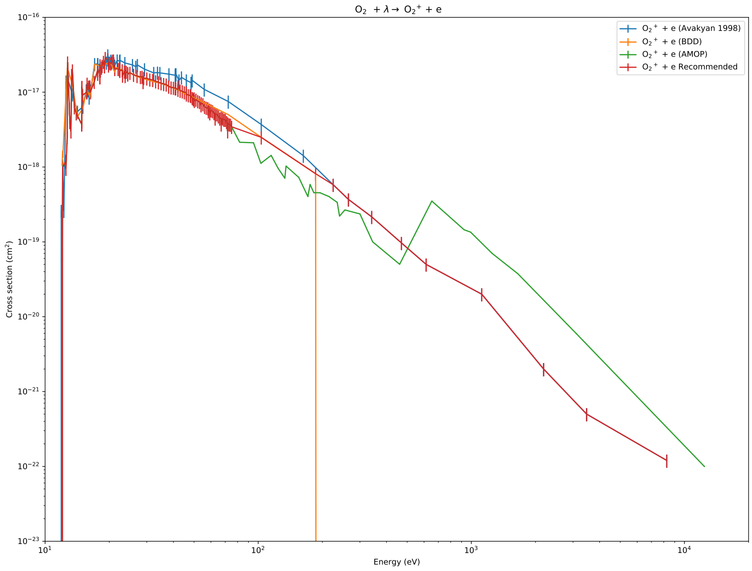

Figure 1.53: Cross sections for $O_2 + \lambda \rightarrow {O_2}^+ + e$

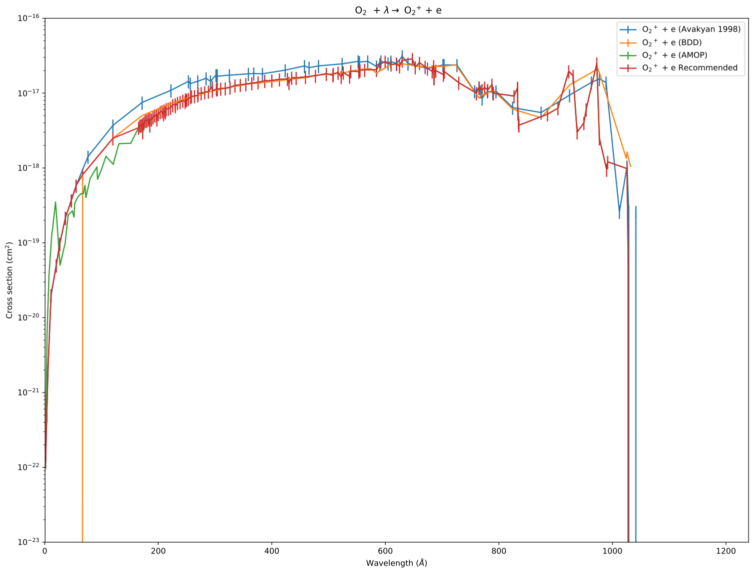

Figure 1.54: Cross sections for $O_2 + \lambda \rightarrow {O_2}^+ + e$ (wavelength version)

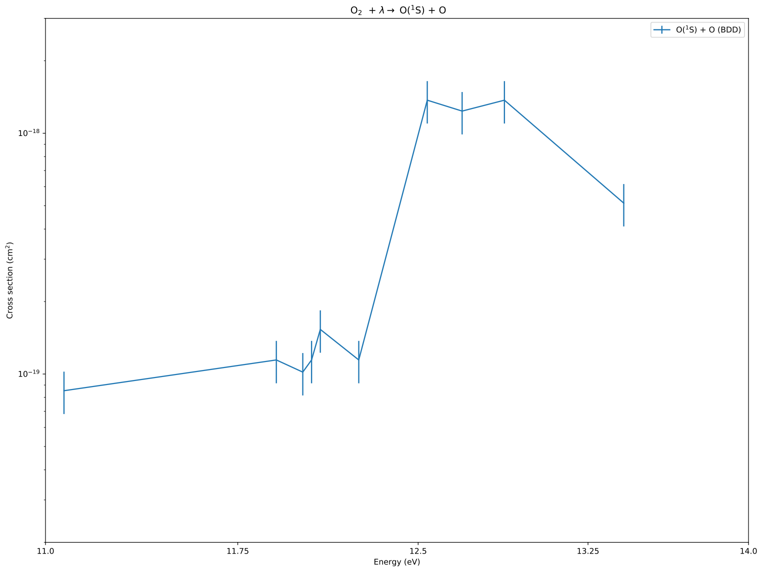

Figure 1.55: Cross sections for $O_2 + \lambda \rightarrow O(^1S) + O$

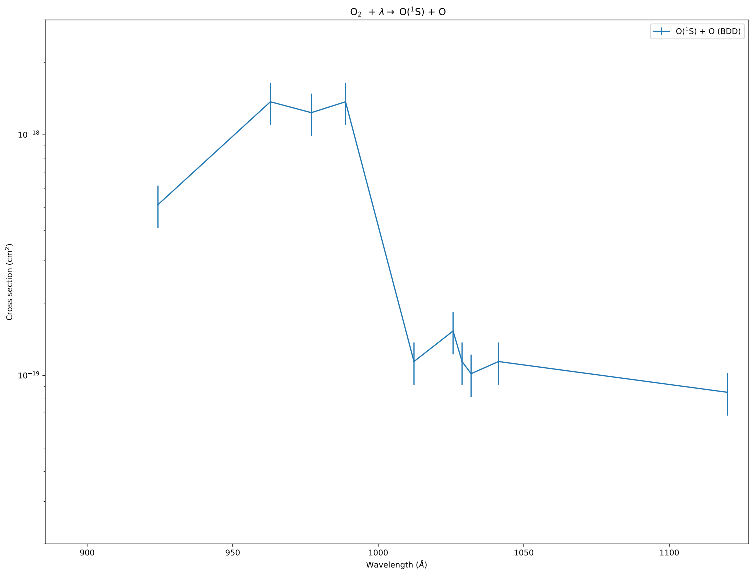

Figure 1.56: Cross sections for $O_2 + \lambda \rightarrow O(^1S) + O$ (wavelength version)

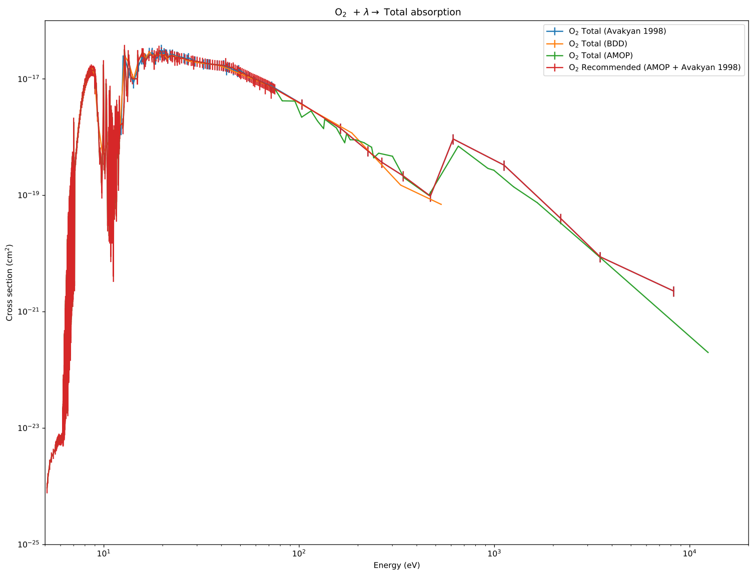

Figure 1.57: Cross sections for O_2 + $\lambda \rightarrow$ Total absorption

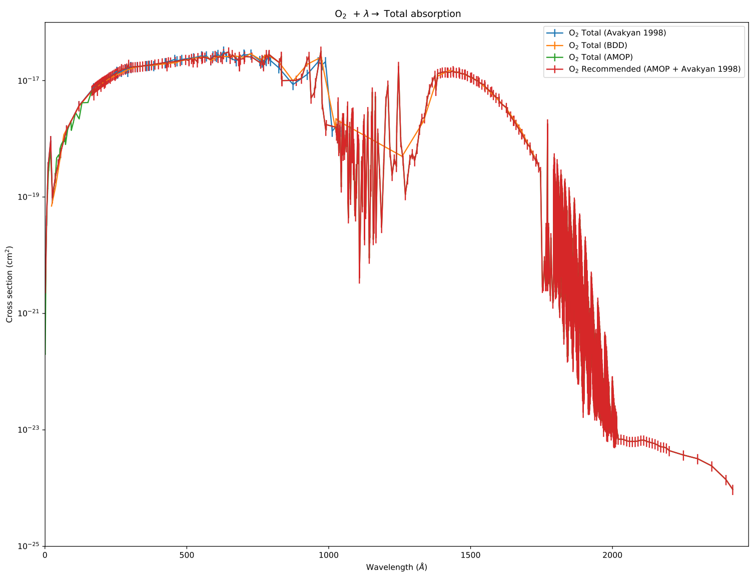

Figure 1.58: Cross sections for O_2 + $\lambda \rightarrow$ Total absorption (wavelength version)

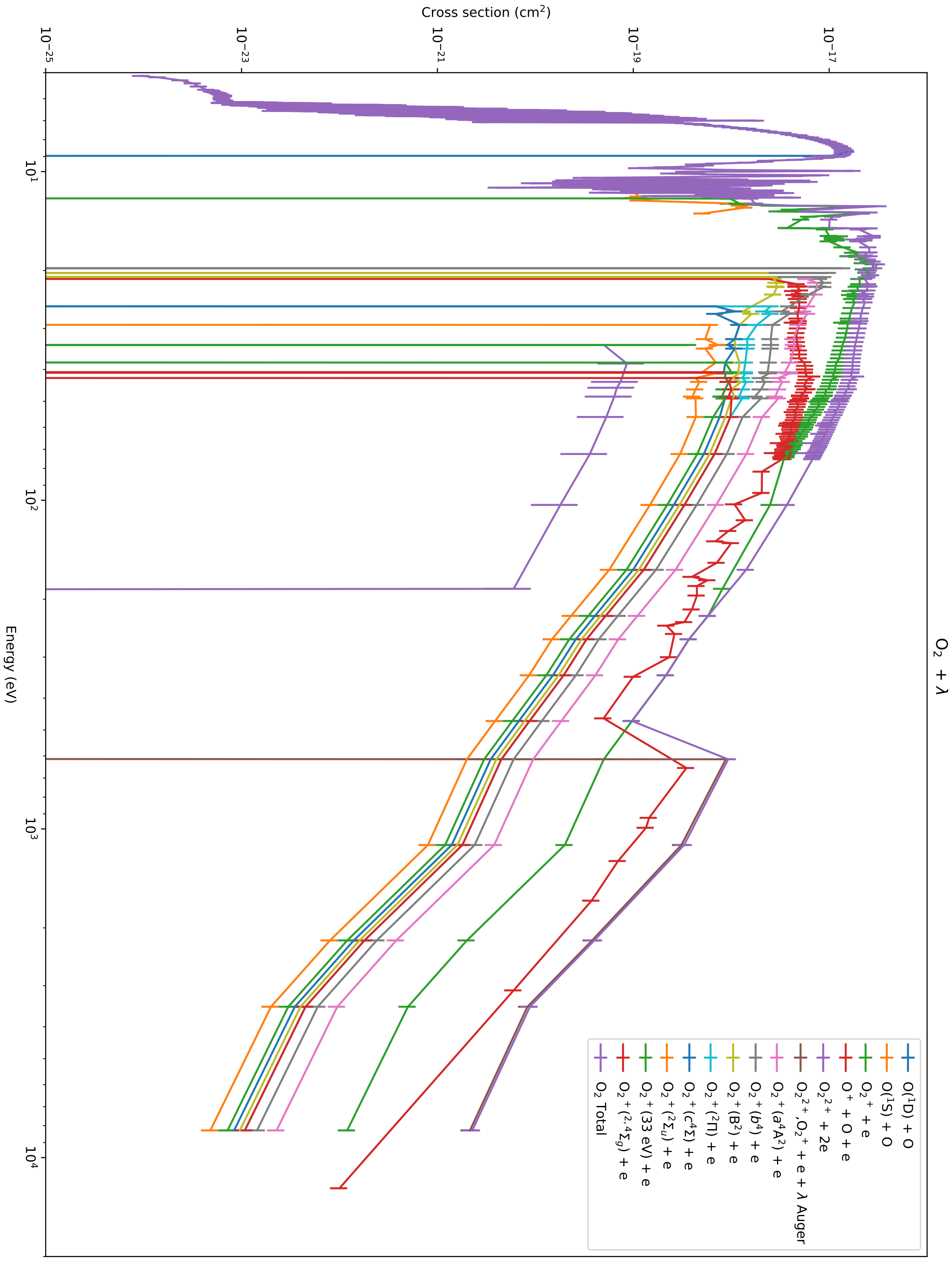

Figure 1.59: Cross sections for O$_2$ + λ

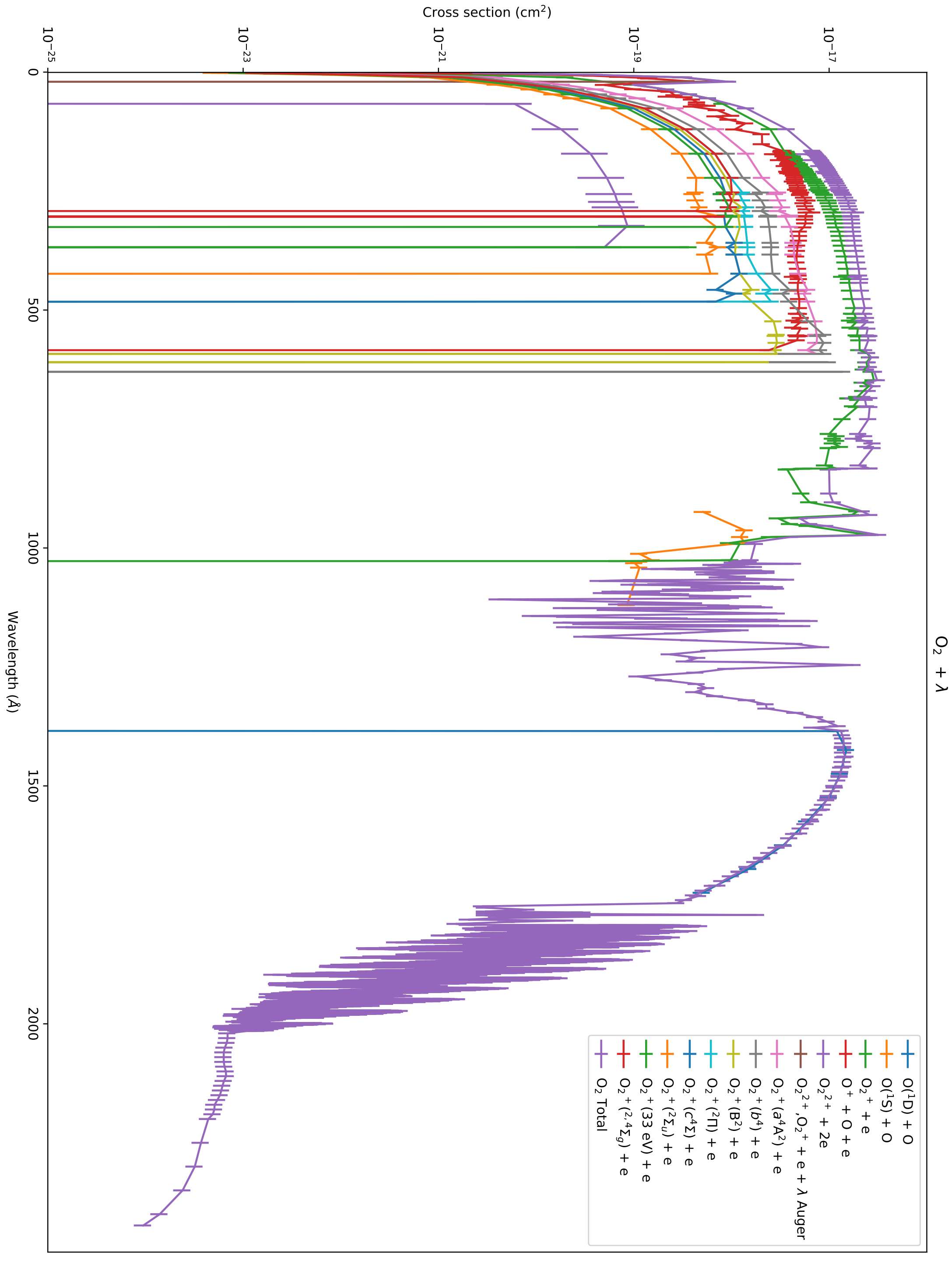

Figure 1.60: Cross sections for O_2 + λ (wavelength version)

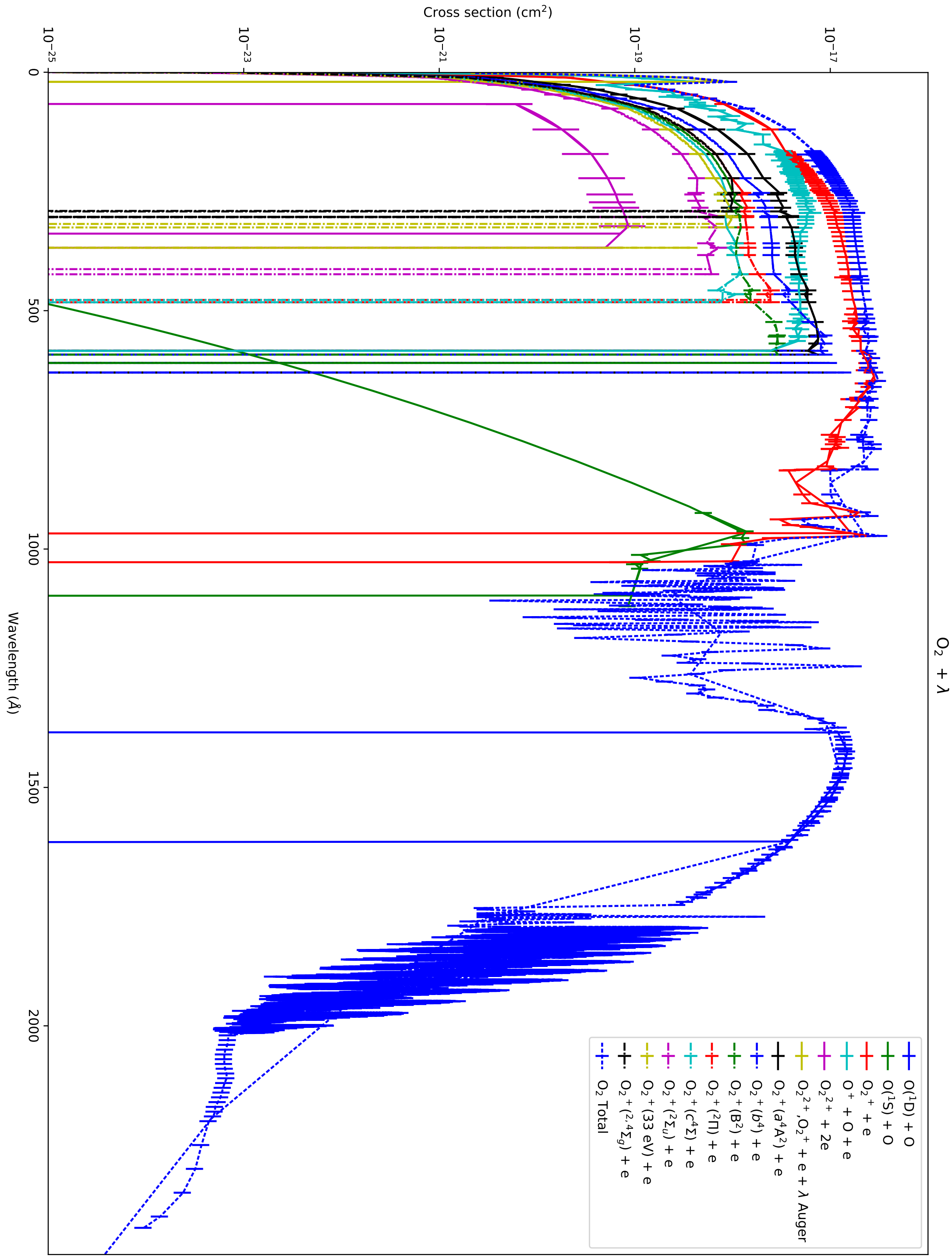

Figure 1.61: Cross sections for $O_2 + \lambda$ (with extrapolation version)

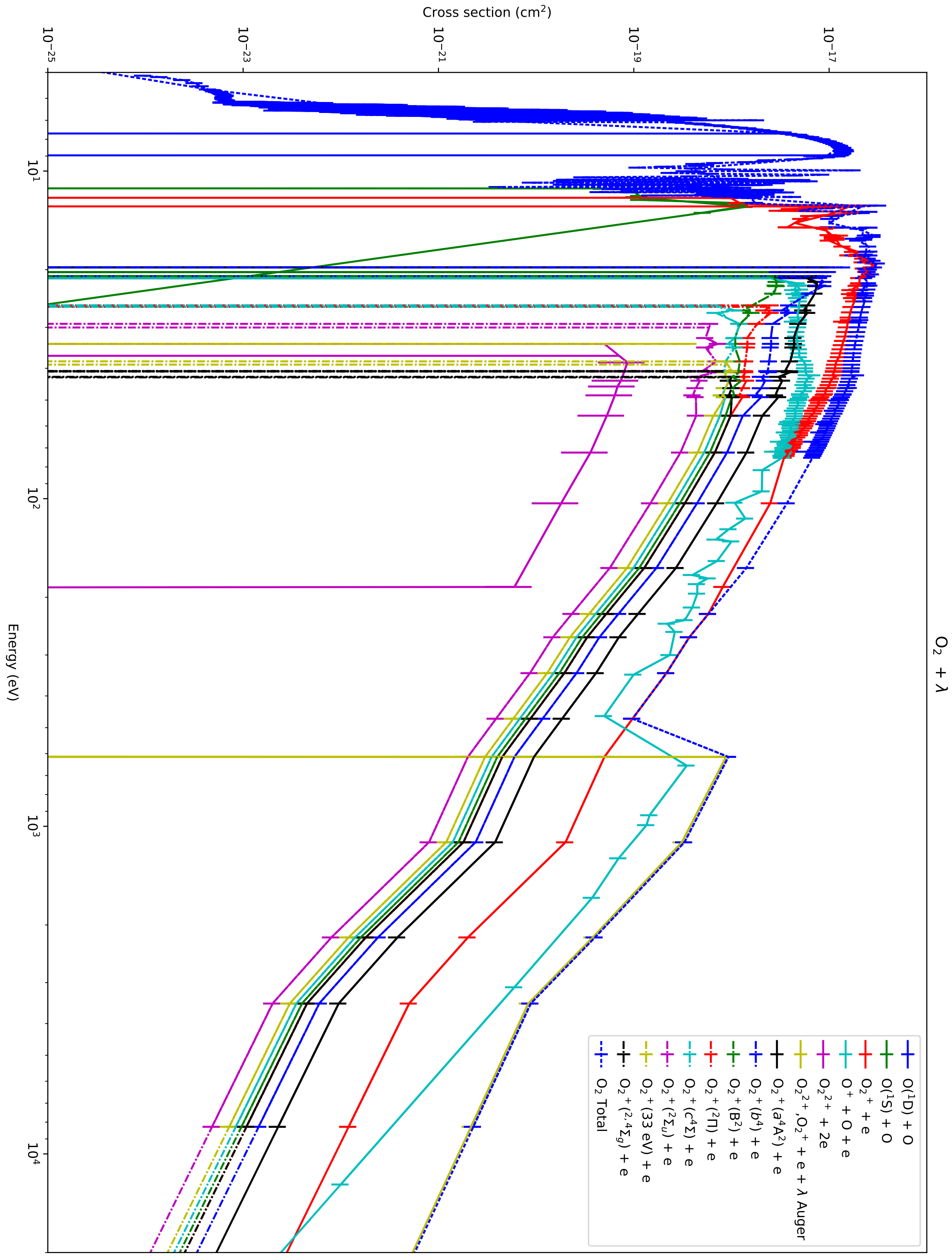

Figure 1.62: Cross sections for $O_2 + \lambda$ (wavelength with extrapolation version)

Reference	Threshold	Range of energy	Uncertainty	Properties	Fig
Revi Avakyan 98	0	0:-1	20%		Fig. 1.75 1.76
???? ? BDD	0	0:-1	???%	U	Fig. 1.75 1.76
Revi AMOP	0	0:-1	???%	U	Fig. 1.75 1.76
Adap AMOP+Avakyan	0	0:-1	20%	RU	Fig. 1.75 1.76

Table 1.13: Total cross section for λ impact on CO

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$CO + \lambda \rightarrow CO^{2+} + 2e$	Revi Avakyan 98	41.294	41.294:-1	20%		Fig. 1.63 1.64
$CO + \lambda \rightarrow O^{+} + C + e$	???? ? BDD	24.71	24.71:-1	???%	U	Fig. 1.65 1.66
$CO + \lambda \rightarrow O^{+}$	Revi AMOP	24.71	24.71:-1	20%	RU	Fig. 1.65 1.66
$CO + \lambda \rightarrow C^{+} + O + e$	???? ? BDD	22.37	22.37:-1	???%	U	Fig. 1.69 1.70
	Revi AMOP	22.37	22.37:-1	20%	RU	Fig. 1.69 1.70
$CO + \lambda \rightarrow CO^{+} + e$	???? ? BDD	14.01	14.01:-1	???%	U	Fig. 1.71 1.72
	Revi AMOP+Avakyan+Masuoka 93	14.01	14.01:-1	20%	RU	Fig. 1.71 1.72
$CO + \lambda \rightarrow CO^{+}$	Revi Avakyan 98	14.014	14.014:-1	20%		Fig. 1.71 1.72
	Revi AMOP	14.01	14.01:-1	???%	U	Fig. 1.71 1.72

Table 1.14: Ionization Cross section for λ impact on CO

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$CO + \lambda \rightarrow O(^1D) + C(^1D)$	Adap AMOP	14.36	14.36:-1	50%	UE	Fig. 1.67 1.68
$CO + \lambda \rightarrow O(^3S) + C$	Meas Wu 1979	18.4	18.4:-1	30%		Fig. 1.73 1.74
	Meas Wu 1979	18.4	18.4:-1	30%		Fig. 1.73 1.74
	Adap Wu 1979	18.4	18.4:-1	30%	RUE	Fig. 1.73 1.74

Table 1.15: Excitation Cross section for λ impact on CO

1.4 Cross section of ph impact with CO

1.4.1 Total Cross Section

1.4.2 Inelastic Cross Sections

Ionization Cross Sections

$\mathbf{CO + \lambda \rightarrow CO^{2+} + 2e}$

$\mathbf{CO + \lambda \rightarrow O^{+} + C + e}$

$\mathbf{CO + \lambda \rightarrow O^{+}}$

$\mathbf{CO + \lambda \rightarrow C^{+} + O + e}$

$\mathbf{CO + \lambda \rightarrow CO^{+} + e}$

$\mathbf{CO + \lambda \rightarrow CO^{+}}$

Excitation Cross Sections

$\mathbf{CO + \lambda \rightarrow O(^1D) + C(^1D)}$

$\mathbf{CO + \lambda \rightarrow O(^3S) + C}$

1.4.3 Recommended data set

$\mathbf{CO + \lambda \rightarrow CO^{2+} + e + \lambda}$ **Auger (C)**

$\mathbf{CO + \lambda \rightarrow CO^{2+} + 2e}$

$\mathbf{CO + \lambda \rightarrow O^{+} + C + e}$

$\mathbf{CO + \lambda \rightarrow CO^{+}(C) + e}$

$\mathbf{CO + \lambda \rightarrow C(^1D)}$

$\mathbf{CO + \lambda \rightarrow CO^{+}(A) + e}$

$\mathbf{CO + \lambda \rightarrow CO^{2+} + e + \lambda}$ **Auger (O)**

$\mathbf{CO + \lambda \rightarrow O(^3S) + C}$

$\mathbf{CO + \lambda \rightarrow CO^{+}(W) + e}$

$\mathbf{CO + \lambda \rightarrow C^{+} + O + e}$

$\mathbf{CO + \lambda \rightarrow CO^{+}(^2S) + e}$

$\mathbf{CO + \lambda \rightarrow CO^{+} + e}$

$\mathbf{CO + \lambda \rightarrow}$ **Total**

$\mathbf{CO + \lambda \rightarrow CO^{+}(B) + e}$

Legend for the properties

R : Recommended cross section for the processus. It is used in the main file. The selection of the recommended cross section is based on the quality of

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	P
$CO + \lambda \rightarrow CO^{2+} + e + \lambda$ Auger (C)	Revi Avakyan 98	282	282:-1	20%	R	Fig. 1.77 1
$CO + \lambda \rightarrow CO^{2+} + 2e$	Revi Avakyan 98	41.294	41.294:-1	20%		Fig. 1.77 1
$CO + \lambda \rightarrow O^{+} + C + e$	Revi AMOP	24.71	24.71:-1	20%	RU	Fig. 1.77 1
$CO + \lambda \rightarrow CO^{+}(C) + e$	Revi Avakyan 98	13.5	13.5:-1	20%		Fig. 1.77 1
$CO + \lambda \rightarrow C(^{1}D)$	Adap AMOP	14.36	14.36:-1	50%	UE	Fig. 1.77 1
$CO + \lambda \rightarrow CO^{+}(A) + e$	Revi Avakyan 98	16.5	16.5:-1	20%		Fig. 1.77 1
$CO + \lambda \rightarrow CO^{2+} + e + \lambda$ Auger (O)	Revi Avakyan 98	539	539:-1	20%	R	Fig. 1.77 1
$CO + \lambda \rightarrow O(^{3}S) + C$	Adap Wu 1979	18.4	18.4:-1	30%	RUE	Fig. 1.77 1
$CO + \lambda \rightarrow CO^{+}(W) + e$	Revi Avakyan 98	32	32:-1	20%		Fig. 1.77 1
$CO + \lambda \rightarrow C^{+} + O + e$	Revi AMOP	22.37	22.37:-1	20%	RU	Fig. 1.77 1
$CO + \lambda \rightarrow CO^{+}(^{2}S) + e$	Revi Avakyan 98	40	40:-1	20%		Fig. 1.77 1
$CO + \lambda \rightarrow CO^{+} + e$	Revi AMOP+Avakyan+Masuoka 93	14.01	14.01:-1	20%	RU	Fig. 1.77 1
$CO + \lambda \rightarrow$ Total	Adap AMOP+Avakyan	0	0:-1	20%	RU	Fig. 1.77 1
$CO + \lambda \rightarrow CO^{+}(B) + e$	Revi Avakyan 98	19.7	19.7:-1	20%		Fig. 1.77 1

Table 1.16: Recommended Cross section for λ impact on CO

the data (e.g. errorbars, comparison with other experiments), the possibility of extrapolation, and the origin of the work, coupled with the consistency (sum of recommended cross sections Total cross section)

U : Estimated uncertainty: sometimes, the uncertainty is not given, because of theoretical work... The authors of the database have to estimate the uncertainty, but the quality of that estimation can be questionable. Moreover, when data from different sources have been adapted (e.g. for extrapolation), the uncertainty can be modified...

E : Validated for extrapolation: the extrapolation of these cross sections is plausible. For example, when an analytic function has been applied...

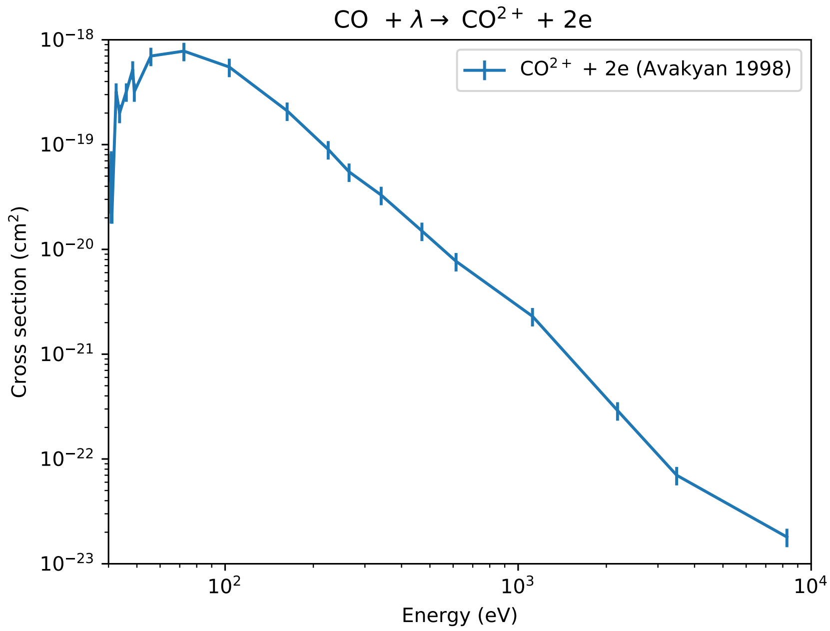

Figure 1.63: Cross sections for CO + $\lambda \rightarrow$ CO^{2+} + 2e

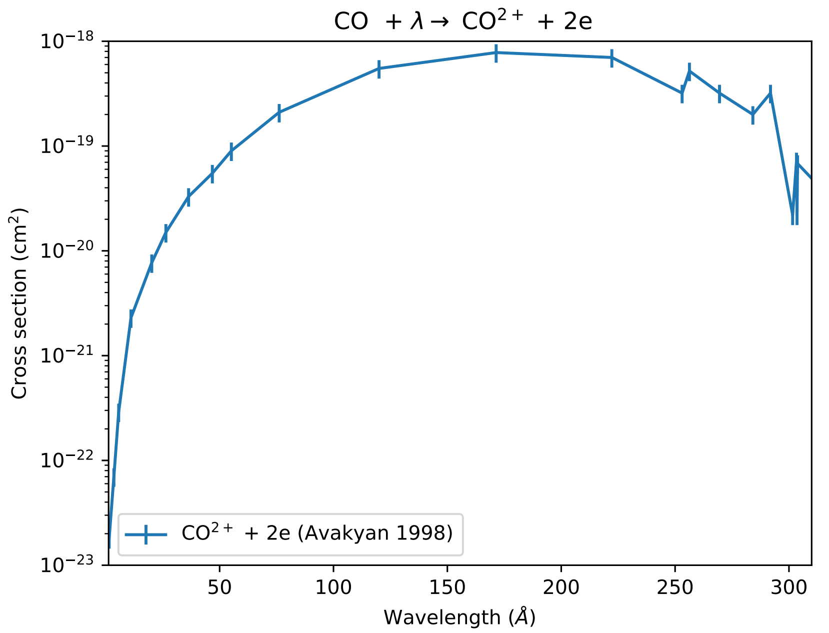

Figure 1.64: Cross sections for CO + $\lambda \rightarrow$ CO^{2+} + 2e (wavelength version)

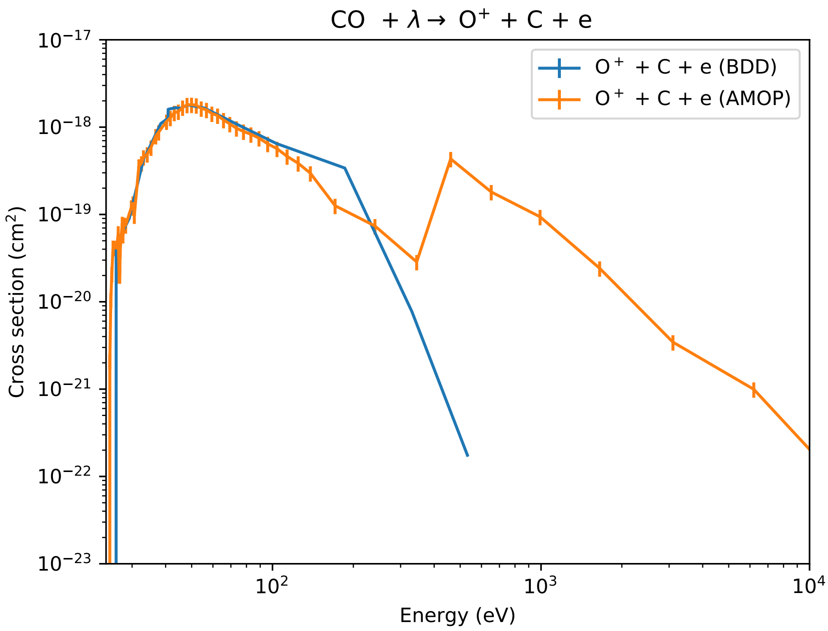

Figure 1.65: Cross sections for $CO + \lambda \rightarrow O^{+} + C + e$

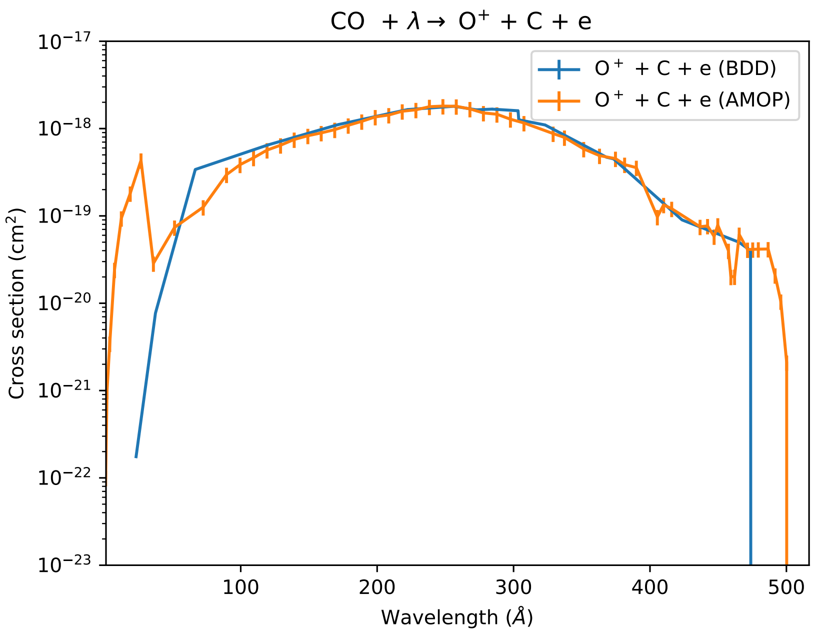

Figure 1.66: Cross sections for $CO + \lambda \rightarrow O^{+} + C + e$ (wavelength version)

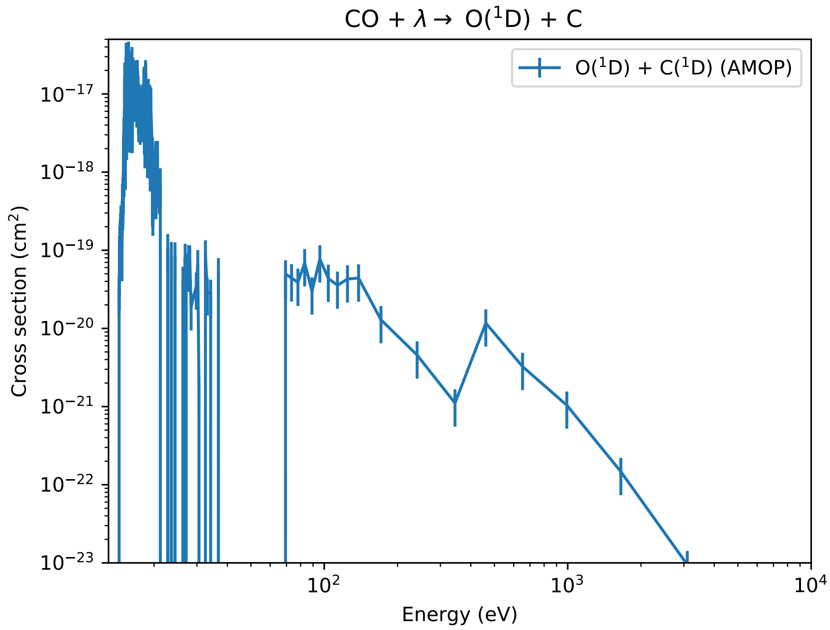

Figure 1.67: Cross sections for $CO + \lambda \rightarrow O(^1D) + C$

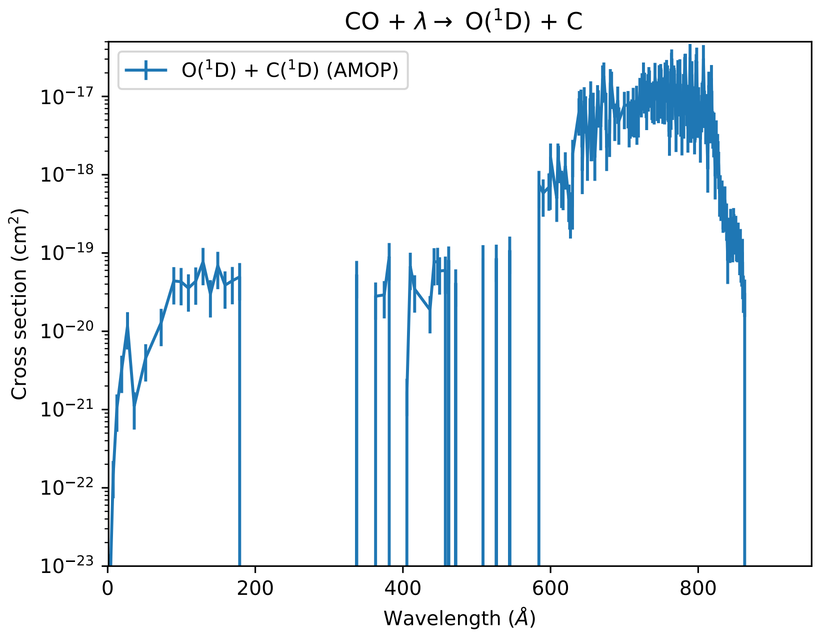

Figure 1.68: Cross sections for $CO + \lambda \rightarrow O(^1D) + C$ (wavelength version)

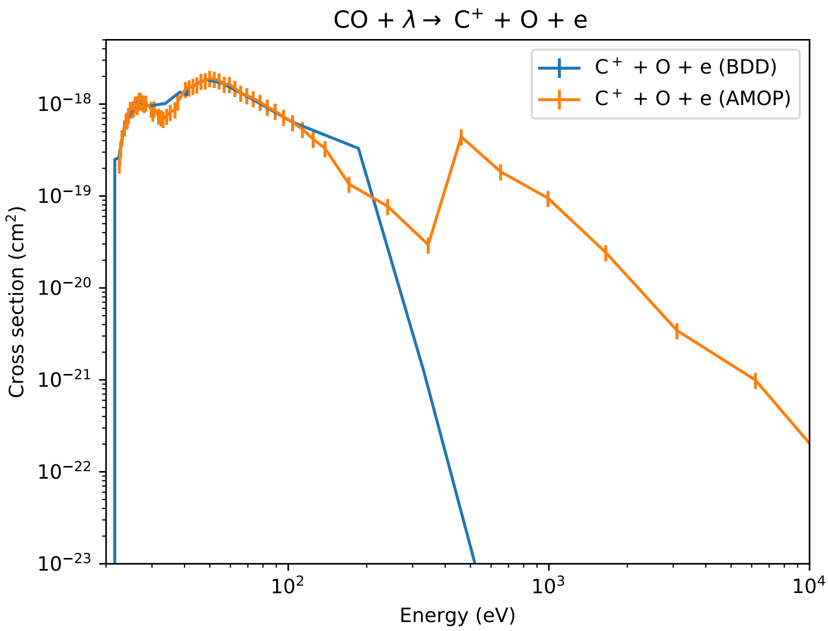

Figure 1.69: Cross sections for CO + $\lambda \rightarrow C^+$ + O + e

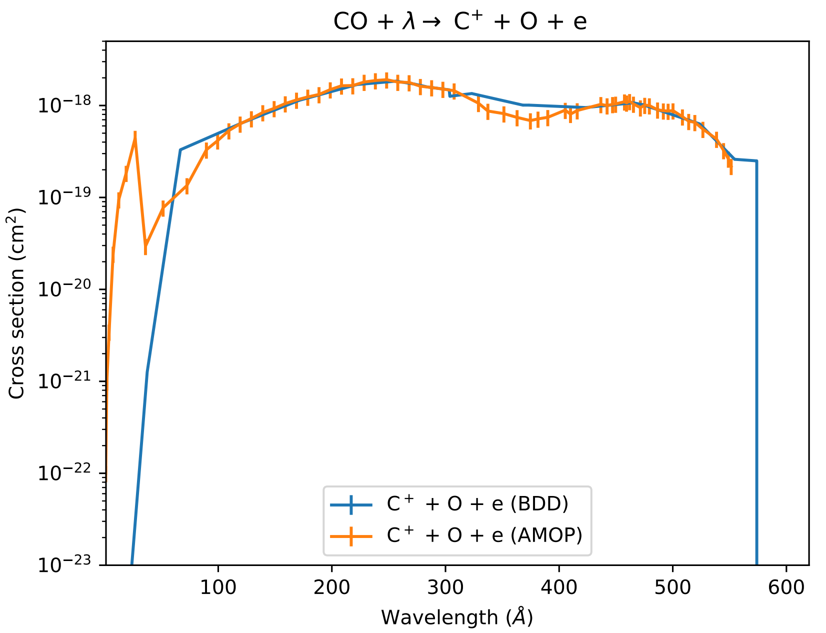

Figure 1.70: Cross sections for CO + $\lambda \rightarrow C^+$ + O + e (wavelength version)

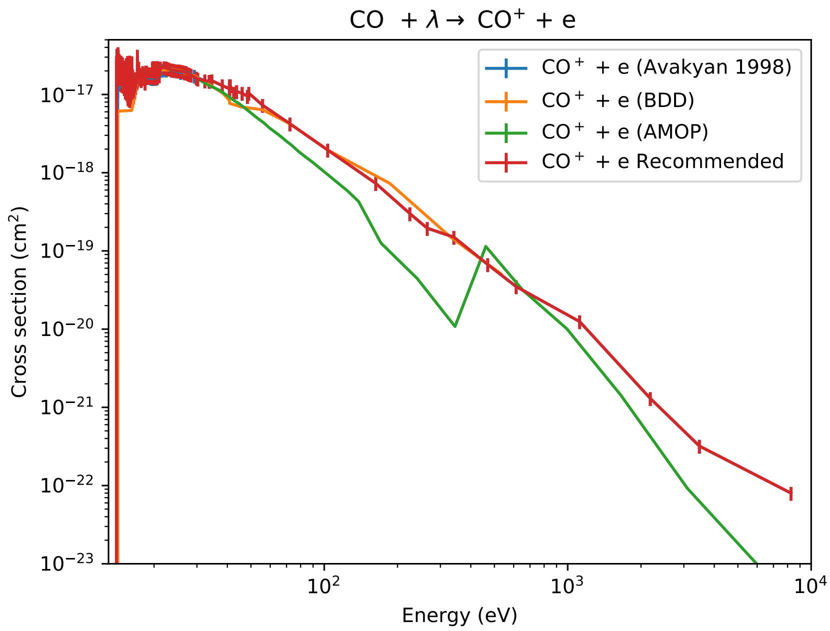

Figure 1.71: Cross sections for CO + $\lambda \rightarrow$ CO$^+$ + e

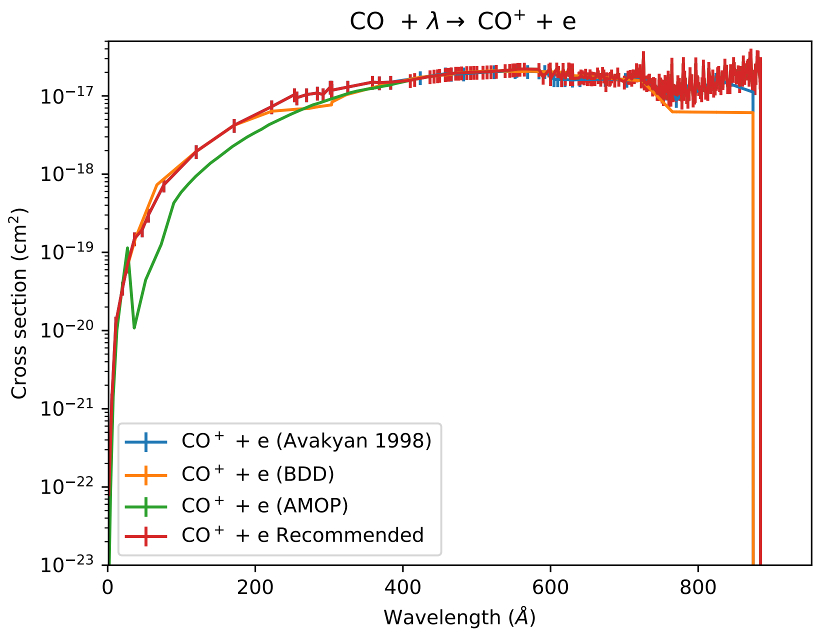

Figure 1.72: Cross sections for CO + $\lambda \rightarrow$ CO$^+$ + e (wavelength version)

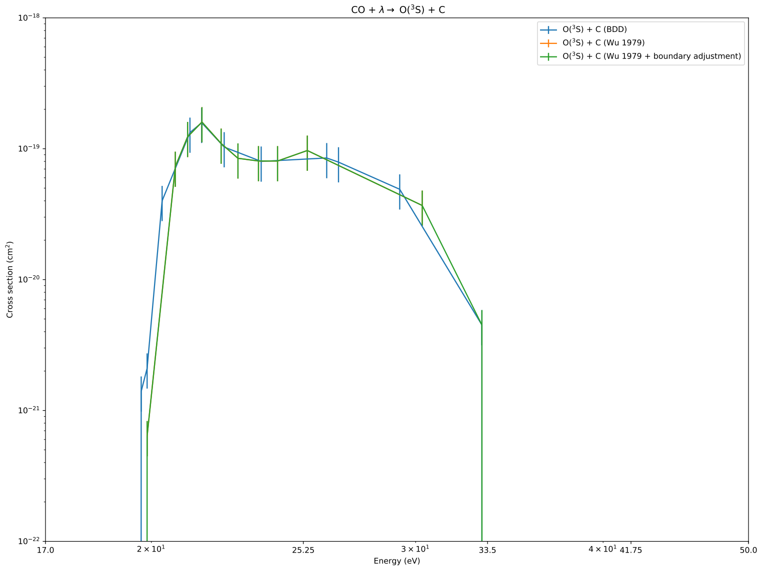

Figure 1.73: Cross sections for CO + $\lambda \rightarrow$ O(^{3}S) + C

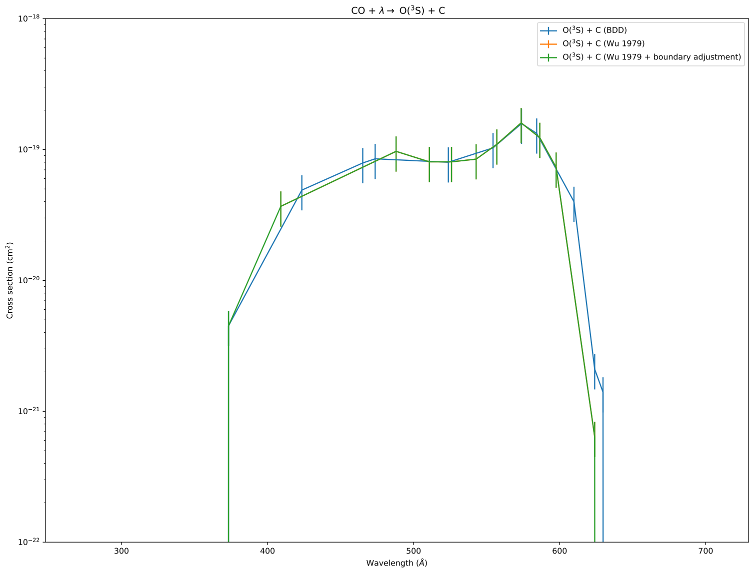

Figure 1.74: Cross sections for CO + $\lambda \rightarrow$ O(^{3}S) + C (wavelength version)

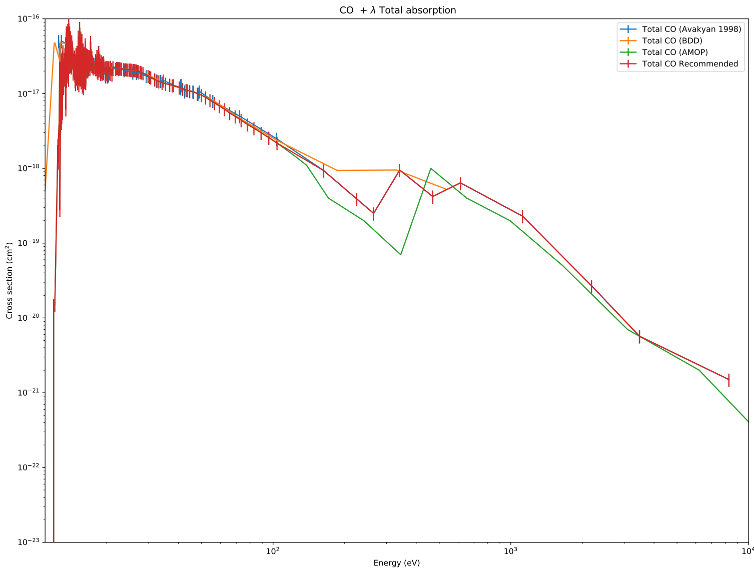

Figure 1.75: Cross sections for CO + λ Total absorption

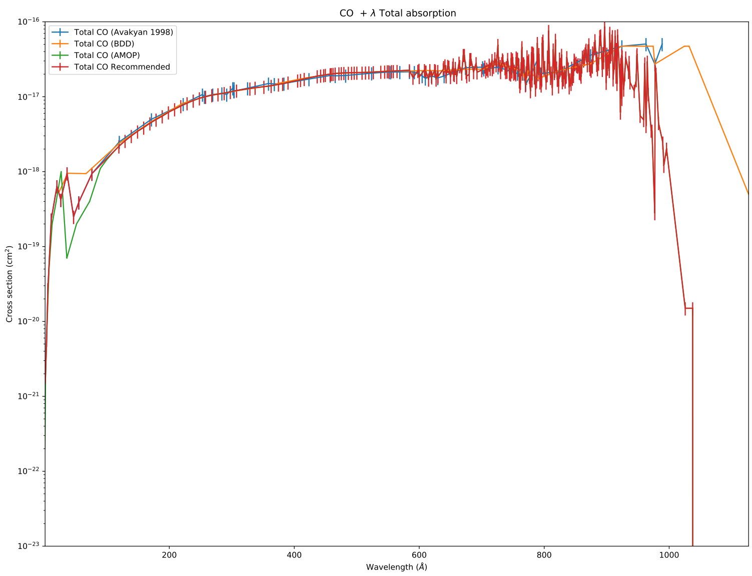

Figure 1.76: Cross sections for CO + λ Total absorption (wavelength version)

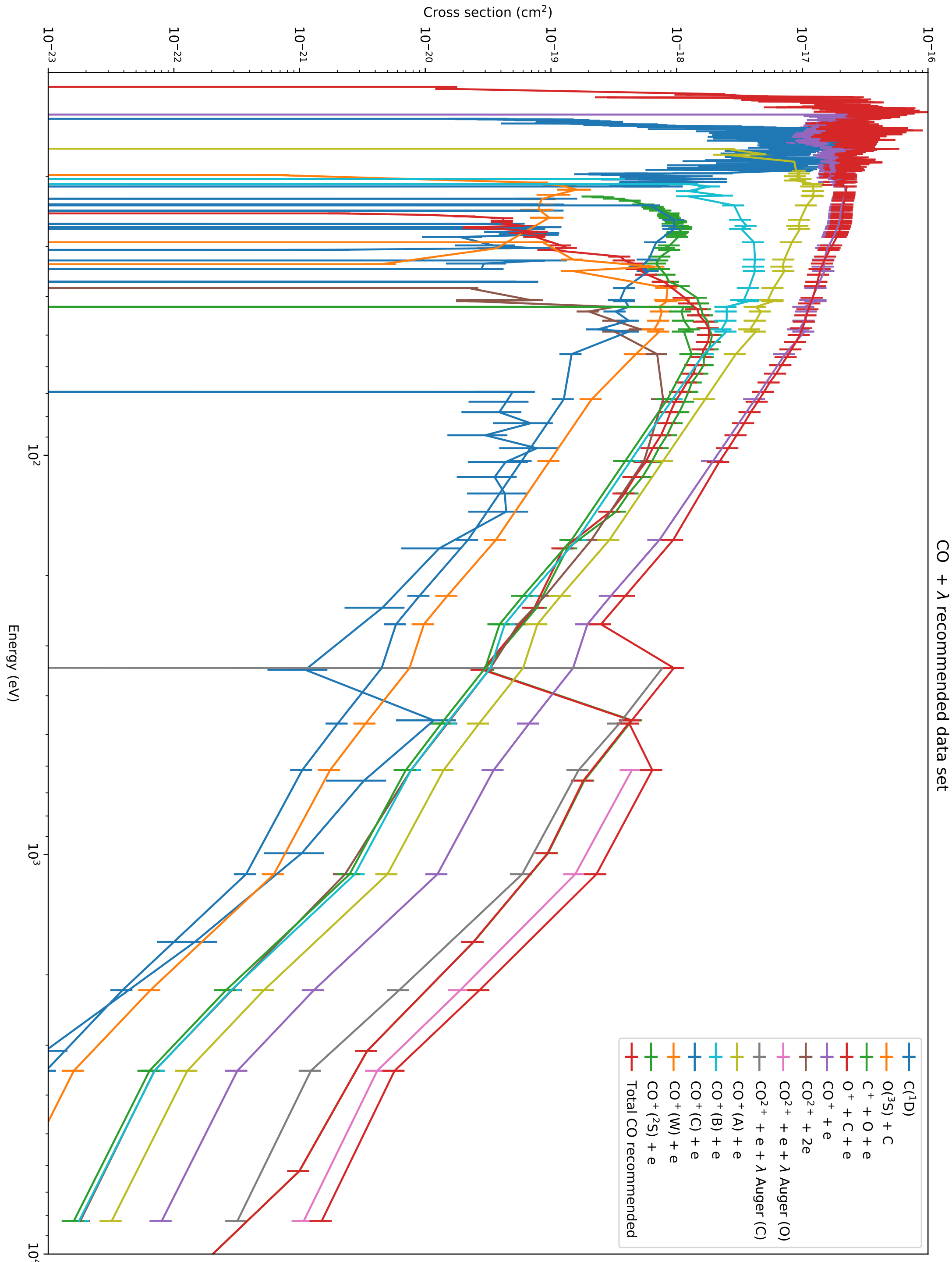

Figure 1.77: Cross sections for CO + λ recommended data set

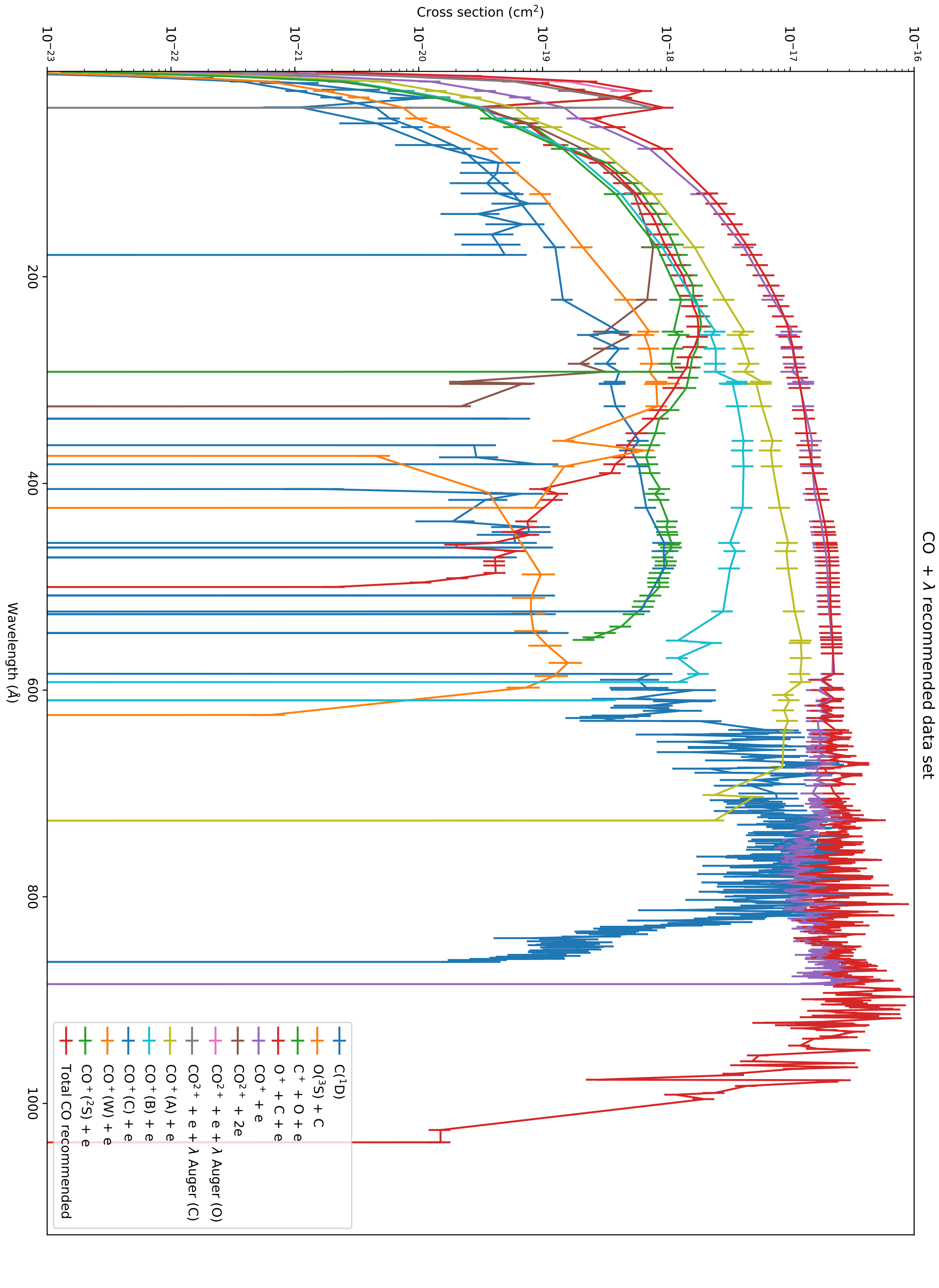

Figure 1.78: Cross sections for CO + λ recommended data set (wavelength version)

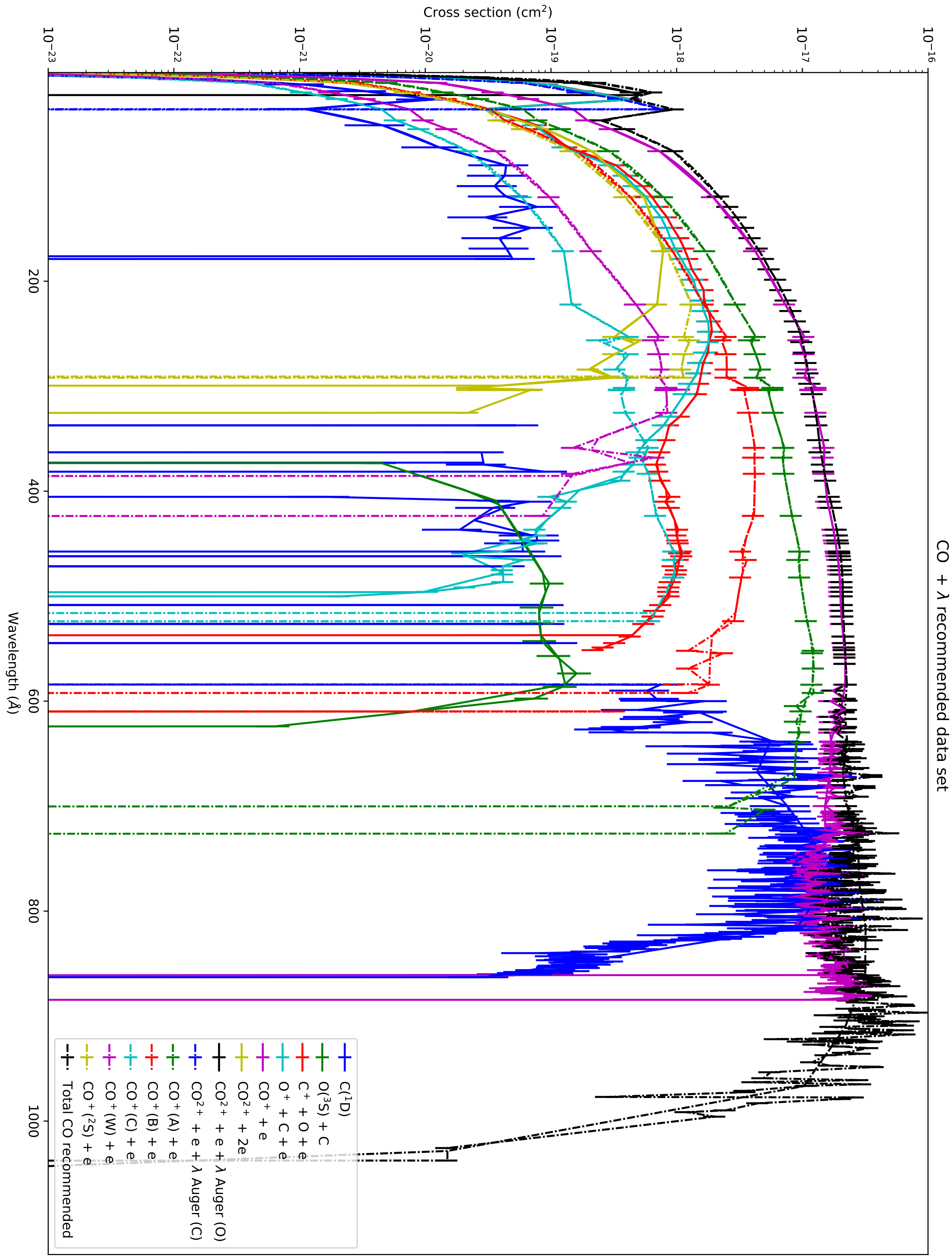

Figure 1.79: Cross sections for CO + λ recommended data set (with extrapolation version)

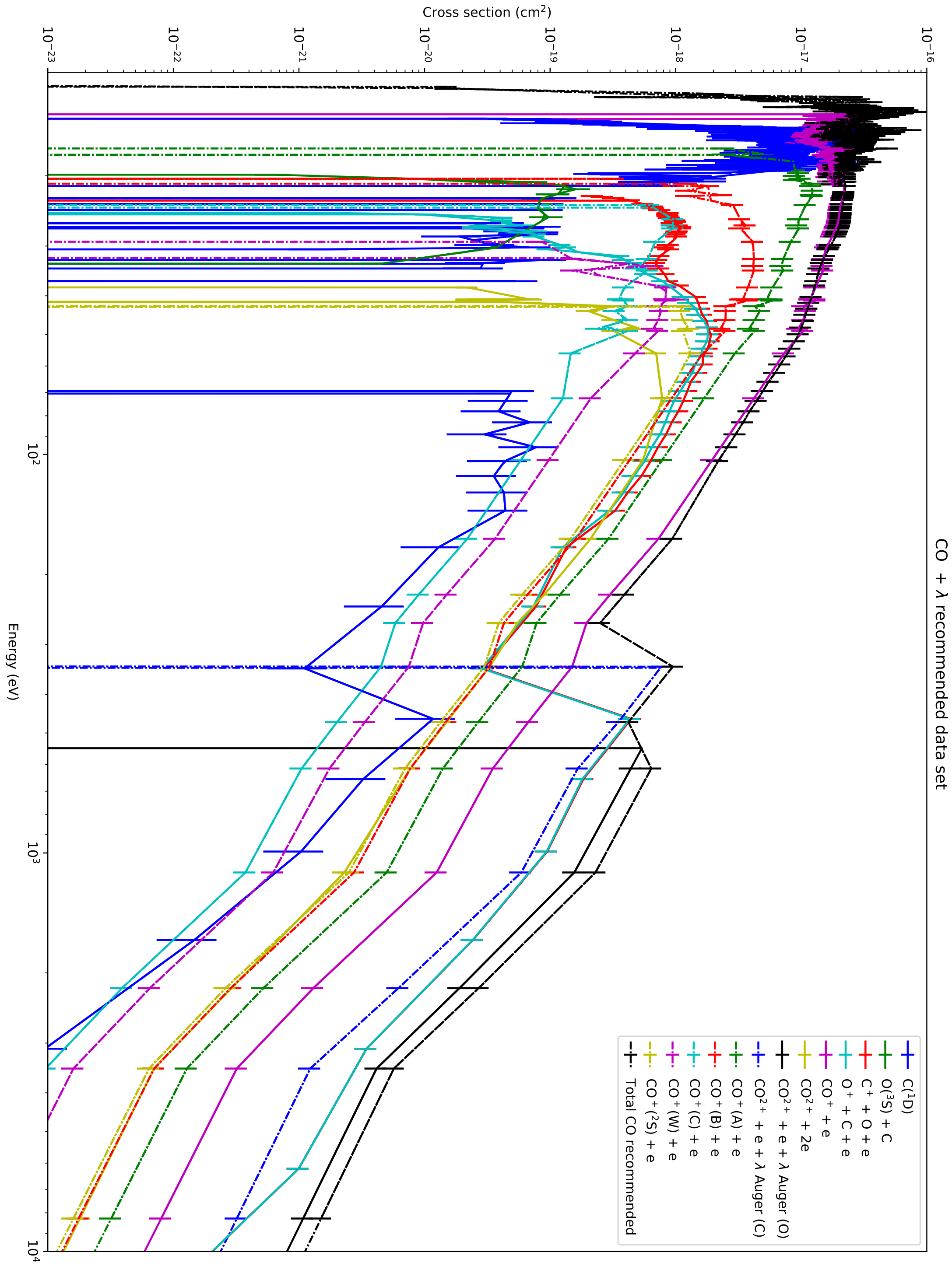

Figure 1.80: Cross sections for CO + λ recommended data set (wavelength with extrapolation version)

1.5 Cross section of ph impact with N_2

1.5.1 Total Cross Section

1.5.2 Inelastic Cross Sections

Ionization Cross Sections

$\mathbf{N_2 + \lambda \rightarrow {N_2}^+ + e}$

$\mathbf{N_2 + \lambda \rightarrow {N_2}^+(ABS) + e}$

$\mathbf{N_2 + \lambda \rightarrow {N_2}^{2+} + 2e}$

$\mathbf{N_2 + \lambda \rightarrow N^+ + N + e}$

1.5.3 Recommended data set

$\mathbf{N_2 + \lambda \rightarrow {N_2}^+(G) + e}$

$\mathbf{N_2 + \lambda \rightarrow {N_2}^+(B) + e}$

$\mathbf{N_2 + \lambda \rightarrow N^+ + N + e}$

$\mathbf{N_2 + \lambda \rightarrow {N_2}^{2+},{N_2}^+, + e + \lambda}$ **Auger (X)**

$\mathbf{N_2 + \lambda \rightarrow {N_2}^+ + e}$

$\mathbf{N_2 + \lambda \rightarrow {N_2}^+({}^2\Sigma_g) + e}$

$\mathbf{N_2 + \lambda \rightarrow {N_2}^{2+} + 2e}$

$\mathbf{N_2 + \lambda \rightarrow {N_2}^+(A) + e}$

$\mathbf{N_2 + \lambda \rightarrow {N_2}^+(F) + e}$

$\mathbf{N_2 + \lambda \rightarrow}$ **Total**

Legend for the properties

R : Recommended cross section for the processus. It is used in the main file. The selection of the recommended cross section is based on the quality of the data (e.g. errorbars, comparison with other experiments), the possibility of extrapolation, and the origin of the work, coupled with the consistency (sum of recommended cross sections   Total cross section)

U : Estimated uncertainty: sometimes, the uncertainty is not given, because of theoretical work... The authors of the database have to estimate the

Reference	Threshold	Range of energy	Uncertainty	Properties	Fig
Revi Avakyan 98	0	0:-1	20%		Fig. 1.87 1.88
???? ? BDD	0	0:-1	???%	U	Fig. 1.87 1.88
Revi AMOP	0	0:-1	???%	U	Fig. 1.87 1.88
Adap AMOP + Avakyan 98	0	0:-1	20%	RU	Fig. 1.87 1.88

Table 1.17: Total cross section for λ impact on N_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$N_2 + \lambda \rightarrow {N_2}^+ + e$	???? ? BDD	15.6	15.6:-1	???%	U	Fig. 1.81 1.82
	Revi AMOP	15.6	15.6:-1	???%	U	Fig. 1.81 1.82
	Adap AMOP+Avakyan	15.6	15.6:-1	20%	U	Fig. 1.81 1.82
$N_2 + \lambda \rightarrow {N_2}^+(ABS) + e$	Revi Avakyan 98	15.581	15.581:-1	20%		Fig. 1.81 1.82
$N_2 + \lambda \rightarrow {N_2}^{2+} + 2e$	???? Pb Ress	43.6	43.6:-1	50%	U	Fig. 1.85 1.86
$N_2 + \lambda \rightarrow N^+ + N + e$	???? ? BDD	24.3	24.3:-1	???%	U	Fig. 1.83 1.84
	Revi AMOP	24.3	24.3:-1	20%	RU	Fig. 1.83 1.84

Table 1.18: Ionization Cross section for λ impact on N_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$N_2 + \lambda \rightarrow N_2{}^{+}(G) + e$	Revi Avakyan 98	31	31:-1	20%		Fig. 1.89 1.90
$N_2 + \lambda \rightarrow N_2{}^{+}(B) + e$	Revi Avakyan 98	18.75	18.75:-1	20%		Fig. 1.89 1.90
$N_2 + \lambda \rightarrow N^{+} + N + e$	Revi AMOP	24.3	24.3:-1	20%	RU	Fig. 1.89 1.90
$N_2 + \lambda \rightarrow N_2{}^{2+}, N_2{}^{+}, + e + \lambda$ Auger (X)	Revi Avakyan 98	400	400:-1	20%	R	Fig. 1.89 1.90
$N_2 + \lambda \rightarrow N_2{}^{+} + e$	Adap AMOP+Avakyan	15.6	15.6:-1	20%	U	Fig. 1.89 1.90
$N_2 + \lambda \rightarrow N_2{}^{+}({}^2\Sigma_g) + e$	Revi Avakyan 98	35	35:-1	20%		Fig. 1.89 1.90
$N_2 + \lambda \rightarrow N_2{}^{2+} + 2e$	???? Pb Ress	43.6	43.6:-1	50%	U	Fig. 1.89 1.90
$N_2 + \lambda \rightarrow N_2{}^{+}(A) + e$	Revi Avakyan 98	16.7	16.7:-1	20%		Fig. 1.89 1.90
$N_2 + \lambda \rightarrow N_2{}^{+}(F) + e$	Revi Avakyan 98	27	27:-1	20%		Fig. 1.89 1.90
$N_2 + \lambda \rightarrow$ Total	Adap AMOP + Avakyan 98	0	0:-1	20%	RU	Fig. 1.89 1.90

Table 1.19: Recommended Cross section for λ impact on N_2

uncertainty, but the quality of that estimation can be questionable. Moreover, when data from different sources have been adapted (e.g. for extrapolation), the uncertainty can be modified...

E : Validated for extrapolation: the extrapolation of these cross sections is plausible. For example, when an analytic function has been applied...

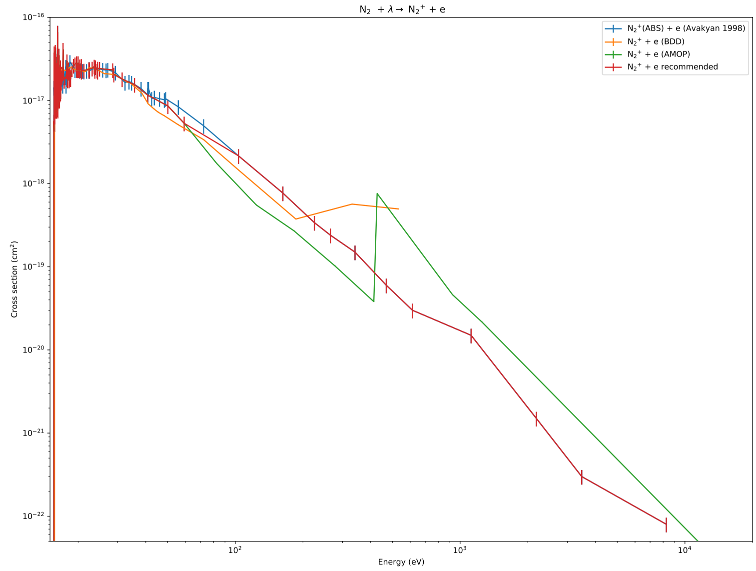

Figure 1.81: Cross sections for $N_2 + \lambda \rightarrow {N_2}^+ + e$

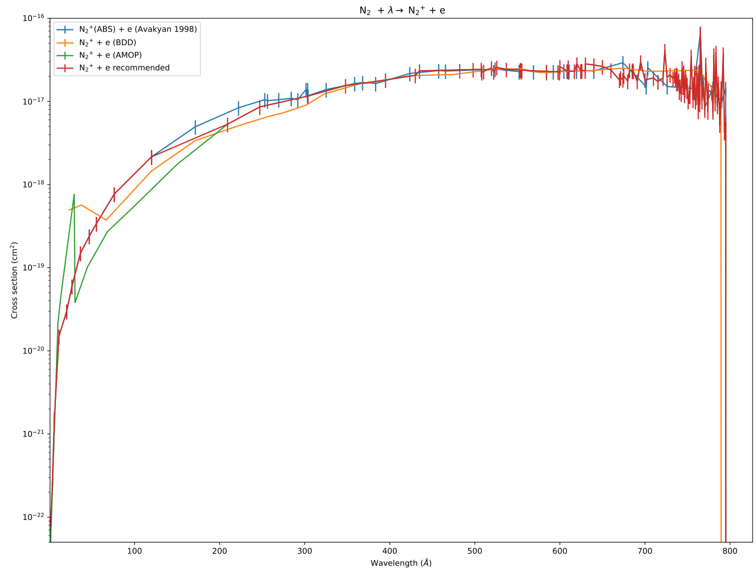

Figure 1.82: Cross sections for $N_2 + \lambda \rightarrow {N_2}^+ + e$ (wavelength version)

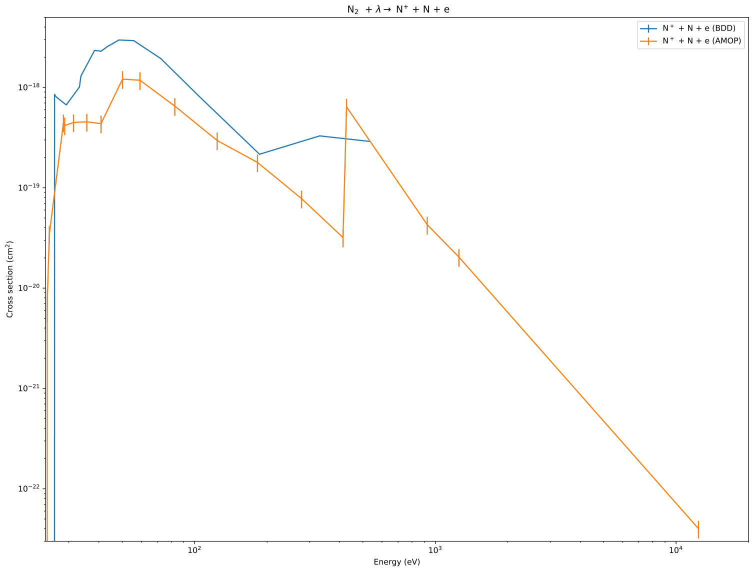

Figure 1.83: Cross sections for $N_2 + \lambda \rightarrow N^+ + N + e$

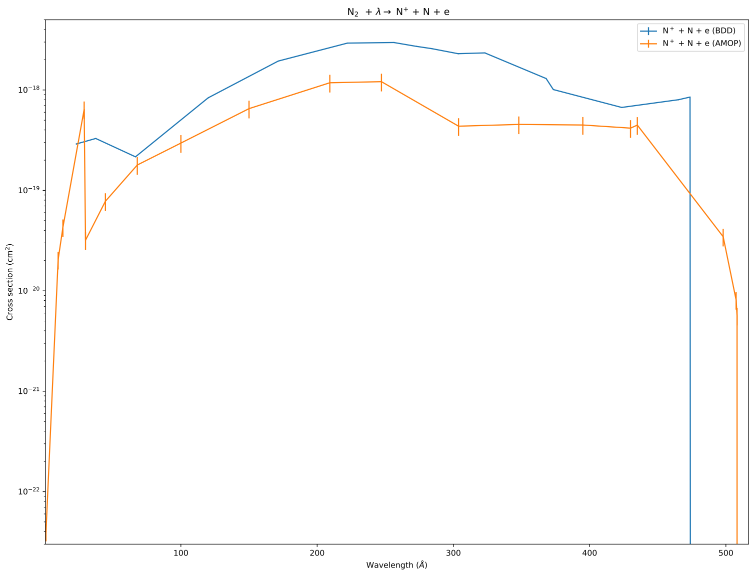

Figure 1.84: Cross sections for $N_2 + \lambda \rightarrow N^+ + N + e$ (wavelength version)

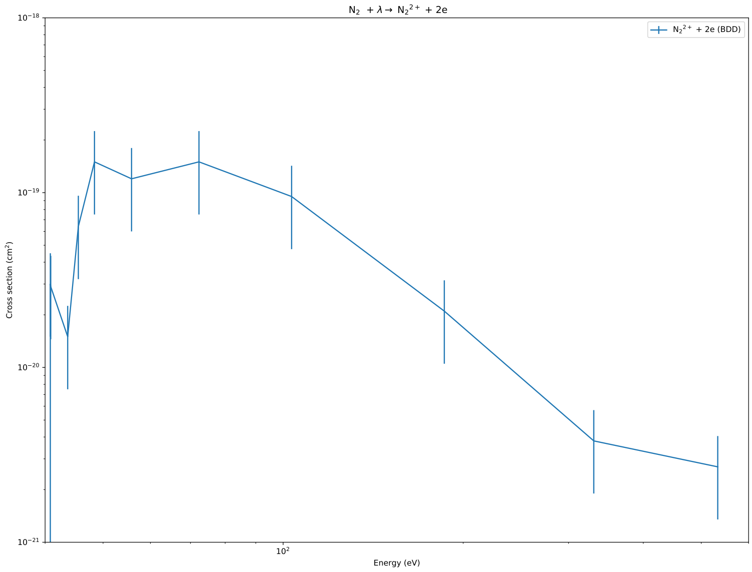

Figure 1.85: Cross sections for $N_2 + \lambda \rightarrow {N_2}^{2+} + 2e$

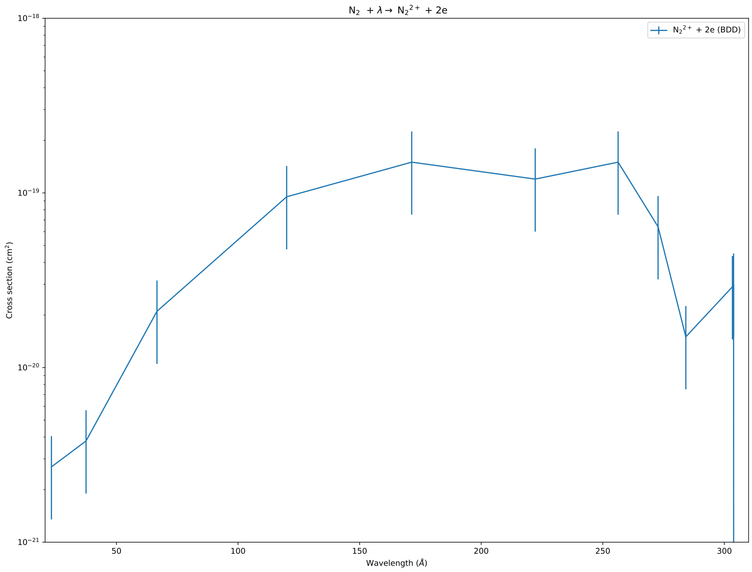

Figure 1.86: Cross sections for $N_2 + \lambda \rightarrow {N_2}^{2+} + 2e$ (wavelength version)

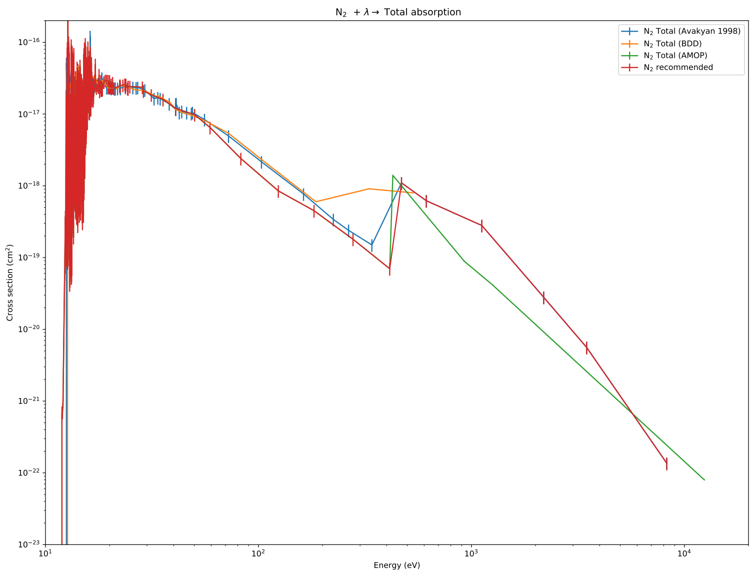

Figure 1.87: Cross sections for N_2 + $\lambda \rightarrow$ Total absorption

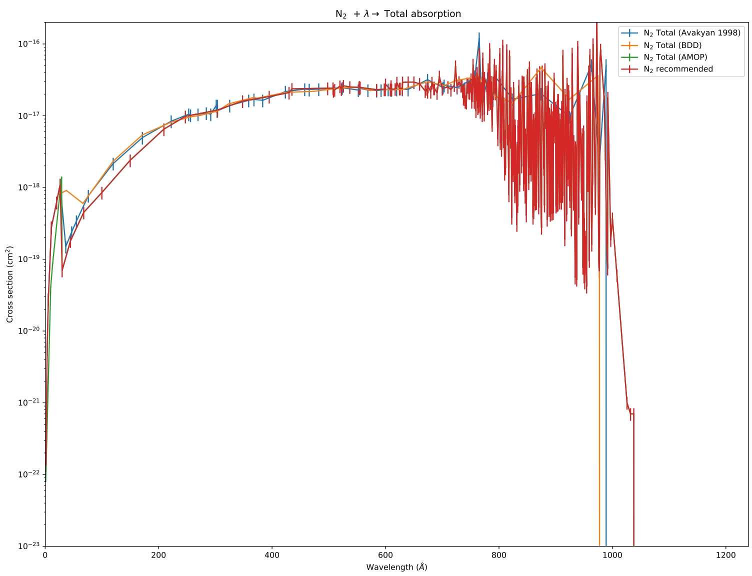

Figure 1.88: Cross sections for N_2 + $\lambda \rightarrow$ Total absorption (wavelength version)

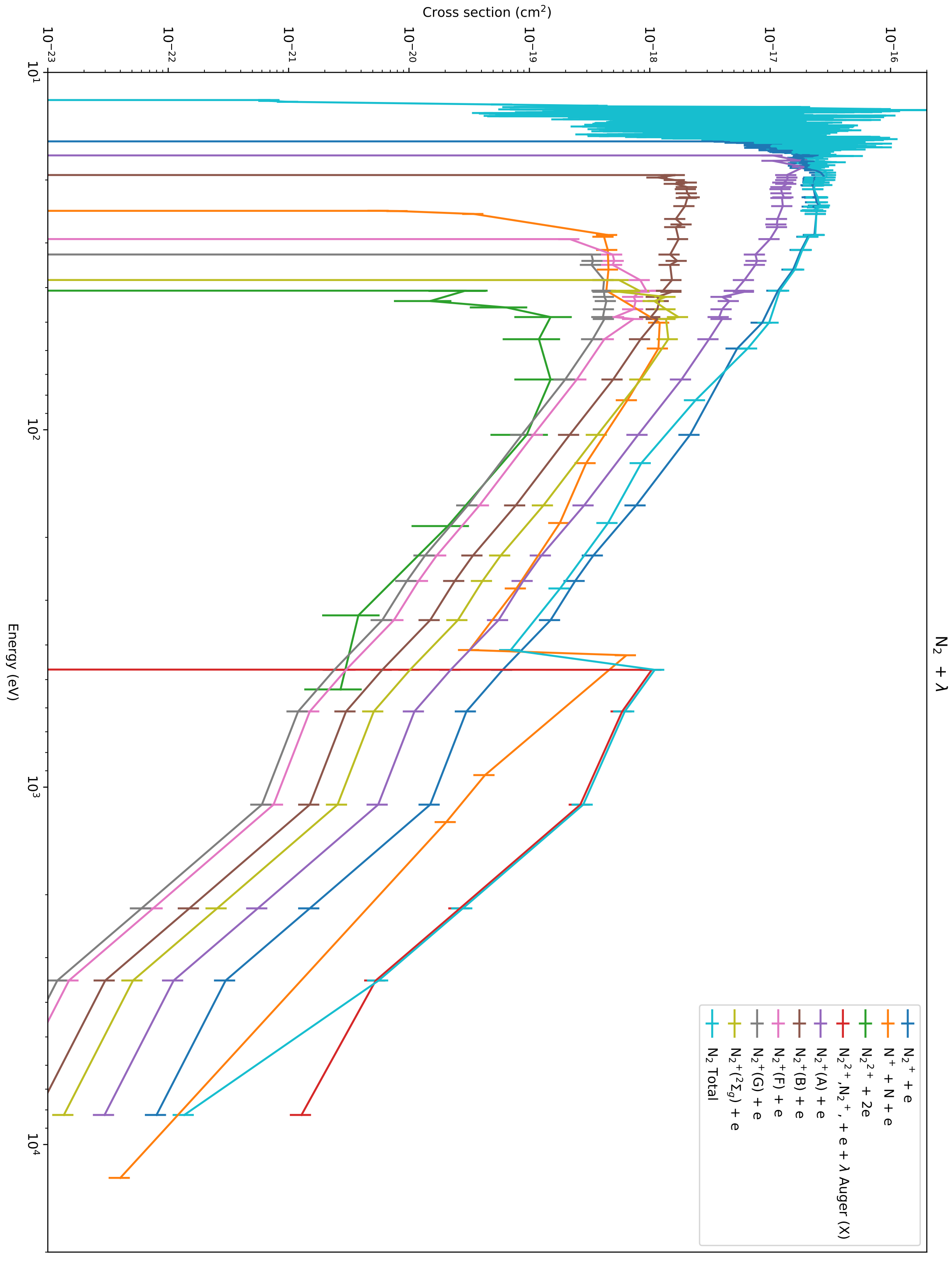

Figure 1.89: Cross sections for $N_2 + \lambda$

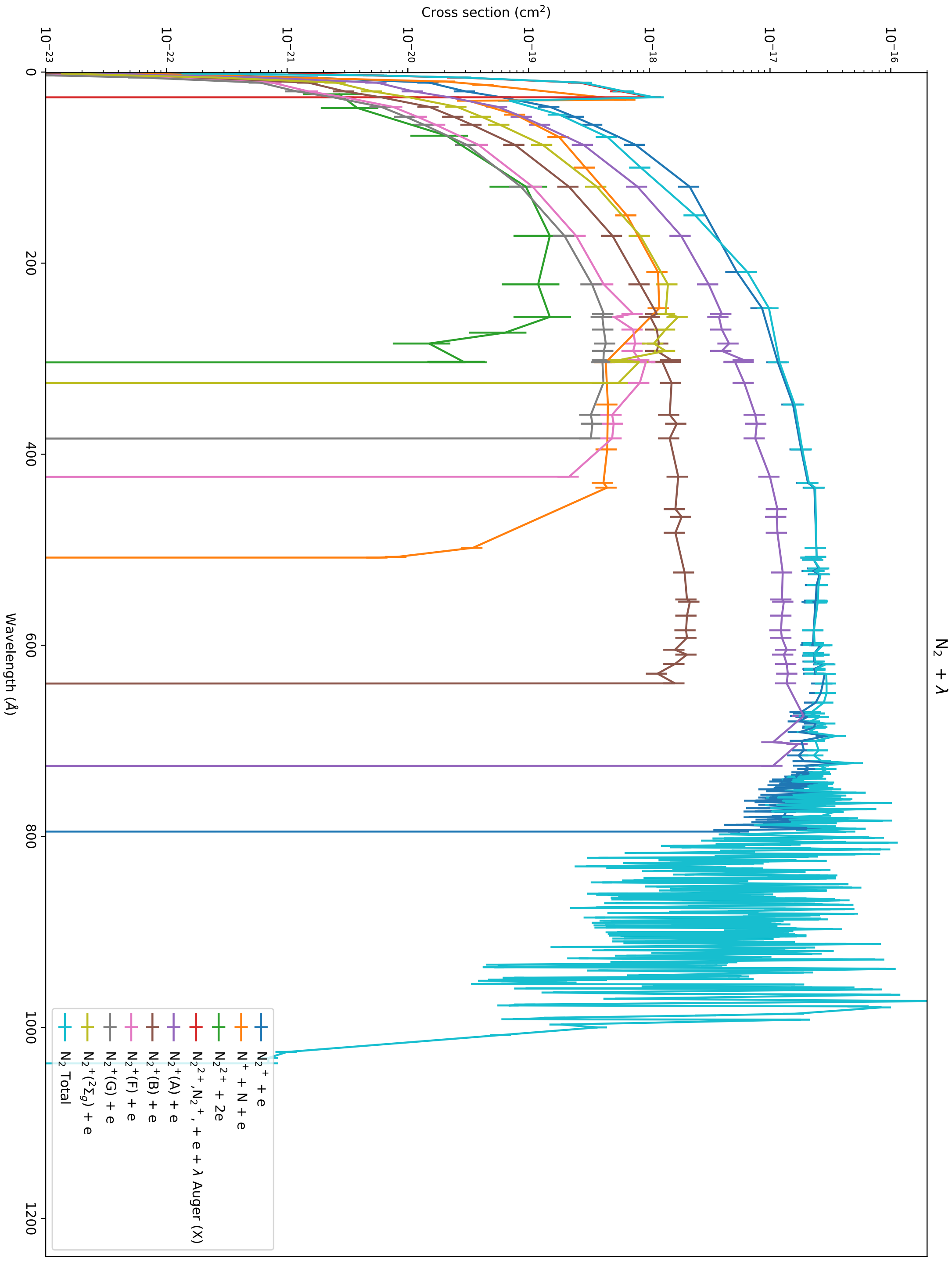

Figure 1.90: Cross sections for $N_2 + \lambda$ (wavelength version)

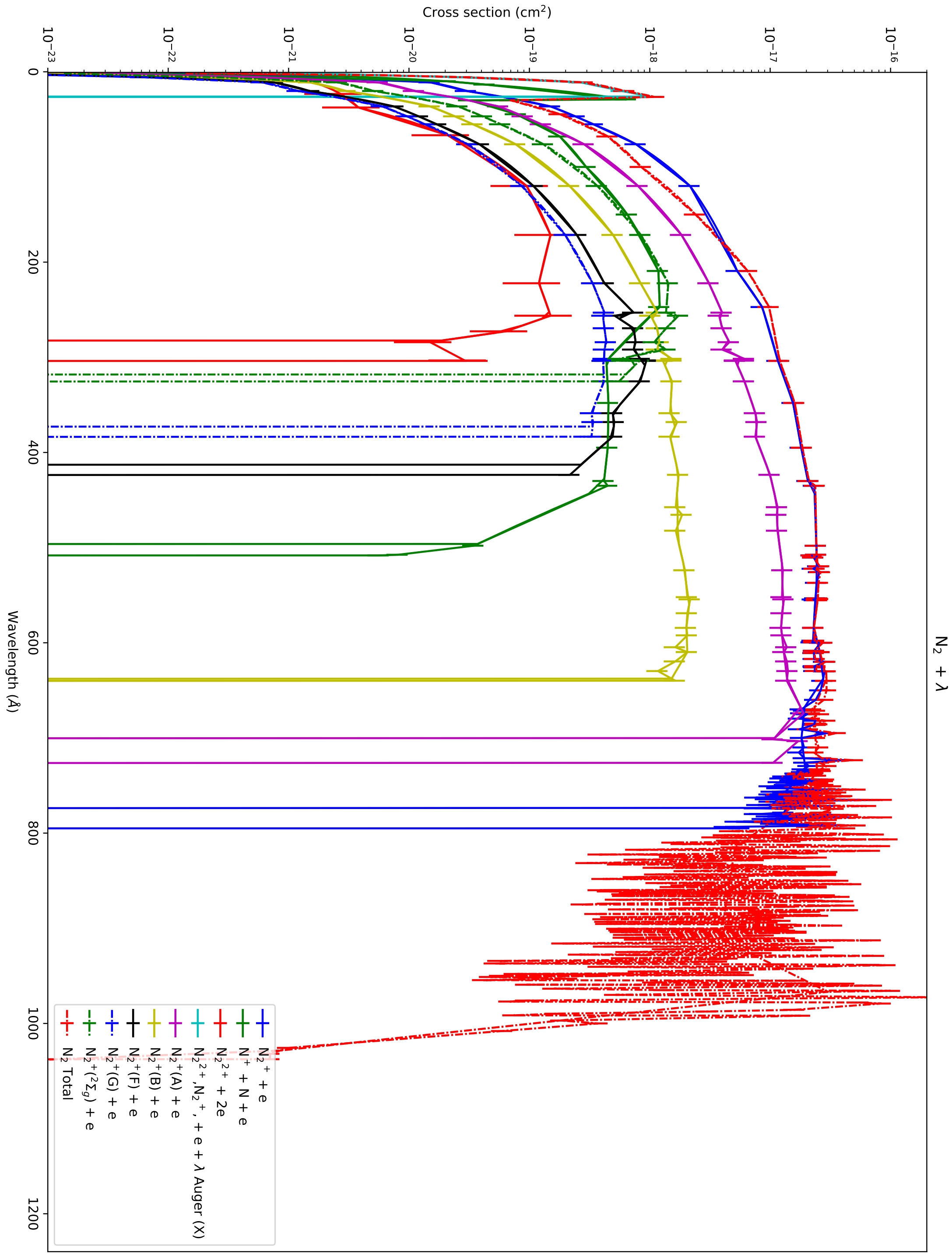

Figure 1.91: Cross sections for N_2 + λ (with extrapolation version)

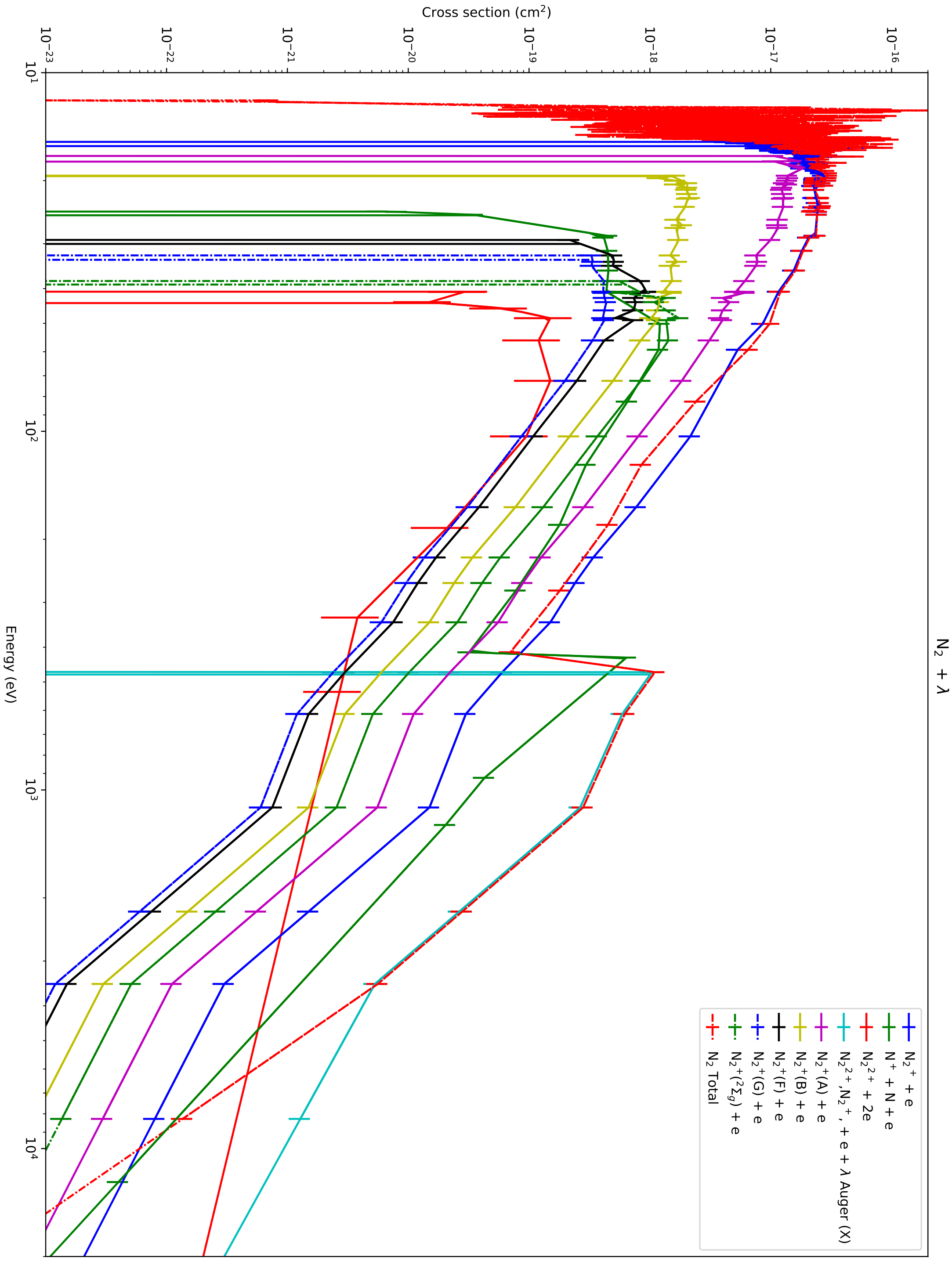

Figure 1.92: Cross sections for N_2 + λ (wavelength with extrapolation version)

Chapter 2

Electron impact

Introduction

2.1 Cross section of e impact with CH_4

2.1.1 Elastic Cross Section

2.1.2 Inelastic Cross Sections

Ionization Cross Sections

CH_4 + e → C+

CH_4 + e → CH4+

CH_4 + e → CH+

CH_4 + e → H+

CH_4 + e → H2+

CH_4 + e → CH4++(Auger)

Notes for CH_4^{++} K-Shell ionization, Frémont 2006 + Shirai 2002 + Straub 2004 The K-Shell ionization of CH_4 by electron impact has been studied in [**?**]. The ratio K-shell/simple ionization has been taken in that paper. The total cross section has been computed by multiplying this ratio by the recommended ionization cross section, coming from an adaptation of the work of [**?**] with the analytic cross sections in [4].

Reference	Threshold	Range of energy	Uncertainty	Properties	Fig
???? ? Rees?	0	0:-1	???%	U	Fig. 2.4
Revi Kanik 1993	0	0:-1	???%	U	Fig. 2.4
Revi Shirai 2002	0	0.2 : 1000.0	20%	RE	Fig. 2.4

Table 2.1: Elastic cross section for e impact on CH_4

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$CH_4 + e \rightarrow C^+$	Meas Straub 2004	28.200000	15.0 : 1000.0	8.5%		Fig. 2.7
	Revi Shirai 2002	28.200000	30.0 : 1000.0	8.5%	E	Fig. 2.7
	Adap Straub 2004 + Shirai 2002	28.200000	28.200000:-1	8.5%	RUE	Fig. 2.7
$CH_4 + e \rightarrow CH_4^+$	???? ? Rees?	12.10	12.10:-1	???%	U	Fig. 2.8
	Meas Straub 2004	12.10	15.0 : 1000.0	5%		Fig. 2.8
	Revi Shirai 2002	12.99	15.0 : 1000.0	5%	E	Fig. 2.8
	Adap Straub 2004 + Shirai 2002	12.99	12.99:-1	5%	RUE	Fig. 2.8
$CH_4 + e \rightarrow CH^+$	Meas Straub 2004	24.14	15.0 : 1000.0	6.5%		Fig. 2.9
	Revi Shirai 2002	24.140000	25.0 : 1000.0	10%	E	Fig. 2.9
	Adap Straub 2004 + Shirai 2002	24.140000	24.140000:-1	6.5%	RUE	Fig. 2.9
$CH_4 + e \rightarrow H^+$	Meas Straub 2004	18.00	15.0 : 1000.0	5.5%		Fig. 2.6
	Revi Shirai 2002	18.00	25.0 : 1000.0	7%	E	Fig. 2.6
	Adap Straub 2004 + Shirai 2002	18.00	18.00:-1	5.5%	RUE	Fig. 2.6
$CH_4 + e \rightarrow H_2^+$	Meas Straub 2004	20.230000	15.0 : 1000.0	7.5%		Fig. 2.2
	Revi Shirai 2002	20.230000	25.0 : 1000.0	20%	E	Fig. 2.2
	Adap Straub 2004 + Shirai 2002	20.230000	20.230000:-1	7.5%	RUE	Fig. 2.2
$CH_4 + e \rightarrow CH_4^+$+(Auger)	Adap Fremont 2006 + Shirai 2002+Straub 2004	282	282:-1	50%	RUE	Fig. 2.5
$CH_4 + e \rightarrow CH_2^+$	Meas Straub 2004	15.200000	15.0 : 1000.0	6.5%		Fig. 2.3
	Revi Shirai 2002	15.200000	17.5 : 1000.0	10%	E	Fig. 2.3
	Adap Straub 2004 + Shirai 2002	15.200000	15.200000:-1	6.5%	RUE	Fig. 2.3
$CH_4 + e \rightarrow CH_3^+$	???? ? Rees?	14.30	14.30:-1	???%	U	Fig. 2.1
	Meas Straub 2004	14.24	15.0 : 1000.0	5%		Fig. 2.1
	Revi Shirai 2002	14.24	15.0 : 1000.0	7%	E	Fig. 2.1
	Adap Straub 2004 + Shirai 2002	14.24	14.24:-1	5%	RUE	Fig. 2.1

Table 2.2: Ionization Cross section for e impact on CH_4

CH_4 + e → CH2+

CH_4 + e → CH3+

2.1.3 Recommended data set

CH_4 + e → C+

CH_4 + e → CH

CH_4 + e → Elastic

CH_4 + e → CH4+

CH_4 + e → CH+

CH_4 + e → vib 1-3

CH_4 + e → H+

CH_4 + e → CH2

CH_4 + e → CH3

CH_4 + e → H2+

CH_4 + e → CH(A2D)

CH_4 + e → rot+vib

CH_4 + e → CH2+

CH_4 + e → CH4++(Auger)

CH_4 + e → CH3+

Legend for the properties

R : Recommended cross section for the processus. It is used in the main file. The selection of the recommended cross section is based on the quality of the data (e.g. errorbars, comparison with other experiments), the possibility of extrapolation, and the origin of the work, coupled with the consistency (sum of recommended cross sections Total cross section)

U : Estimated uncertainty: sometimes, the uncertainty is not given, because of theoretical work... The authors of the database have to estimate the uncertainty, but the quality of that estimation can be questionable. Moreover, when data from different sources have been adapted (e.g. for extrapolation), the uncertainty can be modified...

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
CH_4 + e → C^+	Adap Straub 2004 + Shirai 2002	28.200000	28.200000:-1	8.5%	RUE	Fig. 2.10
CH_4 + e → CH	Adap Erwin 2005	25.	25.:-1	20%	RUE	Fig. 2.10
CH_4 + e → Elastic	Revi Shirai 2002	0	0.2 : 1000.0	20%	RE	Fig. 2.10
CH_4 + e → CH_4^+	Adap Straub 2004 + Shirai 2002	12.99	12.99:-1	5%	RUE	Fig. 2.10
CH_4 + e → CH^+	Adap Straub 2004 + Shirai 2002	24.140000	24.140000:-1	6.5%	RUE	Fig. 2.10
CH_4 + e → vib 1-3	Theo Davies 1989	0.361	0.361:-1	???%	U	Fig. 2.10
CH_4 + e → H^+	Adap Straub 2004 + Shirai 2002	18.00	18.00:-1	5.5%	RUE	Fig. 2.10
CH_4 + e → CH_2	Adap Erwin 2005	15.	15.:-1	20	RUE	Fig. 2.10
CH_4 + e → CH_3	Adap Erwin 2005	14.	14.:-1	20%	RUE	Fig. 2.10
CH_4 + e → H_2^+	Adap Straub 2004 + Shirai 2002	20.230000	20.230000:-1	7.5%	RUE	Fig. 2.10
CH_4 + e → CH(A2D)	Revi Shirai 2002	12.200000	14.6 : 5000.0	30%	UE	Fig. 2.10
CH_4 + e → rot+vib	Theo Davies 1989	0.162	0.162:-1	???%	U	Fig. 2.10
CH_4 + e → CH_2^+	Adap Straub 2004 + Shirai 2002	15.200000	15.200000:-1	6.5%	RUE	Fig. 2.10
CH_4 + e → CH_4^++(Auger)	Adap Fremont 2006 + Shirai 2002+Straub 2004	282	282:-1	50%	RUE	Fig. 2.10
CH_4 + e → CH_3^+	Adap Straub 2004 + Shirai 2002	14.24	14.24:-1	5%	RUE	Fig. 2.10

Table 2.3: Recommended Cross section for e impact on CH_4

E : Validated for extrapolation: the extrapolation of these cross sections is plausible. For example, when an analytic function has been applied...

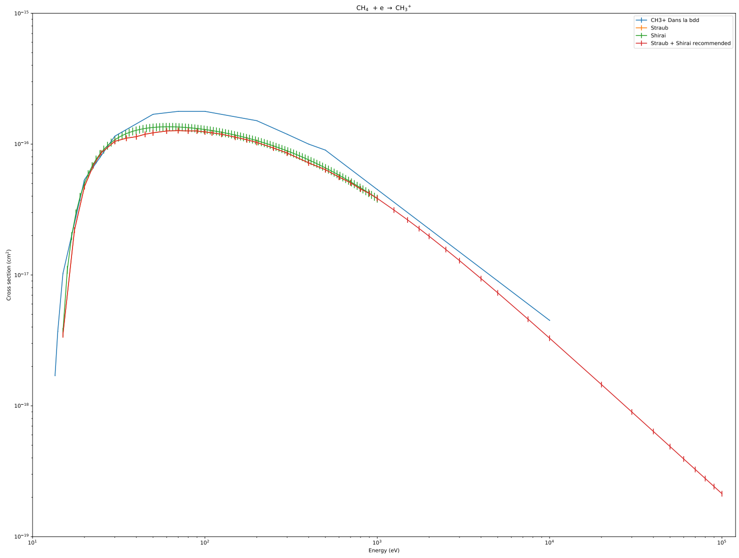

Figure 2.1: Cross sections for CH_4 + e → $CH_3{}^+$

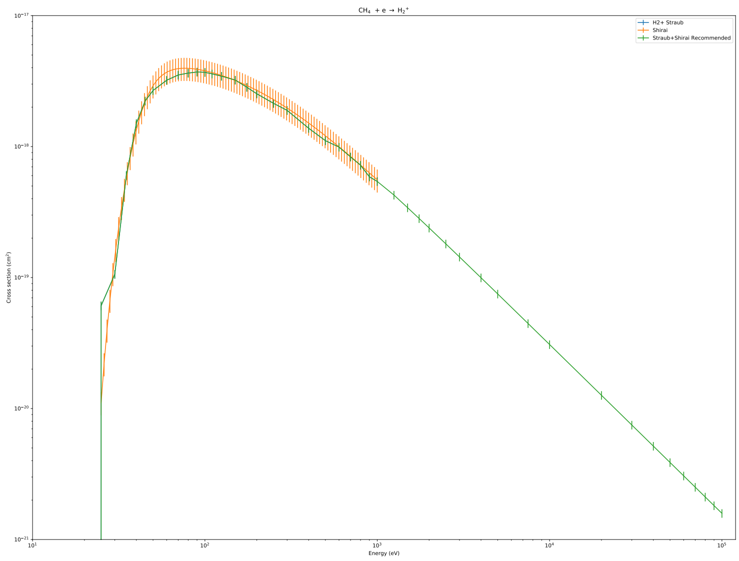

Figure 2.2: Cross sections for CH_4 + e → $H_2{}^+$

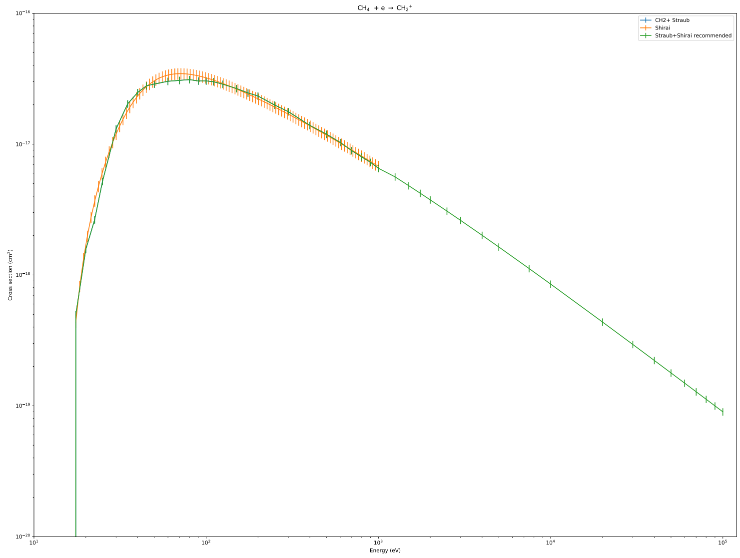

Figure 2.3: Cross sections for CH_4 + e → ${CH_2}^+$

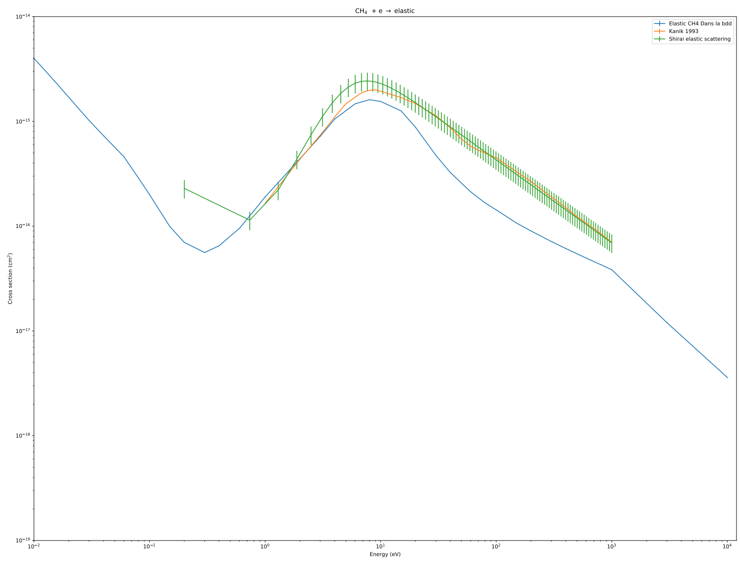

Figure 2.4: Cross sections for CH_4 + e → elastic

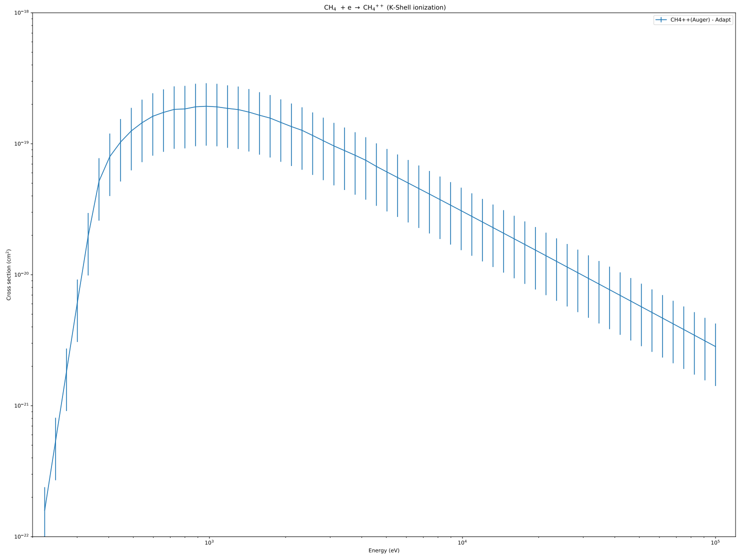

Figure 2.5: Cross sections for CH_4 + e $\rightarrow$ CH_4^{++} (K-Shell ionization)

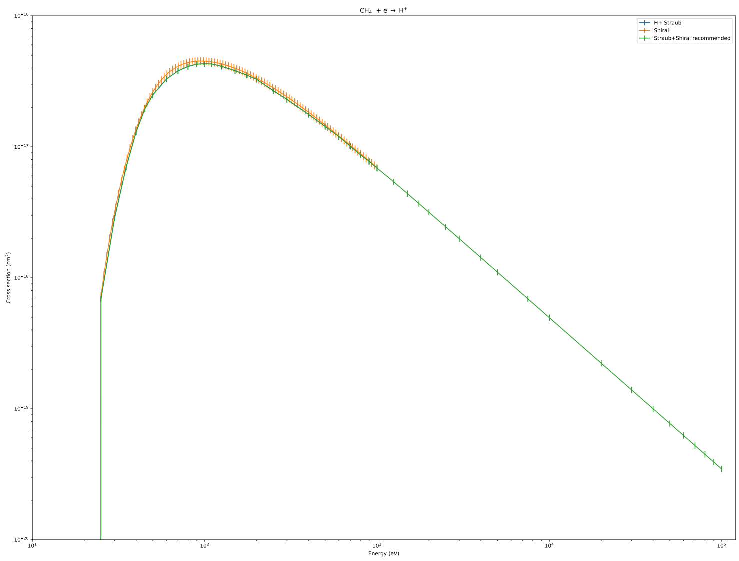

Figure 2.6: Cross sections for CH_4 + e $\rightarrow$ H^+

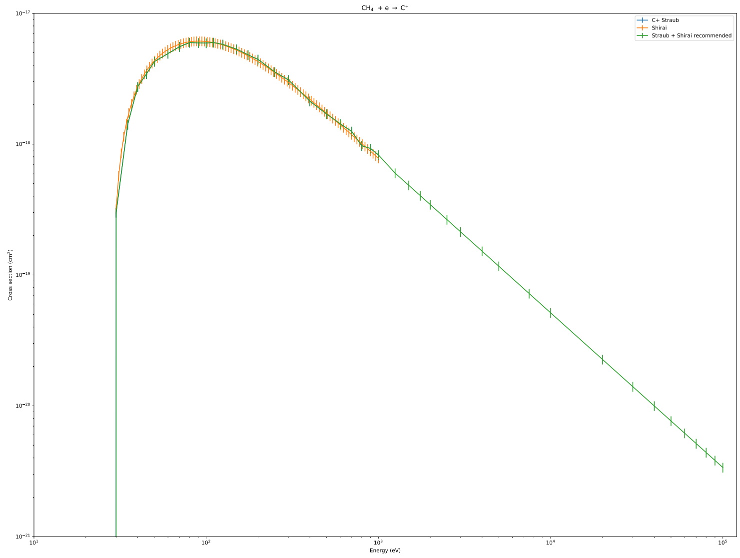

Figure 2.7: Cross sections for $CH_4 + e \rightarrow C^+$

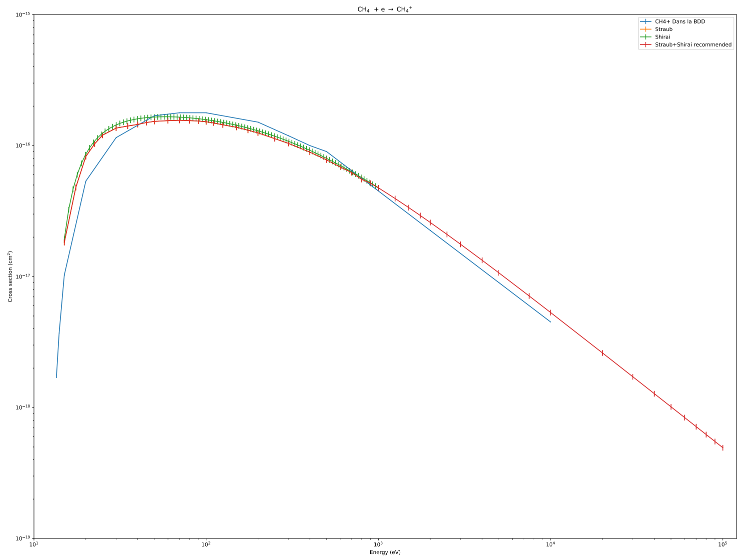

Figure 2.8: Cross sections for $CH_4 + e \rightarrow {CH_4}^+$

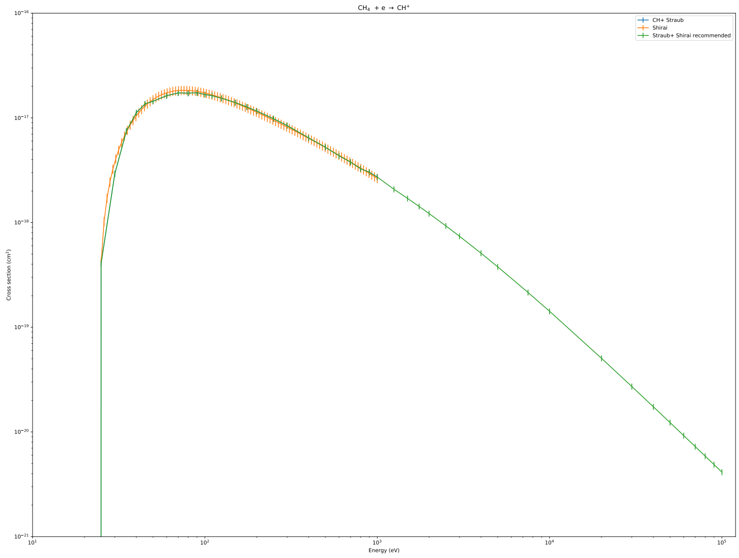

Figure 2.9: Cross sections for CH_4 + e → CH^+

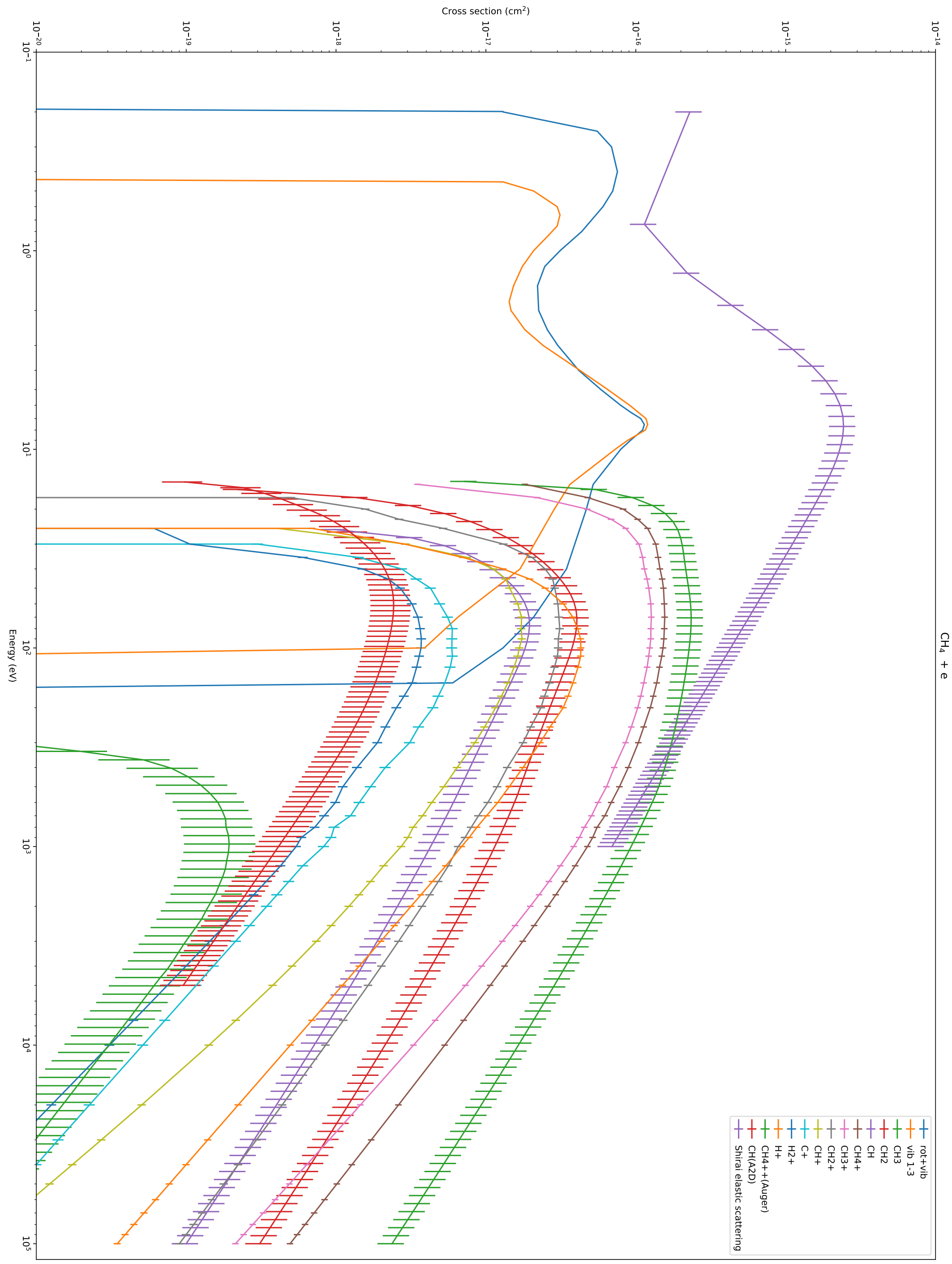

Figure 2.10: Cross sections for CH_4 + e

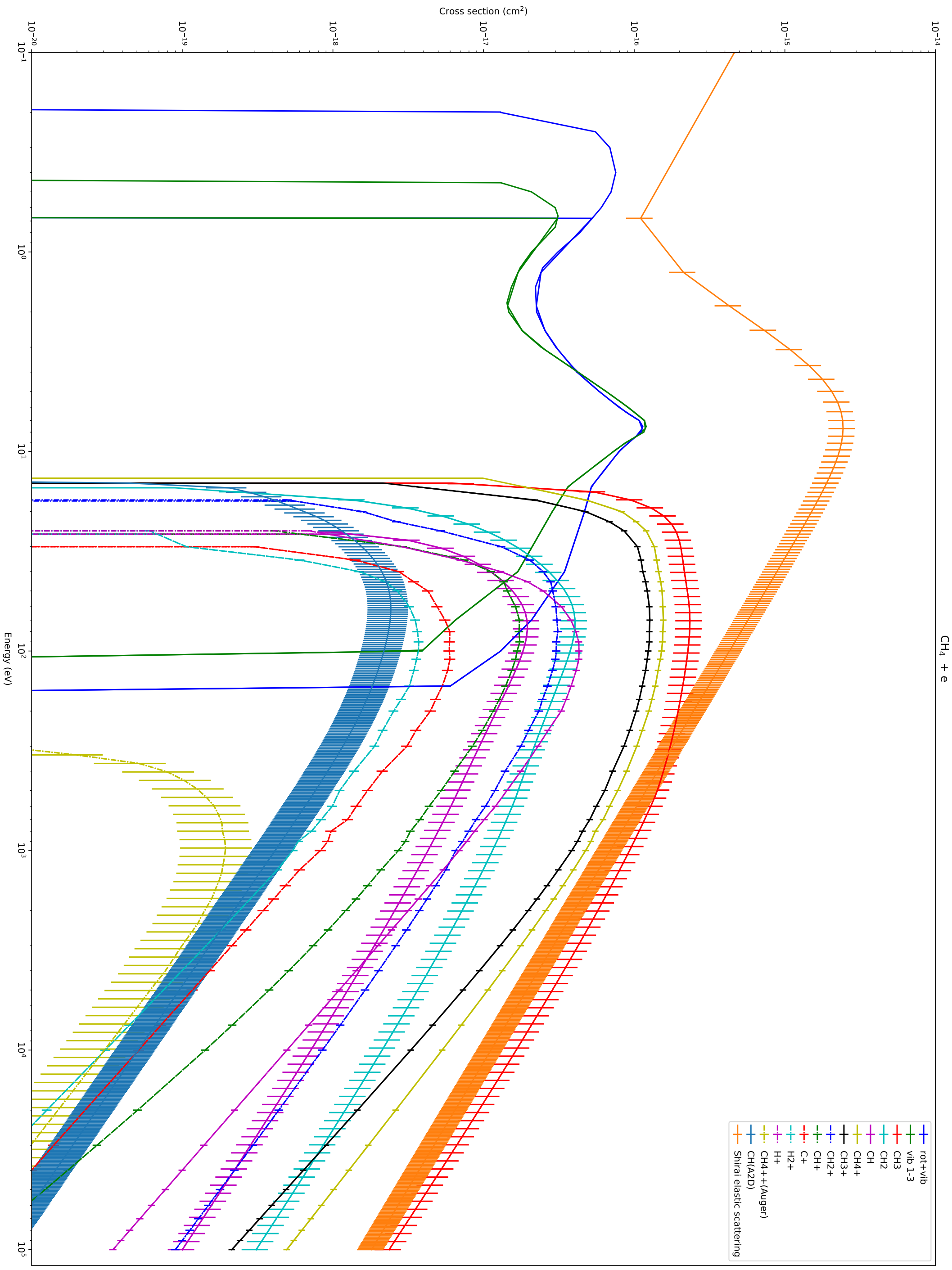

Figure 2.11: Cross sections for CH_4 + e (wavelength with extrapolation version)

2.2 Cross section of e impact with CO_2

2.2.1 Total Cross Section

2.2.2 Elastic Cross Section

2.2.3 Inelastic Cross Sections

Ionization Cross Sections

CO_2 + e → C+

CO_2 + e → O+

CO_2 + e → C++

CO_2 + e → CO2++

CO_2 + e → CO2++(Auger)

Notes for CO_2^{++} K-Shell ionization, Frémont 2006 + Straub 2004 + Shirai 2001 The K-Shell ionization of CO_2 by electron impact has not been studied in [**?**], but we assumed that the K-Shell/single ionization ratio is close to the CH_4 one which is used here. The total cross section has been computed by multiplying this ratio by the recommended ionization cross section, coming from [**?**] and [3].

Reference	Threshold	Range of energy	Uncertainty	Properties	Fig
Revi Shirai 2001	0	0.5 : 5000.0	7%	E	Fig. 2.19
Revi Itikawa 2002	0	0.1 : 1000.0	5%		Fig. 2.19
???? ? BDD	0	0:-1	???%	U	Fig. 2.19
Adap Itikawa+Shirai+Straub+...	0	0:-1	20%	U	Fig. 2.19

Table 2.4: Total cross section for e impact on CO_2

Reference	Threshold	Range of energy	Uncertainty	Properties	Fig
Revi Shirai 2001	0	1.0 : 1000.0	28%	E	Fig. 2.20
Revi Tanaka 1998	0	.1 : 5000.0	50%		Fig. 2.20
Revi Itikawa 2002	0	3.5 : 1000.0	18%		Fig. 2.20
Adap Itikawa 2002 + Shirai 2001	0	3.5 : 1000.0	18%	RUE	Fig. 2.20

Table 2.5: Elastic cross section for e impact on CO_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$CO_2 + e \rightarrow C^+$	Revi Shirai 2001	27.8000000	30.0 : 1000.0	9%	E	Fig. 2.
	Meas Straub 2004	27.8	27.8:-1	5%		Fig. 2.
	Revi Itikawa 2002	27.8	27.8:-1	5%		Fig. 2.
	???? ? BDD	27.8	27.8:-1	???%	U	Fig. 2.
	Adap Straub 2004 + Shirai 2001	27.8	27.8:-1	5%	RUE	Fig. 2.
$CO_2 + e \rightarrow O^+$	Revi Shirai 2001	19.000000	25.0 : 1000.0	7%	E	Fig. 2.
	Meas Straub 2004	19.0	19.0:-1	5%		Fig. 2.
	Revi Itikawa 2002	19	19:-1	5%		Fig. 2.
	???? ? BDD	19	19:-1	???%	U	Fig. 2.
	Adap Straub 2004 + Shirai 2001	19.0	19.0:-1	5%	RUE	Fig. 2.
$CO_2 + e \rightarrow C^{++}$	Revi Shirai 2001	52.20	80.0 : 1000.0	15%	E	Fig. 2.
	Meas Straub 2004	52.20	52.20:-1	11%		Fig. 2.
	Revi Itikawa 2002	52.20	52.20:-1	11%		Fig. 2.
	???? ? BDD	51.2	51.2:-1	???%	U	Fig. 2.
	Adap Straub 2004 + Shirai 2001	52.20	52.20:-1	11%	RUE	Fig. 2.
$CO_2 + e \rightarrow CO_2^{++}$	Revi Shirai 2001	37.2	45.0 : 1000.0	12%	E	Fig. 2.
	Meas Straub 2004	37.4	37.4:-1	6%		Fig. 2.
	Revi Itikawa 2002	37.4	37.4:-1	6%		Fig. 2.
	Adap Straub 2004 + Shirai 2001	37.4	37.4:-1	6%	RUE	Fig. 2.
$CO_2 + e \rightarrow CO_2^{++}$(Auger)	Adap Fremont 2006 + Shirai 2001+Straub 2004	539	539:-1	50%	RUE	Fig. 2.21
$CO_2 + e \rightarrow O^{++}$	Revi Shirai 2001	54.20	80.0 : 1000.0	20%	E	Fig. 2.
	Meas Straub 2004	54.20	54.20:-1	11%		Fig. 2.
	Revi Itikawa 2002	54.20	54.20:-1	11%		Fig. 2.
	???? ? BDD	54.20	54.20:-1	???%	U	Fig. 2.
	Adap Straub 2004 + Shirai 2001	54.20	54.20:-1	11%	RUE	Fig. 2.
$CO_2 + e \rightarrow CO_2^+$	Revi Shirai 2001	13.800000	15.0 : 1000.0	12%	E	Fig. 2.
	Meas Straub 2004	13.8000	13.8000:-1	5%		Fig. 2.
	Revi Itikawa 2002	13.80000	13.80000:-1	5%		Fig. 2.
	Adap Straub 2004 + Shirai 2001	13.80000	13.80000:-1	5%	RUE	Fig. 2.
$CO_2 + e \rightarrow CO^+$	Revi Shirai 2001	19.500000	25.0 : 1000.0	9%	E	Fig. 2.
	Meas Straub 2004	19.5000	19.5000:-1	5%		Fig. 2.
	Revi Itikawa 2002	19.5	19.5:-1	5%		Fig. 2.
	???? ? BDD	19.5	19.5:-1	???%	U	Fig. 2.
	Adap Straub 2004 + Shirai 2001	19.5000	19.5000:-1	5%	RUE	Fig. 2.

Table 2.6: Ionization Cross section for e impact on CO_2

CO_2 + e → O++

CO_2 + e → CO2+

CO_2 + e → CO+

Excitation Cross Sections

CO_2 + e → CO(a3Pi)

CO_2 + e → CO2(8.60)

CO_2 + e → CO(A1Pi)

CO_2 + e → CO2(vib1)

CO_2 + e → CO2(vib3)

CO_2 + e → O(1S)

CO_2 + e → CO2(vib2)

CO_2 + e → O(5S)

CO_2 + e → O(3S)

CO_2 + e → CO2(9.3)

2.2.4 Emission Cross Sections

CO_2 + e → CO2+(A)

CO_2 + e → CO2+(B)

2.2.5 Recommended data set

CO_2 + e → C+

CO_2 + e → CO2+(A)

CO_2 + e → CO(a3Pi)

CO_2 + e → O+

CO_2 + e → CO2++(Auger)

CO_2 + e → CO2+

CO_2 + e → O(1S)

CO_2 + e → CO2(8.60)

CO_2 + e → CO(A1Pi)

CO_2 + e → O++

CO_2 + e → CO2(vib1)

CO_2 + e → Elastic

CO_2 + e → C++

CO_2 + e → CO2(vib3)

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$CO_2 + e \rightarrow CO(a^3\Pi)$	Adap Avakyan 1998+Simon 2008	11.46	11.46:-1	75%	U	Fig. 2.31 2.31
	Adap Avakyan + Gronoff 2012	11.46	11.46:-1	25%	RU	Fig. 2.31 2.31
$CO_2 + e \rightarrow CO_2(8.60)$	???? ? BDD	8.60	8.60:-1	???%	U	Fig. 2.25
$CO_2 + e \rightarrow CO(A^1\Pi)$	Adap Ajello 1971+Simon2008	13.48	13.48:-1	50%	RU	Fig. 2.17 2.17
	Revi Shirai 2001	13.60	15.0 : 350.0	20%	E	Fig. 2.17 2.17
$CO_2 + e \rightarrow CO_2(vib1)$	Revi Itikawa 2002	0.08300000	0.08300000:-1	30%		Fig. 2.27
	???? ? BDD	0.083	0.083:-1	???%	U	Fig. 2.27
$CO_2 + e \rightarrow CO_2(vib3)$	Revi Itikawa 2002	0.29100	1.5:30	30%		Fig. 2.14
	???? ? BDD	0.291	0.291:-1	???%	U	Fig. 2.14
$CO_2 + e \rightarrow O(^1S)$	Meas Leclair 1994	9.64	9.64:-1	12%		Fig. 2.34
	Adap Leclair 1994 + Shirai 2001	9.64	9.64:-1	12%	RUE	Fig. 2.34
	Revi Shirai 2001	11.000000	12.0 : 1000.0	15%	E	Fig. 2.34
$CO_2 + e \rightarrow CO_2(vib2)$	Revi Itikawa 2002	0.16700000	0.16700000:-1	30%		Fig. 2.23
	???? ? BDD	0.167	0.167:-1	???%	U	Fig. 2.23
	Adap Itikawa 2002+BDD+extrapolation	0.167	0.167:-1	???%	RUE	Fig. 2.23
$CO_2 + e \rightarrow O(^5S)$	Meas Ajello 1971	25	25:-1	30%		Fig. 2.18
$CO_2 + e \rightarrow O(^3S)$	Meas Ajello 1971	20	20:-1	30%		Fig. 2.35
$CO_2 + e \rightarrow CO_2(9.3)$	???? ? BDD	9.30	9.30:-1	???%	U	Fig. 2.13

Table 2.7: Excitation Cross section for e impact on CO_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$CO_2 + e \rightarrow CO_2^+(A)$	Revi Shirai 2001	17.300000	20.0 : 2000.0	25%	RE	Fig. 2.36
	Revi Itikawa 2002	17.30000	17.30000:-1	25%		Fig. 2.36
	???? ? BDD	17.32	17.32:-1	25%		Fig. 2.36
$CO_2 + e \rightarrow CO_2^+(B)$	Revi Shirai 2001	18.100000	20.0 : 2000.0	25%	RE	Fig. 2.12
	Revi Itikawa 2002	18.80000	18.80000:-1	25%		Fig. 2.12
	???? ? BDD	18.8	18.8:-1	25%		Fig. 2.12

Table 2.8: Emission Cross section for e impact on CO_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$CO_2 + e \to C^+$	Adap Straub 2004 + Shirai 2001	27.8	27.8:-1	5%	RUE	Fig. 2.37
$CO_2 + e \to CO_2^+(A)$	Revi Shirai 2001	17.32	20.0 : 2000.0	25%	RE	Fig. 2.37
$CO_2 + e \to CO(a^3\Pi)$	Adap Gronoff 2012	11.46	11.46:-1	25%	RU	Fig. 2.37
$CO_2 + e \to O^+$	Adap Straub 2004 + Shirai 2001	19.1	19.1:-1	5%	RUE	Fig. 2.37
$CO_2 + e \to CO_2^{++}(Auger)$	Adap Fremont 2006 + Shirai 2001+Straub 2004	539	539:-1	50%	RUE	Fig. 2.37
$CO_2 + e \to CO_2^+$	Adap Straub 2004 + Shirai 2001	13.770	13.770:-1	5%	RUE	Fig. 2.37
$CO_2 + e \to O(^1S)$	Adap Leclair 1994 + Shirai 2001	9.64	9.64:-1	12%	RUE	Fig. 2.37
$CO_2 + e \to CO_2(8.60)$	???? ? BDD	9.30	9.30:-1	???%	U	Fig. 2.37
$CO_2 + e \to CO(A^1\Pi)$	Adap Ajello 1971+Simon2008	13.48	13.48:-1	50%	RU	Fig. 2.37
$CO_2 + e \to O^{++}$	Adap Straub 2004 + Shirai 2001	54.2	54.2:-1	11%	RUE	Fig. 2.37
$CO_2 + e \to CO_2(vib1)$	???? ? BDD	0.083	0.083:-1	???%	U	Fig. 2.37
$CO_2 + e \to$ Elastic	Adap Itikawa 2002 + Shirai 2001	0	3.5 : 1000.0	18%	RUE	Fig. 2.37
$CO_2 + e \to C^{++}$	Adap Straub 2004 + Shirai 2001	51.2	51.2:-1	11%	RUE	Fig. 2.37
$CO_2 + e \to CO_2(vib3)$	???? ? BDD	0.291	0.291:-1	???%	U	Fig. 2.37
$CO_2 + e \to O(^3S)$	Meas Ajello 1971	20	20:-1	30%		Fig. 2.37
$CO_2 + e \to CO_2(vib2)$	???? ? BDD	0.167	0.167:-1	???%	U	Fig. 2.37
$CO_2 + e \to CO^+$	Adap Straub 2004 + Shirai 2001	19.5	19.5:-1	5%	RUE	Fig. 2.37
$CO_2 + e \to O(^5S)$	Meas Ajello 1971	25	25:-1	30%		Fig. 2.37
$CO_2 + e \to CO_2(9.3)$	???? ? BDD	8.60	8.60:-1	???%	U	Fig. 2.37
$CO_2 + e \to CO_2^{++}$	Adap Straub 2004 + Shirai 2001	37.4	37.4:-1	6%	RUE	Fig. 2.37
$CO_2 + e \to CO_2^+(B)$	Revi Shirai 2001	18.8	20.0 : 2000.0	25%	RE	Fig. 2.37

Table 2.9: Recommended Cross section for e impact on CO_2

the data (e.g. errorbars, comparison with other experiments), the possibility of extrapolation, and the origin of the work, coupled with the consistency (sum of recommended cross sections Total cross section)

U : Estimated uncertainty: sometimes, the uncertainty is not given, because of theoretical work... The authors of the database have to estimate the uncertainty, but the quality of that estimation can be questionable. Moreover, when data from different sources have been adapted (e.g. for extrapolation), the uncertainty can be modified...

E : Validated for extrapolation: the extrapolation of these cross sections is plausible. For example, when an analytic function has been applied...

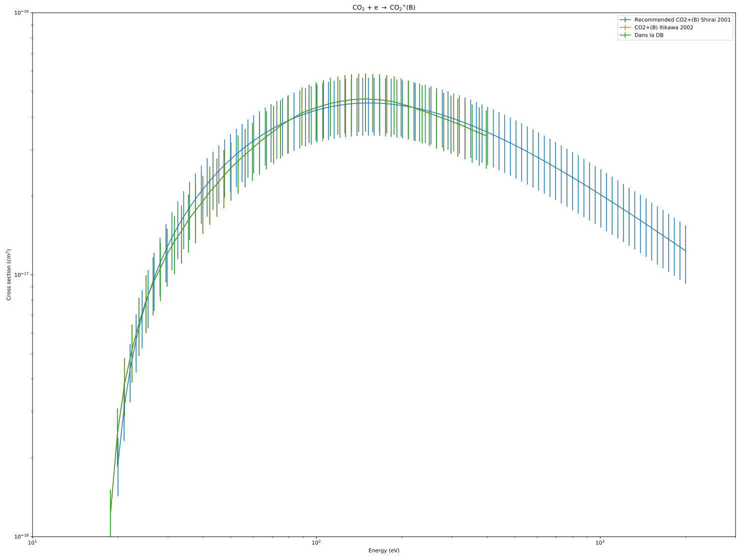

Figure 2.12: Cross sections for CO_2 + e → CO_2^+(B)

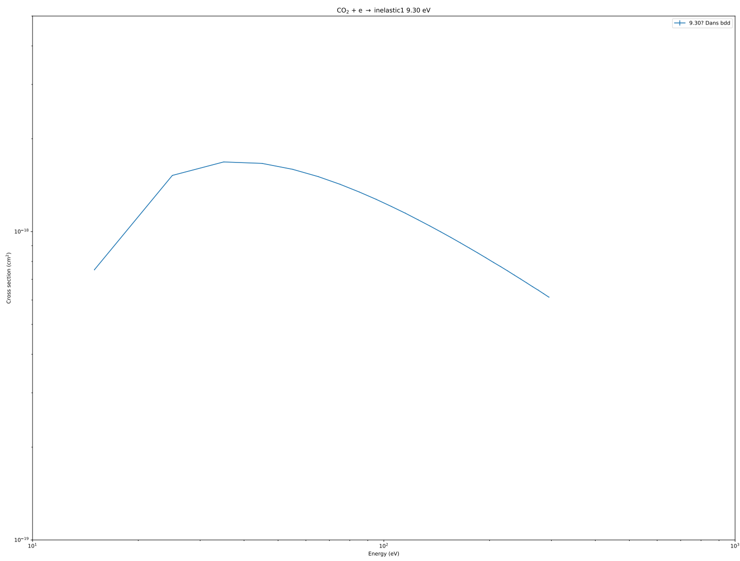

Figure 2.13: Cross sections for CO_2 + e → inelastic1 9.30 eV

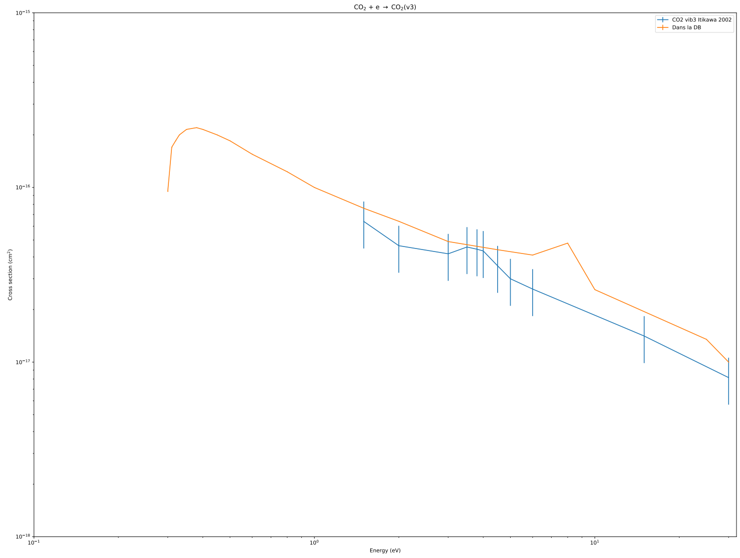

Figure 2.14: Cross sections for CO_2 + e → CO_2(v3)

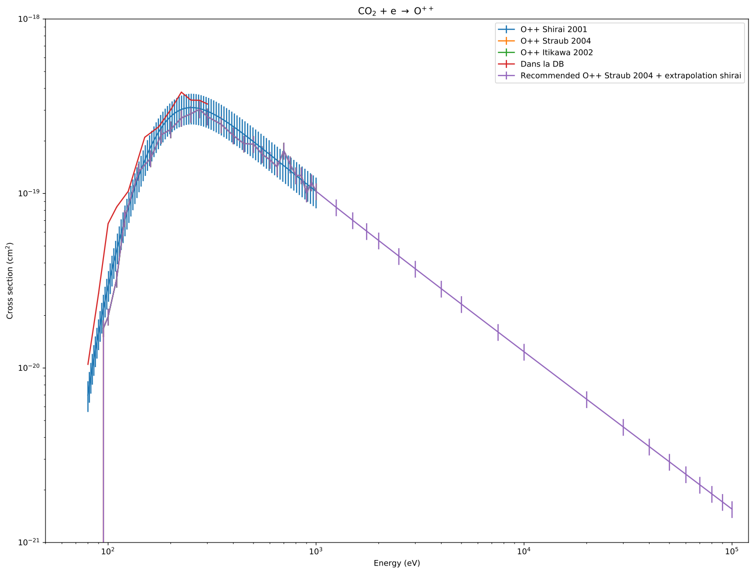

Figure 2.15: Cross sections for CO_2 + e → O^{++}

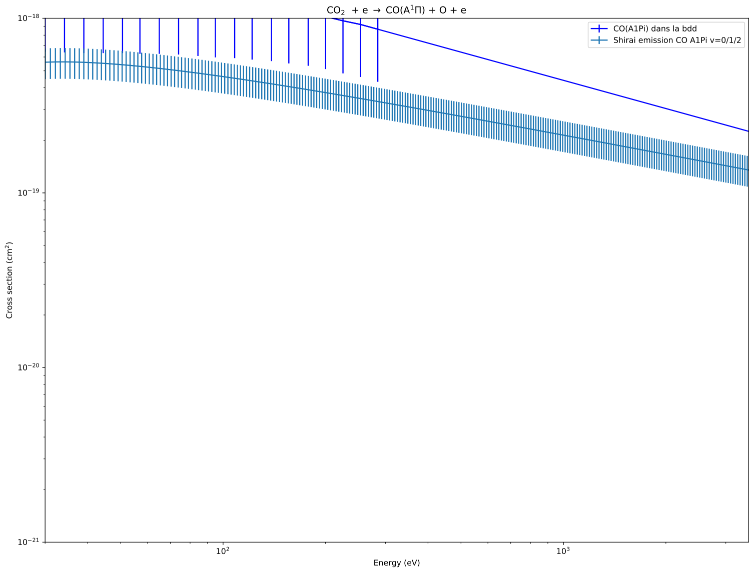

Figure 2.16: Cross sections for CO_2 + e → CO($A^1\Pi$) + O + e

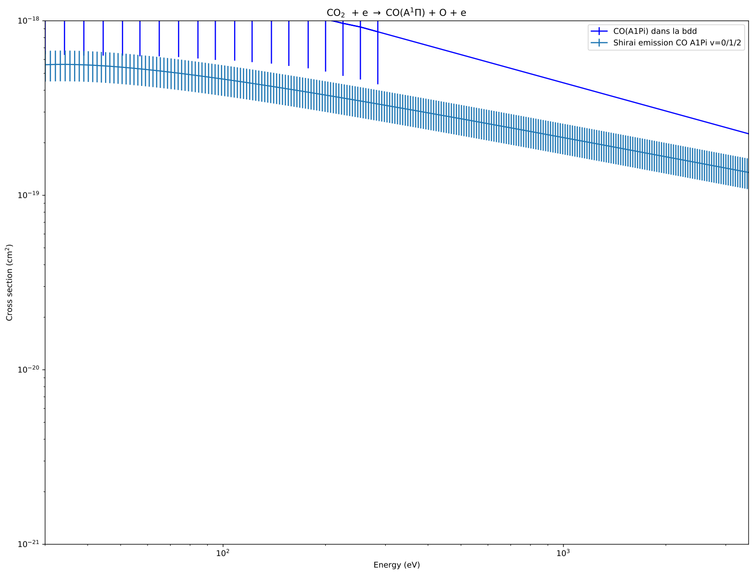

Figure 2.17: Cross sections for CO_2 + e → CO($A^1\Pi$) + O + e (wavelength with extrapolation version)

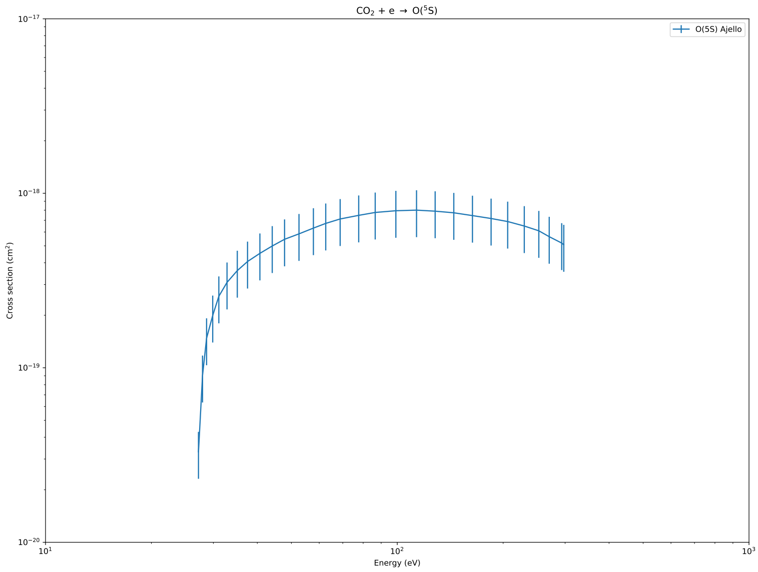

Figure 2.18: Cross sections for CO_2 + e → O(^{5}S)

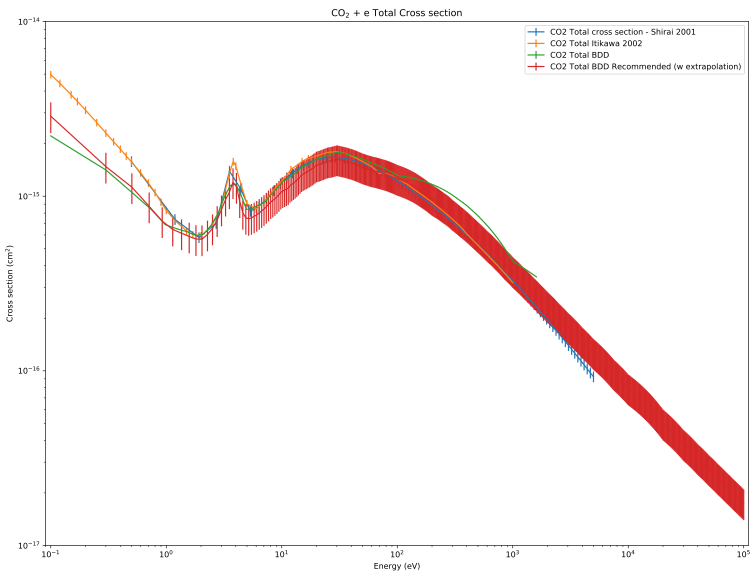

Figure 2.19: Cross sections for CO_2 + e Total Cross section

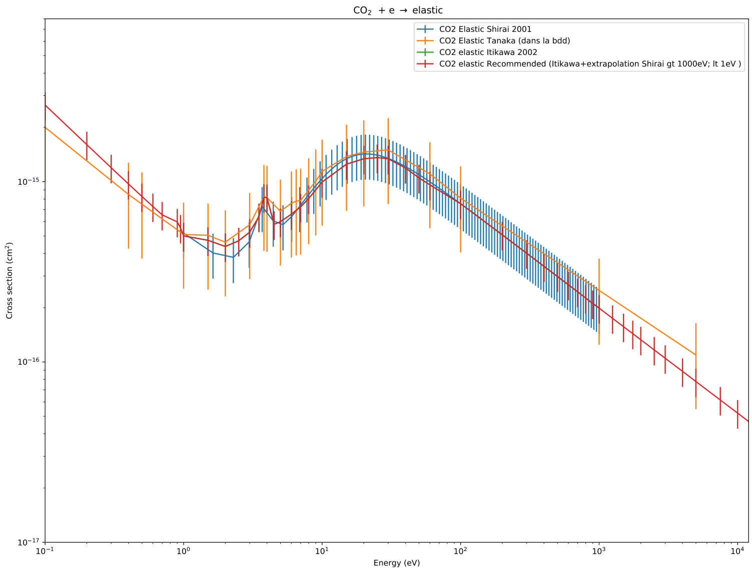

Figure 2.20: Cross sections for CO_2 + e → elastic

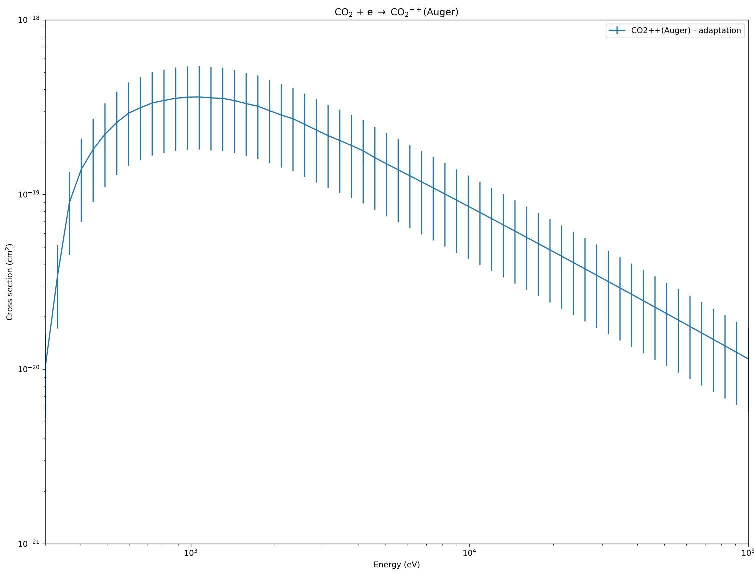

Figure 2.21: Cross sections for CO_2 + e → CO_2^{++}(Auger)

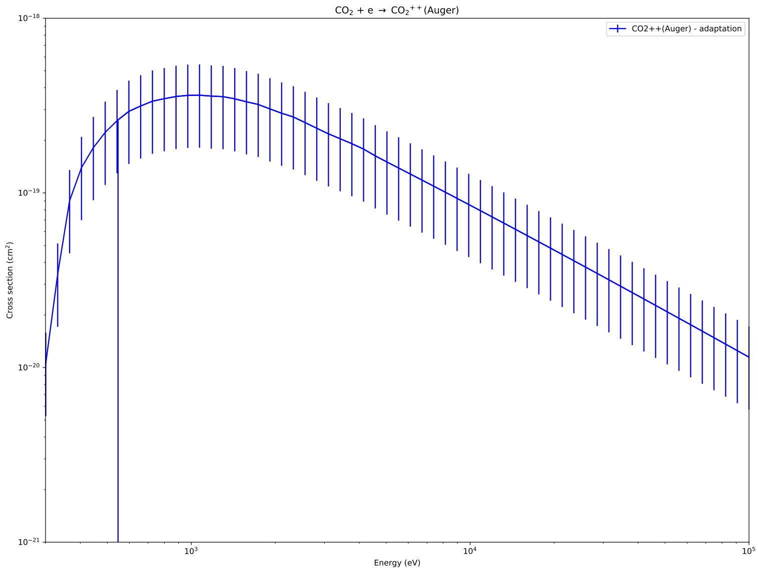

Figure 2.22: Cross sections for CO_2 + e → ${CO_2}^{++}$(Auger) (wavelength with extrapolation version)

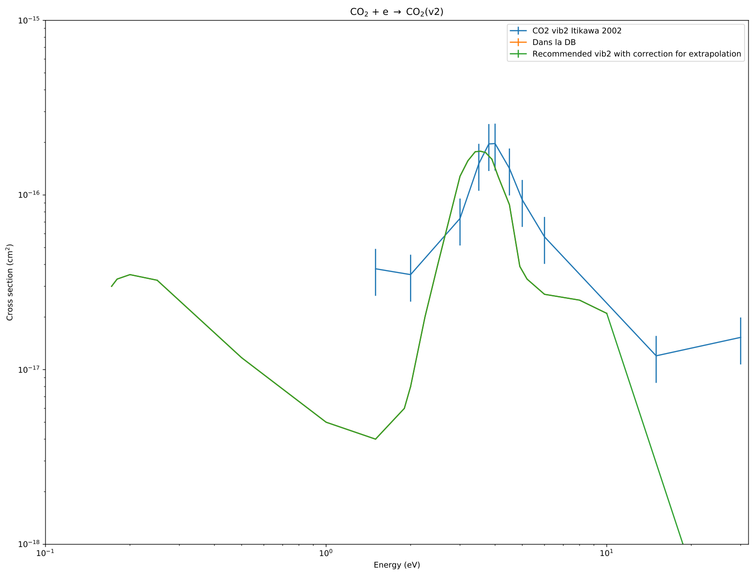

Figure 2.23: Cross sections for CO_2 + e → CO_2(v2)

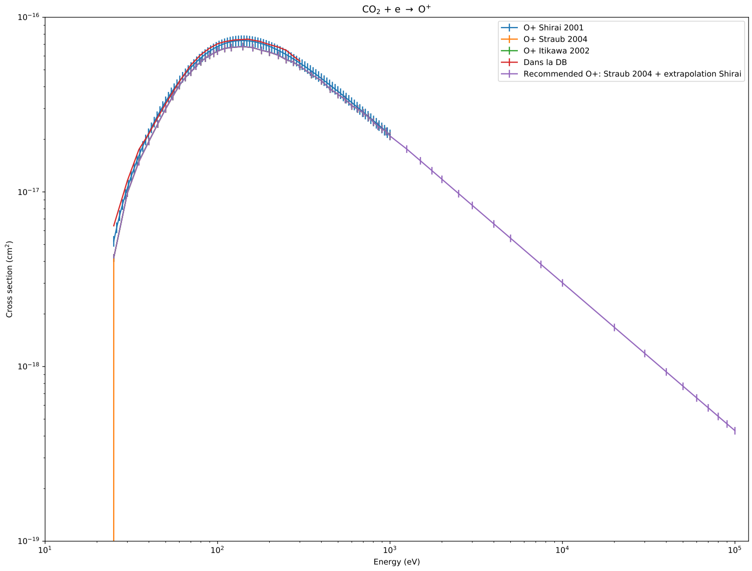

Figure 2.24: Cross sections for CO_2 + e → O^+

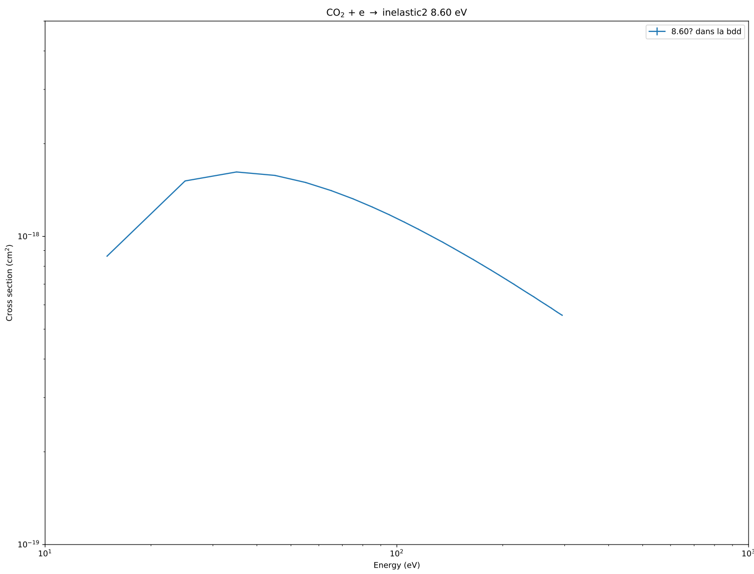

Figure 2.25: Cross sections for CO_2 + e → inelastic2 8.60 eV

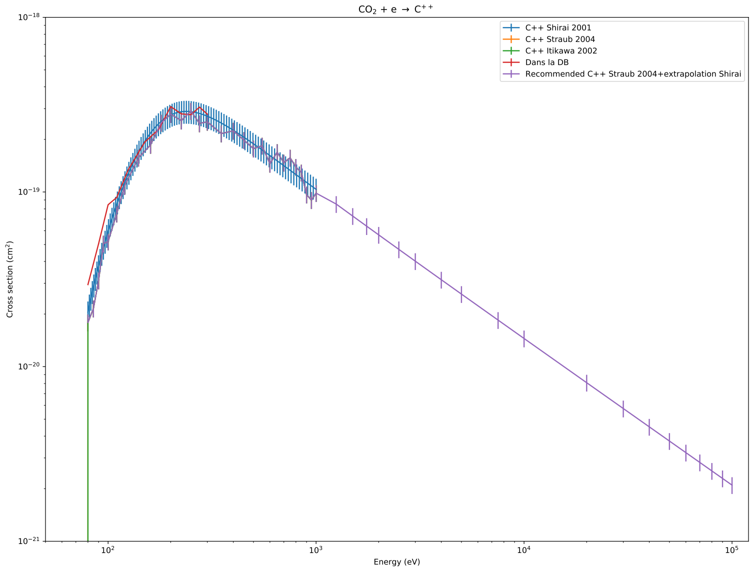

Figure 2.26: Cross sections for $CO_2 + e \rightarrow C^{++}$

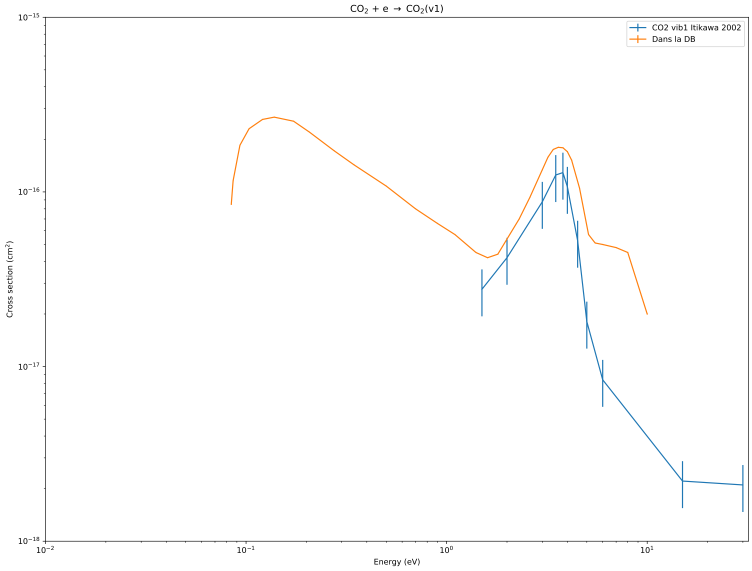

Figure 2.27: Cross sections for $CO_2 + e \rightarrow CO_2(v1)$

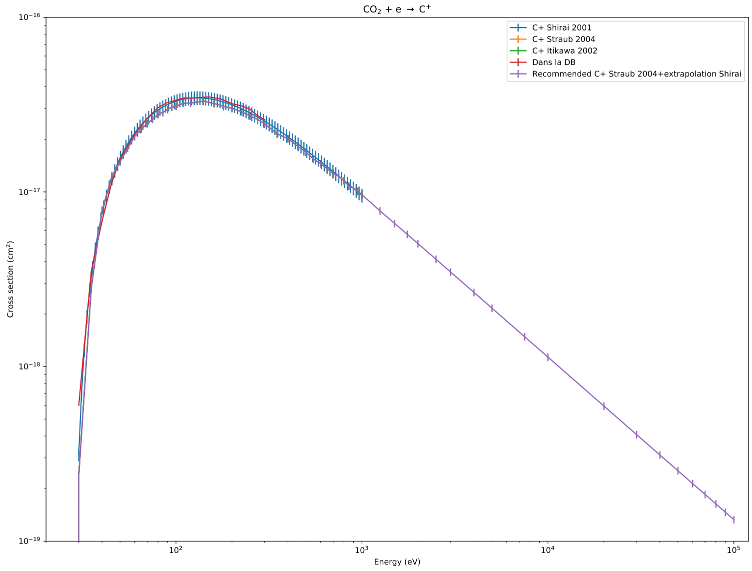

Figure 2.28: Cross sections for CO_2 + e $\rightarrow$ C^+

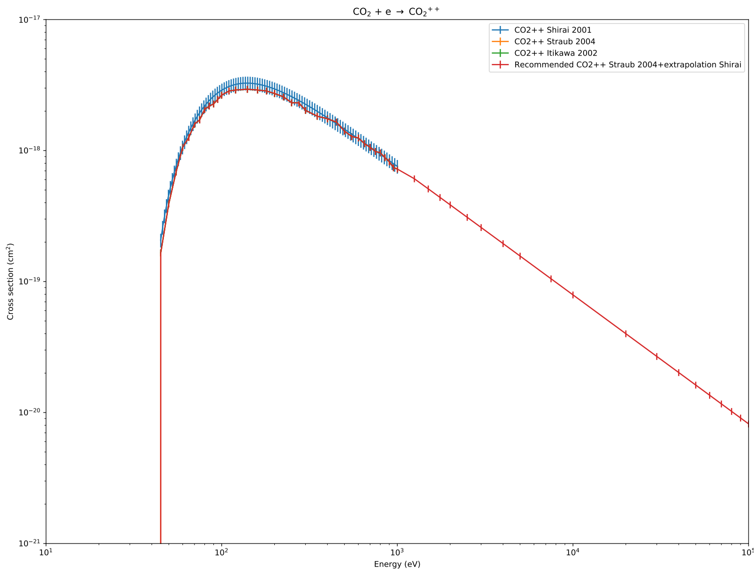

Figure 2.29: Cross sections for CO_2 + e $\rightarrow$ CO_2^{++}

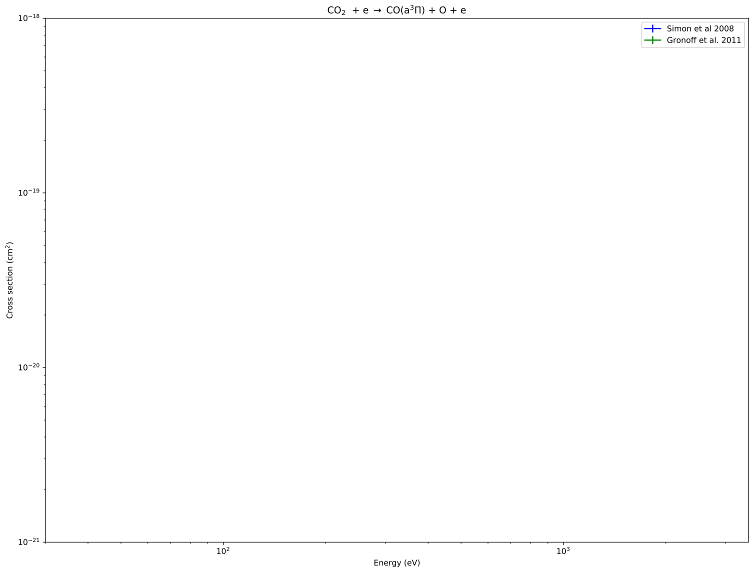

Figure 2.30: Cross sections for CO_2 + e → CO($a^3\Pi$) + O + e

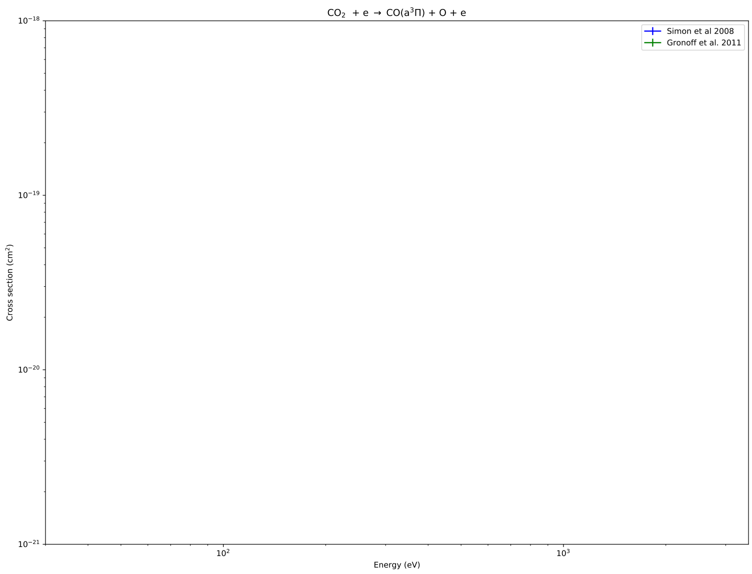

Figure 2.31: Cross sections for CO_2 + e → CO($a^3\Pi$) + O + e (wavelength with extrapolation version)

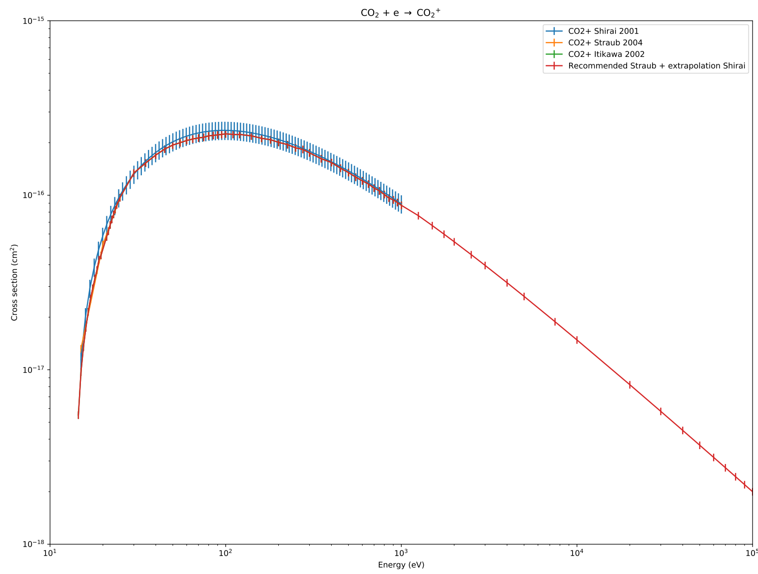

Figure 2.32: Cross sections for CO_2 + e → $CO_2{}^+$

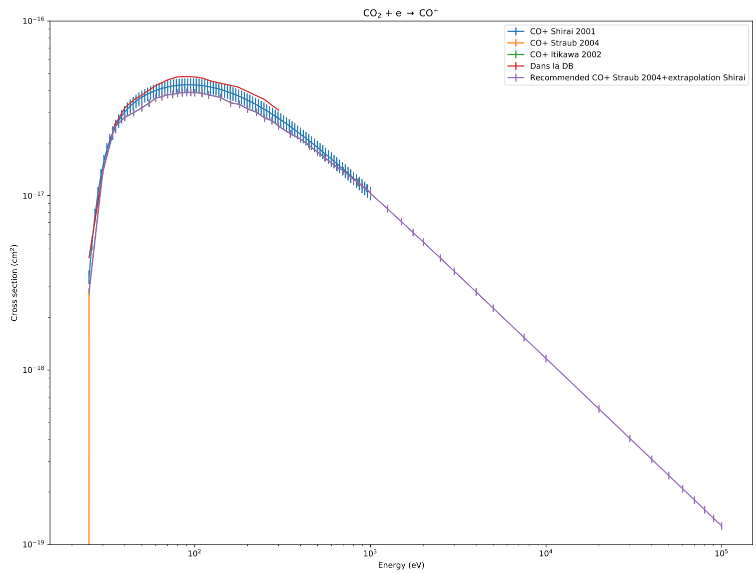

Figure 2.33: Cross sections for CO_2 + e → CO^+

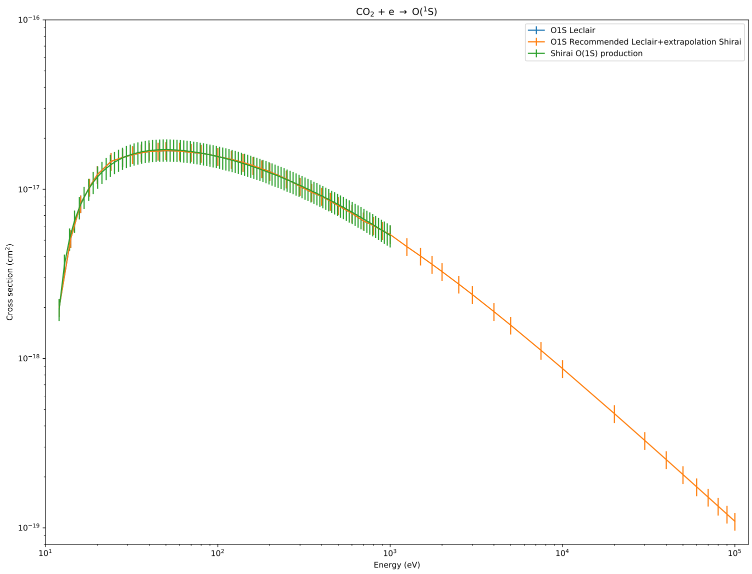

Figure 2.34: Cross sections for CO_2 + e → O(^{1}S)

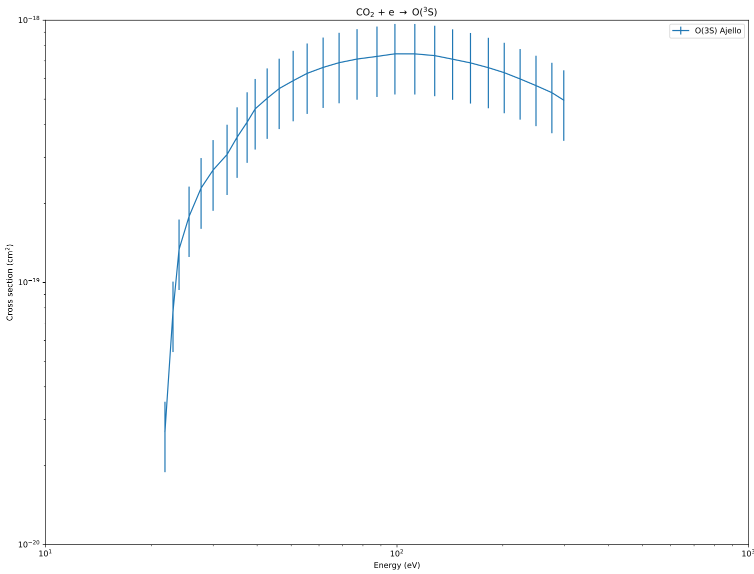

Figure 2.35: Cross sections for CO_2 + e → O(^{3}S)

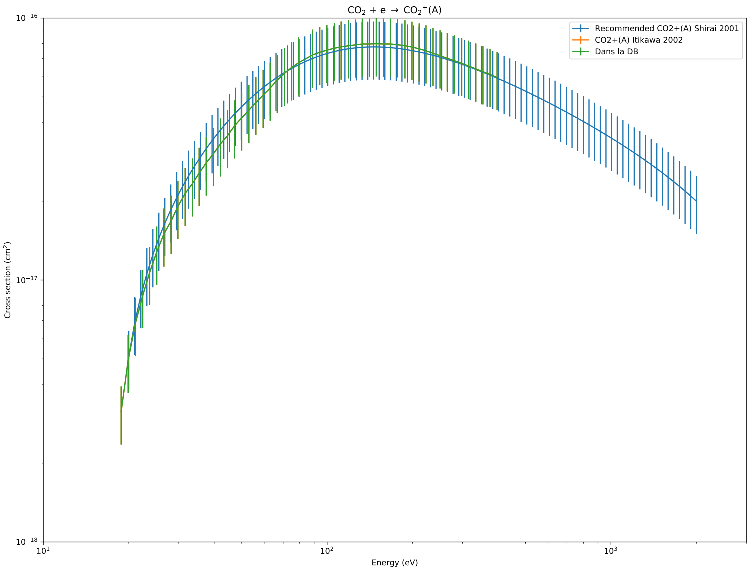

Figure 2.36: Cross sections for CO_2 + e → ${CO_2}^+$(A)

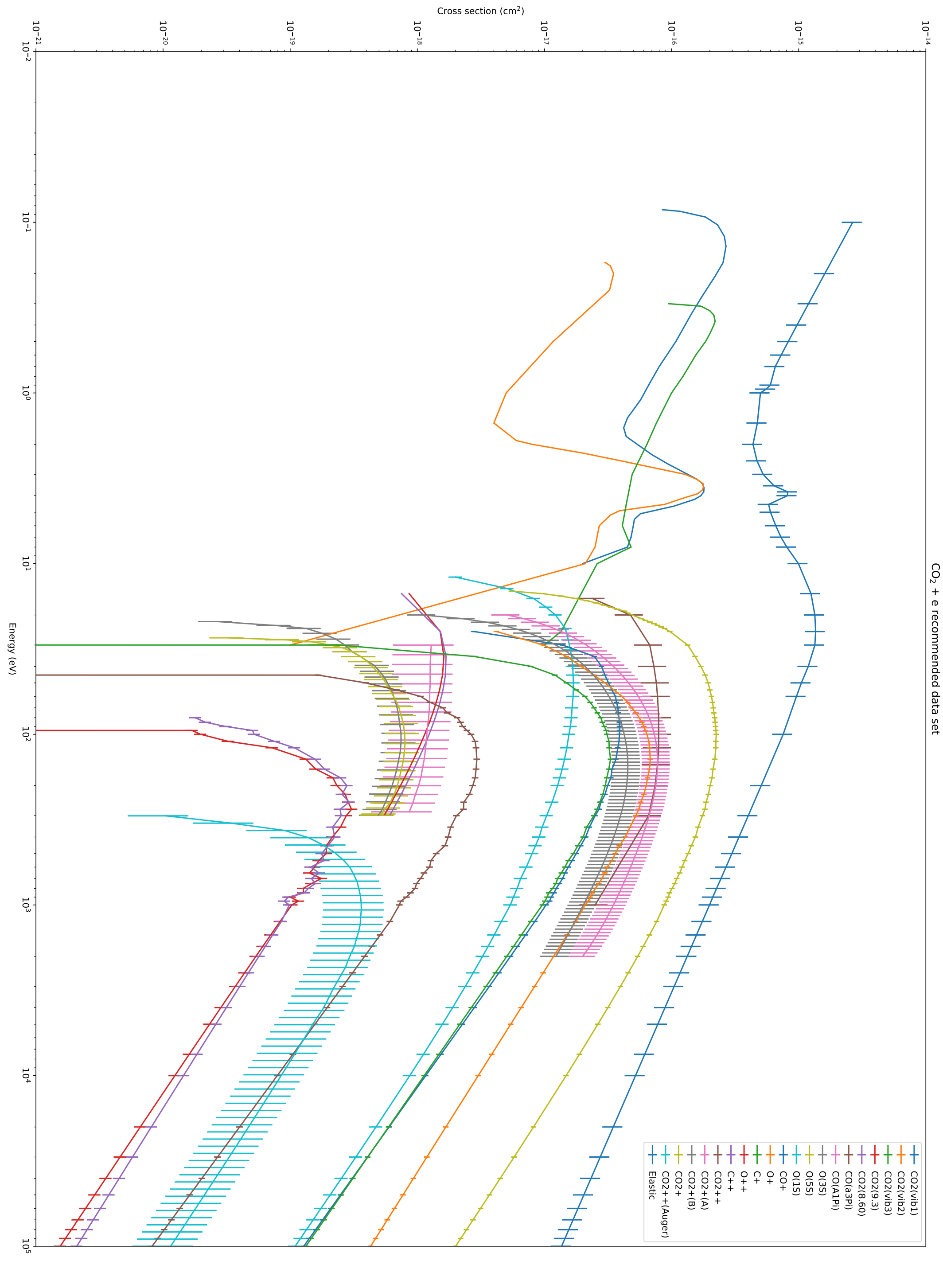

Figure 2.37: Cross sections for CO_2 + e recommended data set

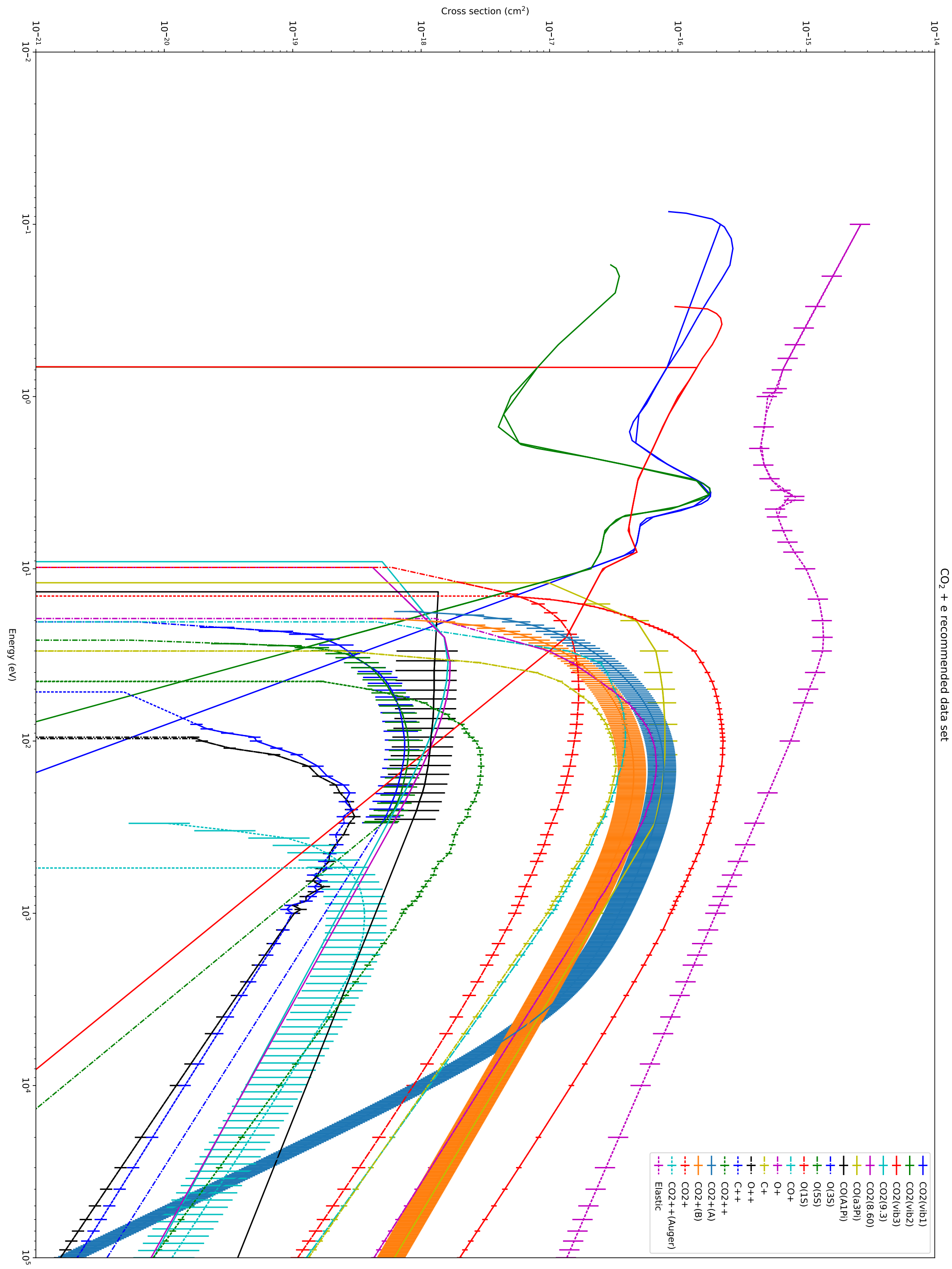

Figure 2.38: Cross sections for CO_2 + e recommended data set (wavelength with extrapolation version)

2.3 Cross section of e impact with CO

2.3.1 Elastic Cross Section

2.3.2 Inelastic Cross Sections

Ionization Cross Sections

CO + e → C+

CO + e → CO++

CO + e → C++

CO + e → CO++(Auger)

Notes for CO^{++} K-Shell ionization, Frémont 2006 + Straub2004
The K-Shell ionization of CO by electron impact has not been studied in [?], but we assumed that the K-Shell/single ionization ratio is close to the CH_4 one which is used here. The total cross section has been computed by multiplying this ratio by the recommended ionization cross section, coming from [?].

Notes for CO^{++} K-Shell ionization, Frémont 2006 + Shirai2002
The K-Shell ionization of CO by electron impact has not been studied in [?], but we assumed that the K-Shell/single ionization ratio is close to the CH_4 one which is used here. The total cross section has been computed by multiplying this ratio by the ionization cross section, coming from [4].

Reference	Threshold	Range of energy	Uncertainty	Properties	Fig
Revi Kanik 1993	0	0:-1	15%	RU	Fig. 2.40
Revi Shirai 2002	0	1.0 : 1000.0	15%	E	Fig. 2.40

Table 2.10: Elastic cross section for e impact on CO

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$CO + e \rightarrow C^{+}$	Revi Shirai 2002	22.400000	25.0 : 600.0	12%	E	Fig. 2.44
	Meas Straub 2004	22.400000	15.0 : 1000.0	6%	RE	Fig. 2.44
$CO + e \rightarrow CO^{++}$	Meas Straub 2004	41.8	15.0 : 1000.0	30%		Fig. 2.45
	Revi Shirai 2001	41.8	50.0 : 600.0	20%	E	Fig. 2.45
	Adap Straub 2004 + Shirai 2001	41.8	41.8:-1	30%	RUE	Fig. 2.45
$CO + e \rightarrow C^{++}$	Revi Shirai 2002	46.800000	60.0 : 600.0	20%	RE	Fig. 2.43
$CO + e \rightarrow CO^{++}$(Auger)	Adap Fremont 2006 + Straub 2004	410	410:-1	50%	RUE	Fig. 2.41
	Adap Fremont 2006 + Shirai 2002	410	410:-1	50%	UE	Fig. 2.41
$CO + e \rightarrow O^{+}$	Revi Shirai 2002	24.700000	30.0 : 600.0	12%	E	Fig. 2.42
	Meas Straub 2004	24.7	15.0 : 1000.0	6%	RE	Fig. 2.42
$CO + e \rightarrow O^{++}$	Revi Shirai 2002	59.800000	80.0 : 600.0	20%	RE	Fig. 2.39
$CO + e \rightarrow CO^{+}$	Revi Shirai 2002	14.000000	17.5 : 600.0	12%	E	Fig. 2.46
	???? ? Rees?	14.01	14.01:-1	???%	U	Fig. 2.46
	Meas Straub 2004	14.01	14.01:-1	5%	RE	Fig. 2.46

Table 2.11: Ionization Cross section for e impact on CO

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$CO + e \rightarrow O(^3S)$	Meas Ajello 1971	20	20:-1	30%	R	Fig. 2.49
$CO + e \rightarrow CO(a^3\Pi)$	Meas Furlong and Newell 1996	6.14	6.14:-1	5%	RE	Fig. 2.47
$CO + e \rightarrow CO(A^1\Pi)$	Meas Beegle et al 99	7.	7.:-1	25%	R	Fig. 2.48

Table 2.12: Excitation Cross section for e impact on CO

CO + e → O+

CO + e → O++

CO + e → CO+

Excitation Cross Sections

CO + e → O(3S)

CO + e → CO(a3Pi)

CO + e → CO(A1Pi)

2.3.3 Recommended data set

CO + e → C+

CO + e → CO++

CO + e → CO(a3Pi)

CO + e → CO++(Auger)

CO + e → Elastic

CO + e → CO(rot+vib)

CO + e → O+

CO + e → CO(A1Pi)

CO + e → C++

CO + e → CO(exc)

CO + e → O(1S)

CO + e → O(3S)

CO + e → CO+

CO + e → O++

Legend for the properties

R : Recommended cross section for the processus. It is used in the main file. The selection of the recommended cross section is based on the quality of the data (e.g. errorbars, comparison with other experiments), the possibility of extrapolation, and the origin of the work, coupled with the consistency (sum of recommended cross sections   Total cross section)

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$CO + e \rightarrow C^+$	Meas Straub 2004	22.400000	15.0 : 1000.0	6%	RE	Fig. 2.50 2.51
$CO + e \rightarrow CO^{++}$	Adap Straub 2004 + Shirai 2001	41.8	41.8:-1	30%	RUE	Fig. 2.50 2.51
$CO + e \rightarrow CO(a^3\Pi)$	Meas Furlong and Newell 1996	6.14	6.14:-1	5%	RE	Fig. 2.50 2.51
$CO + e \rightarrow CO^{++}$(Auger)	Adap Fremont 2006 + Straub 2004	410	410:-1	50%	RUE	Fig. 2.50 2.51
$CO + e \rightarrow$ Elastic	Revi Kanik 1993	0	0:-1	15%	RU	Fig. 2.50 2.51
$CO + e \rightarrow$ CO(rot+vib)	???? ? Rees?	0.64	0.64:-1	???%	U	Fig. 2.50 2.51
$CO + e \rightarrow O^+$	Meas Straub 2004	24.7	15.0 : 1000.0	6%	RE	Fig. 2.50 2.51
$CO + e \rightarrow CO(A^1\Pi)$	Meas Beegle et al 99	7.	7.:-1	25%	R	Fig. 2.50 2.51
$CO + e \rightarrow C^{++}$	Revi Shirai 2002	46.800000	60.0 : 600.0	20%	RE	Fig. 2.50 2.51
$CO + e \rightarrow$ CO(exc)	???? ? Rees?	6.	6.:-1	???%	U	Fig. 2.50 2.51
$CO + e \rightarrow O(^1S)$	Revi Shirai 2002	15.300000	18.0 : 500.0	36%	RE	Fig. 2.50 2.51
$CO + e \rightarrow O(^3S)$	Meas Ajello 1971	20	20:-1	30%	R	Fig. 2.50 2.51
$CO + e \rightarrow CO^+$	Meas Straub 2004	14.01	15.0 : 1000.0	5%	RE	Fig. 2.50 2.51
$CO + e \rightarrow O^{++}$	Revi Shirai 2002	59.800000	80.0 : 600.0	20%	RE	Fig. 2.50 2.51

Table 2.13: Recommended Cross section for e impact on CO

U : Estimated uncertainty: sometimes, the uncertainty is not given, because of theoretical work... The authors of the database have to estimate the uncertainty, but the quality of that estimation can be questionable. Moreover, when data from different sources have been adapted (e.g. for extrapolation), the uncertainty can be modified...

E : Validated for extrapolation: the extrapolation of these cross sections is plausible. For example, when an analytic function has been applied...

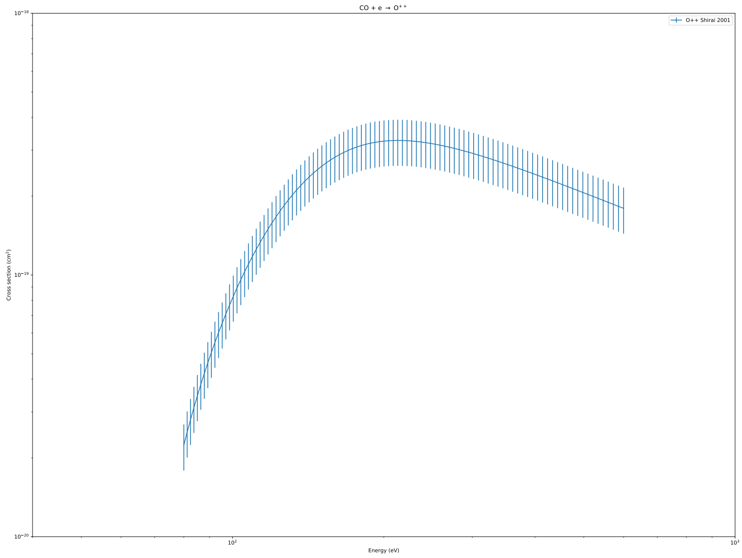

Figure 2.39: Cross sections for CO + e $\rightarrow$ O^{++}

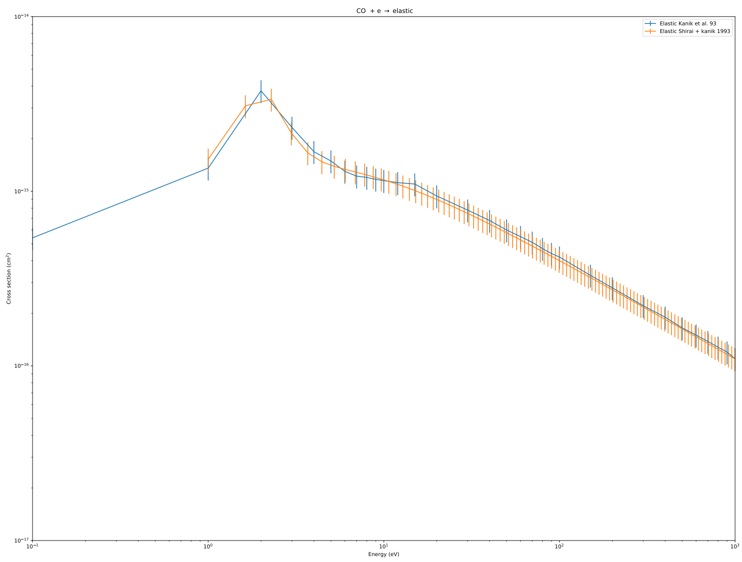

Figure 2.40: Cross sections for CO + e $\rightarrow$ elastic

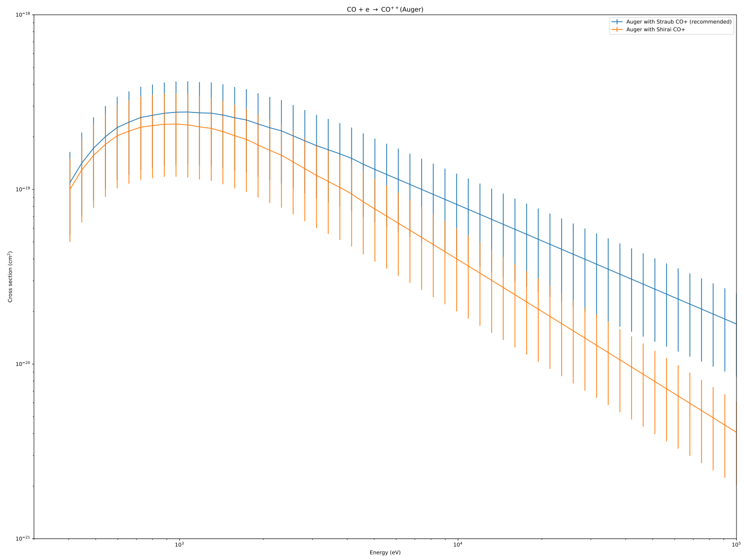

Figure 2.41: Cross sections for CO + e $\rightarrow$ CO^{++}(Auger)

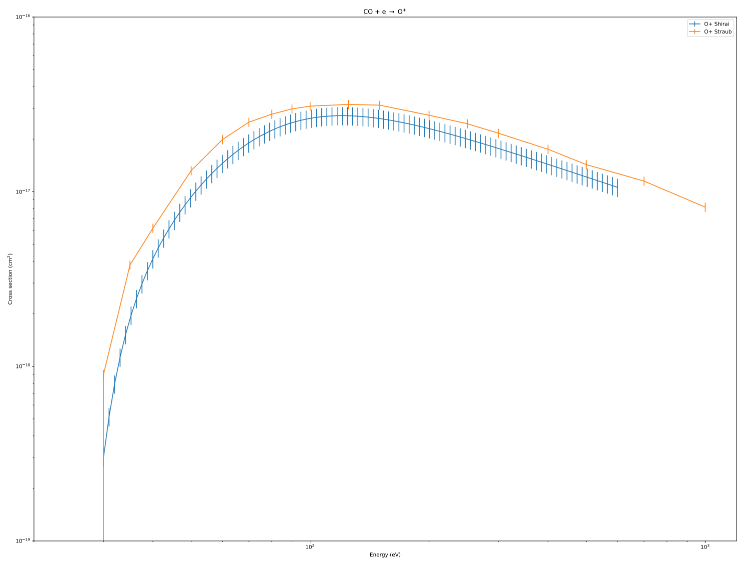

Figure 2.42: Cross sections for CO + e $\rightarrow$ O^{+}

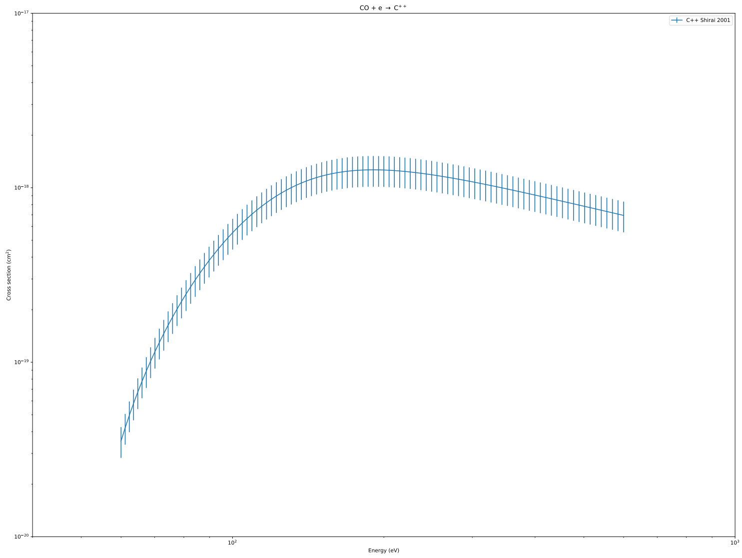

Figure 2.43: Cross sections for CO + e $\rightarrow$ C^{++}

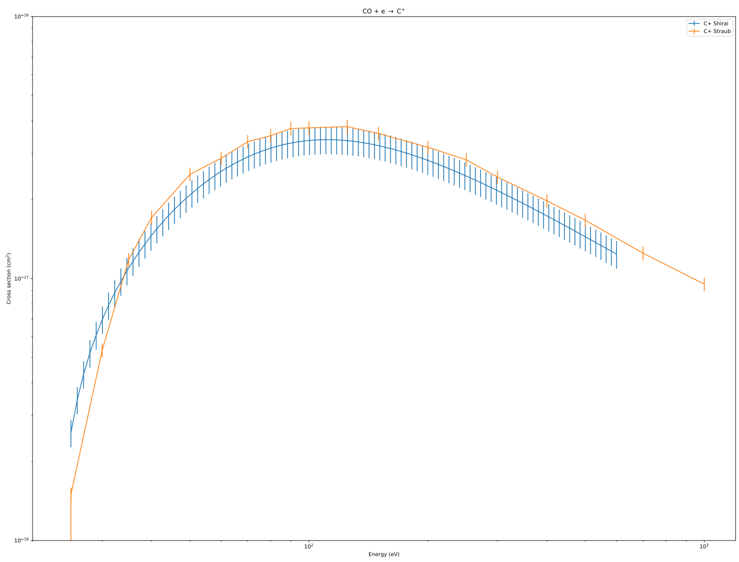

Figure 2.44: Cross sections for CO + e $\rightarrow$ C^{+}

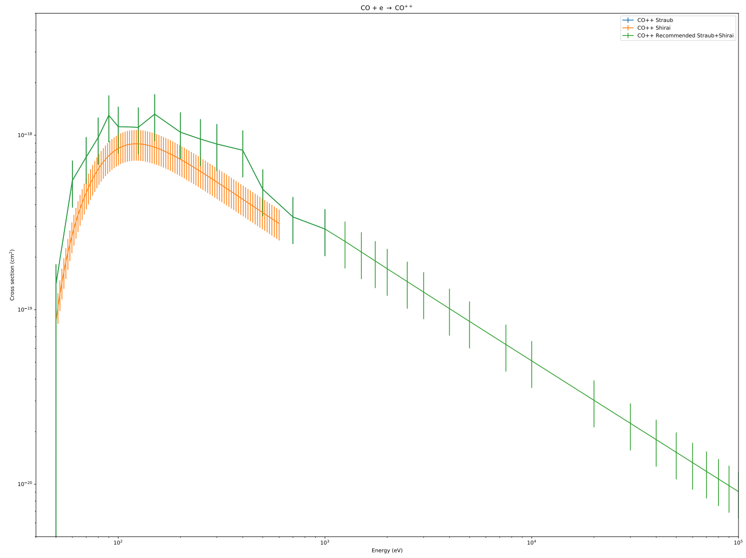

Figure 2.45: Cross sections for CO + e $\rightarrow$ CO^{++}

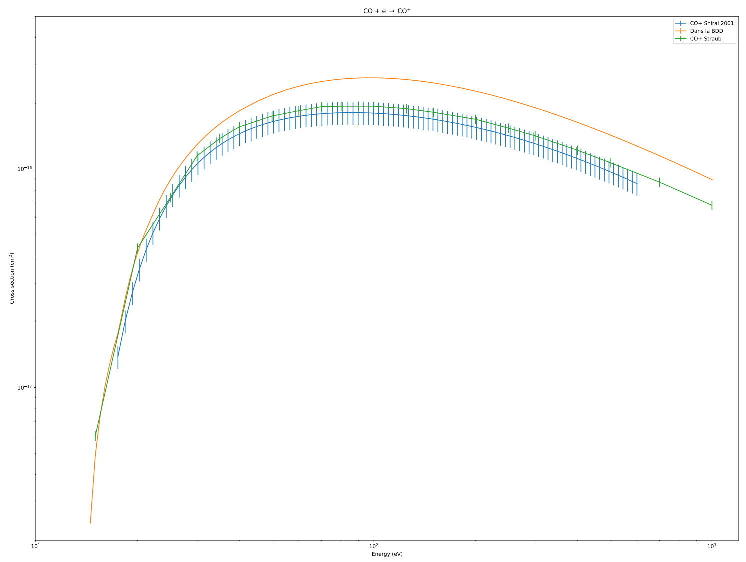

Figure 2.46: Cross sections for CO + e $\rightarrow$ CO^{+}

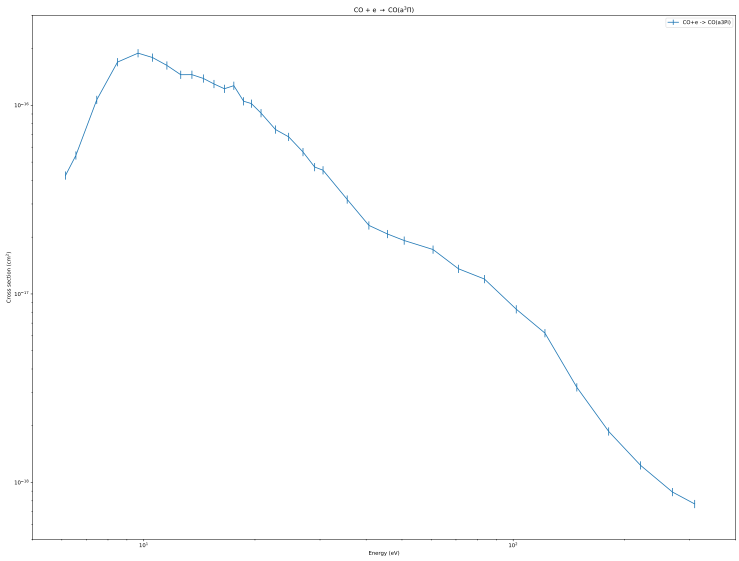

Figure 2.47: Cross sections for CO + e $\rightarrow$ CO(a$^3\Pi$)

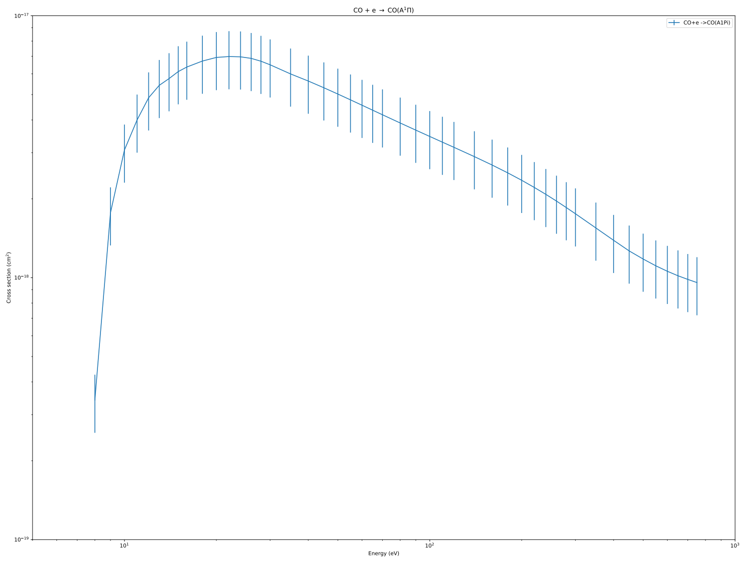

Figure 2.48: Cross sections for CO + e $\rightarrow$ CO(A$^1\Pi$)

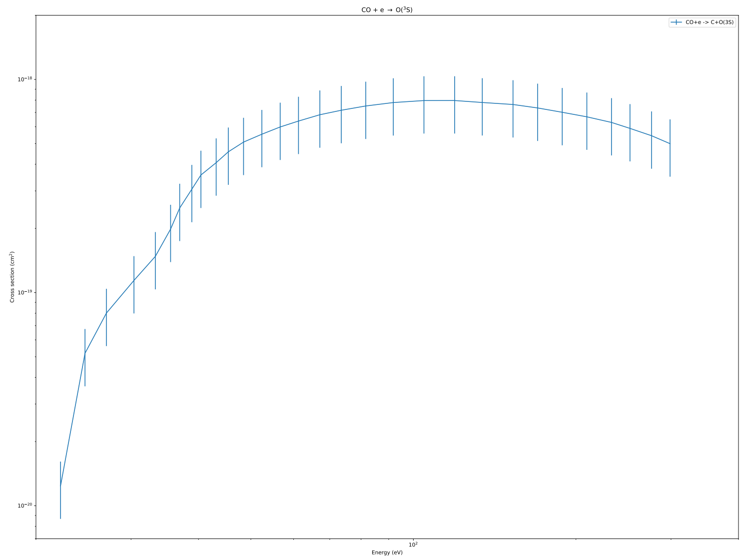

Figure 2.49: Cross sections for CO + e $\rightarrow$ O(^{3}S)

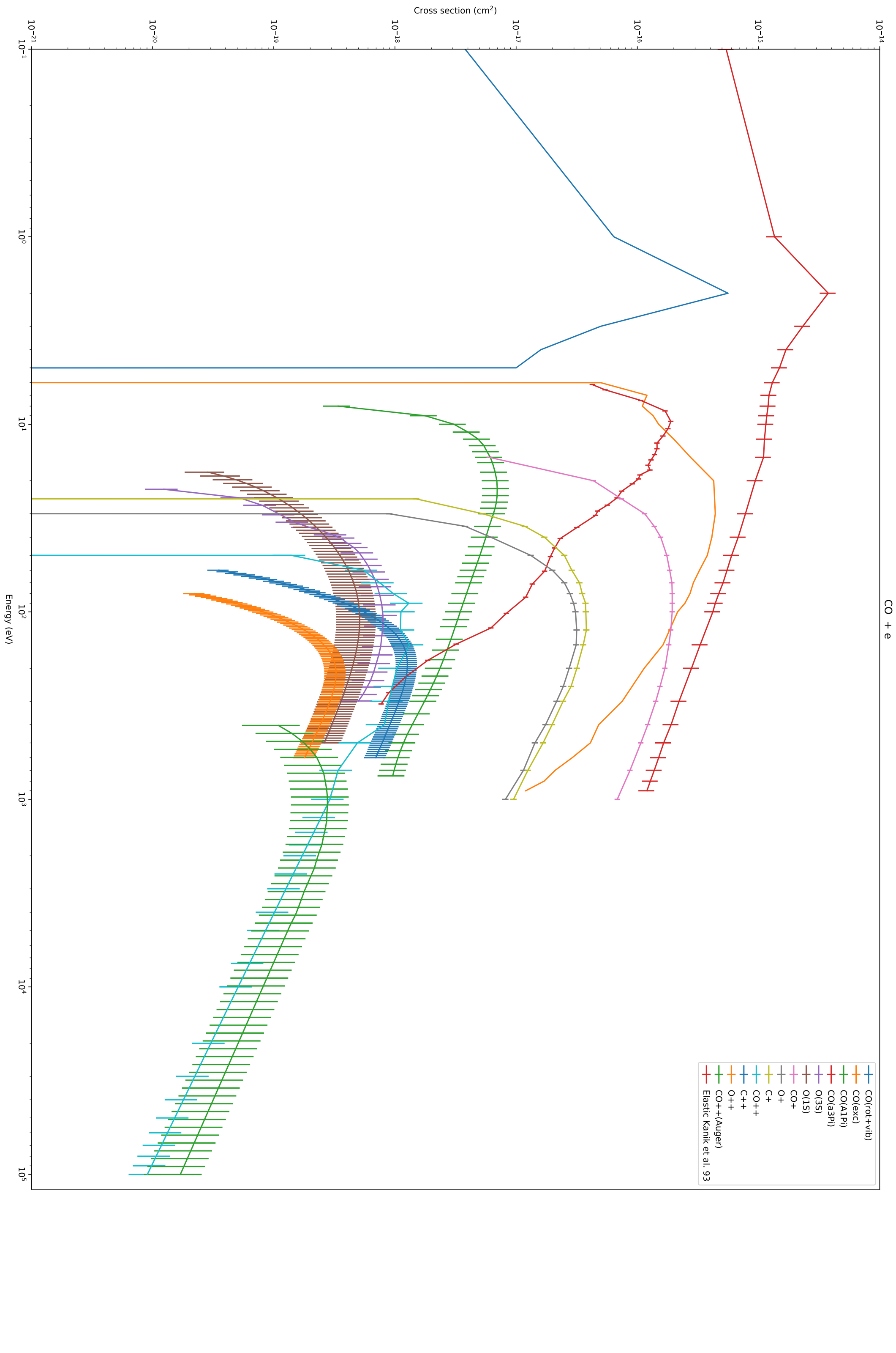

Figure 2.50: Cross sections for CO + e

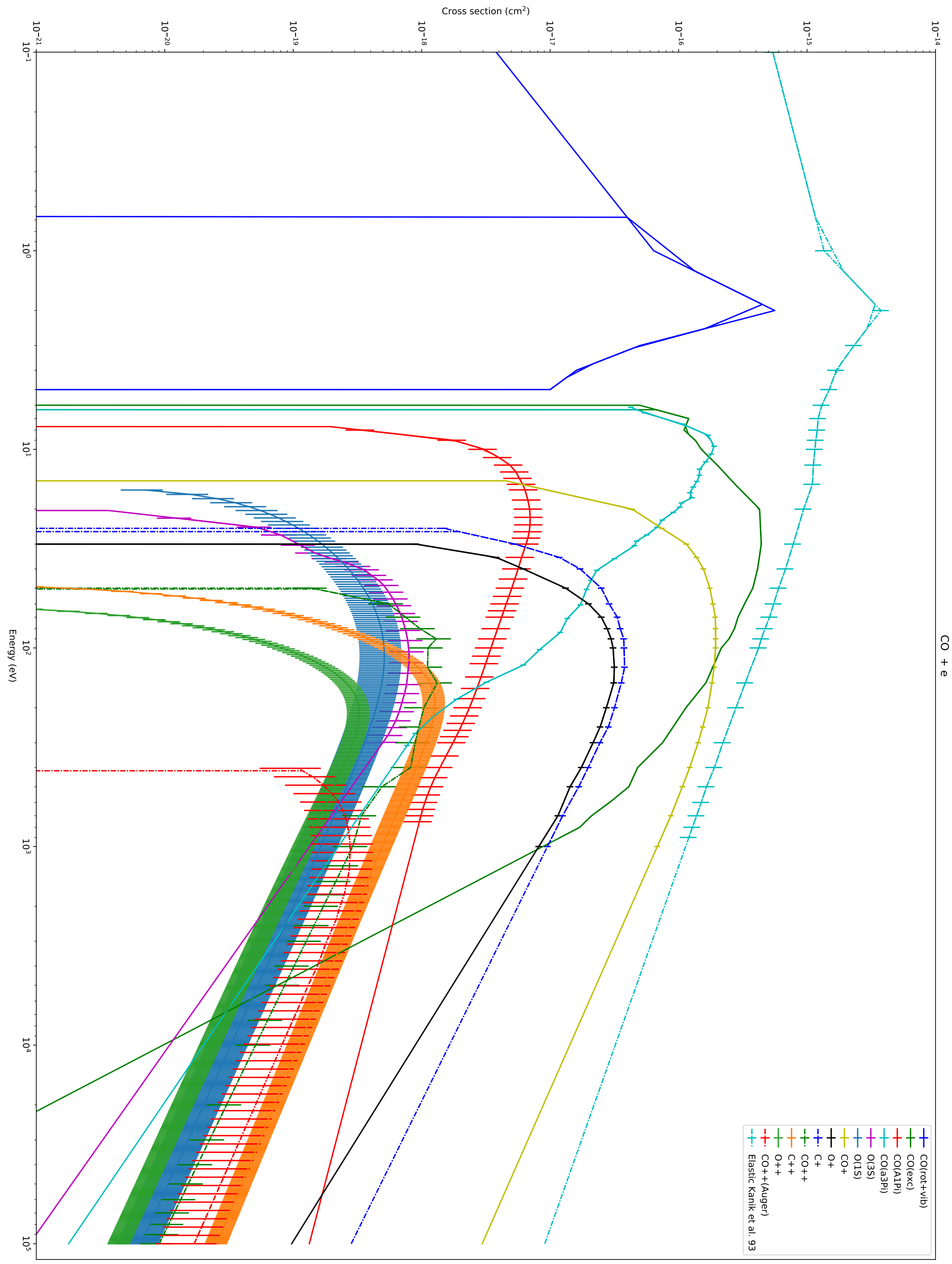

Figure 2.51: Cross sections for CO + e (wavelength with extrapolation version)

2.4 Cross section of e impact with H_2O

2.4.1 Inelastic Cross Sections

2.4.2 Recommended data set

H_2O + e → Elastic

H_2O + e → H2(vib 100 001)

H_2O + e → H2O(rot0-0)

H_2O + e → H2O(rot0-1)

H_2O + e → H2O(rot0-3)

H_2O + e → H2+

H_2O + e → H2O(rot0-2)

H_2O + e → H2O(vib 010)

Legend for the properties

R : Recommended cross section for the processus. It is used in the main file. The selection of the recommended cross section is based on the quality of the data (e.g. errorbars, comparison with other experiments), the possibility of extrapolation, and the origin of the work, coupled with the consistency (sum of recommended cross sections Total cross section)

U : Estimated uncertainty: sometimes, the uncertainty is not given, because of theoretical work... The authors of the database have to estimate the uncertainty, but the quality of that estimation can be questionable. Moreover, when data from different sources have been adapted (e.g. for extrapolation), the uncertainty can be modified...

E : Validated for extrapolation: the extrapolation of these cross sections is plausible. For example, when an analytic function has been applied...

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
H_2O + e → Elastic	Revi Itikawa et al. 2005	0	0:-1	30%	RUE	Fig. 2.52 2.53
H_2O + e → H_2(vib 100 001)	Revi Itikawa et al. 2005	0.453	0.453:-1	30%	RE	Fig. 2.52 2.53
H_2O + e → H_2O(rot0-0)	Revi Itikawa et al. 2005	0.01	0.01:-1	30%	RE	Fig. 2.52 2.53
H_2O + e → H_2O(rot0-1)	Revi Itikawa et al. 2005	0.005	0.005:-1	30%	RE	Fig. 2.52 2.53
H_2O + e → H_2O(rot0-3)	Revi Itikawa et al. 2005	0.02	0.02:-1	30%	RE	Fig. 2.52 2.53
H_2O + e → H_2^+	Adap Liu 2004	15.4	15.4:-1	30%	RE	Fig. 2.52 2.53
H_2O + e → H_2O(rot0-2)	Revi Itikawa et al. 2005	0.009	0.009:-1	30%	RE	Fig. 2.52 2.53
H_2O + e → H_2O(vib 010)	Revi Itikawa et al. 2005	0.198	0.198:-1	30%	RE	Fig. 2.52 2.53

Table 2.14: Recommended Cross section for e impact on H_2O

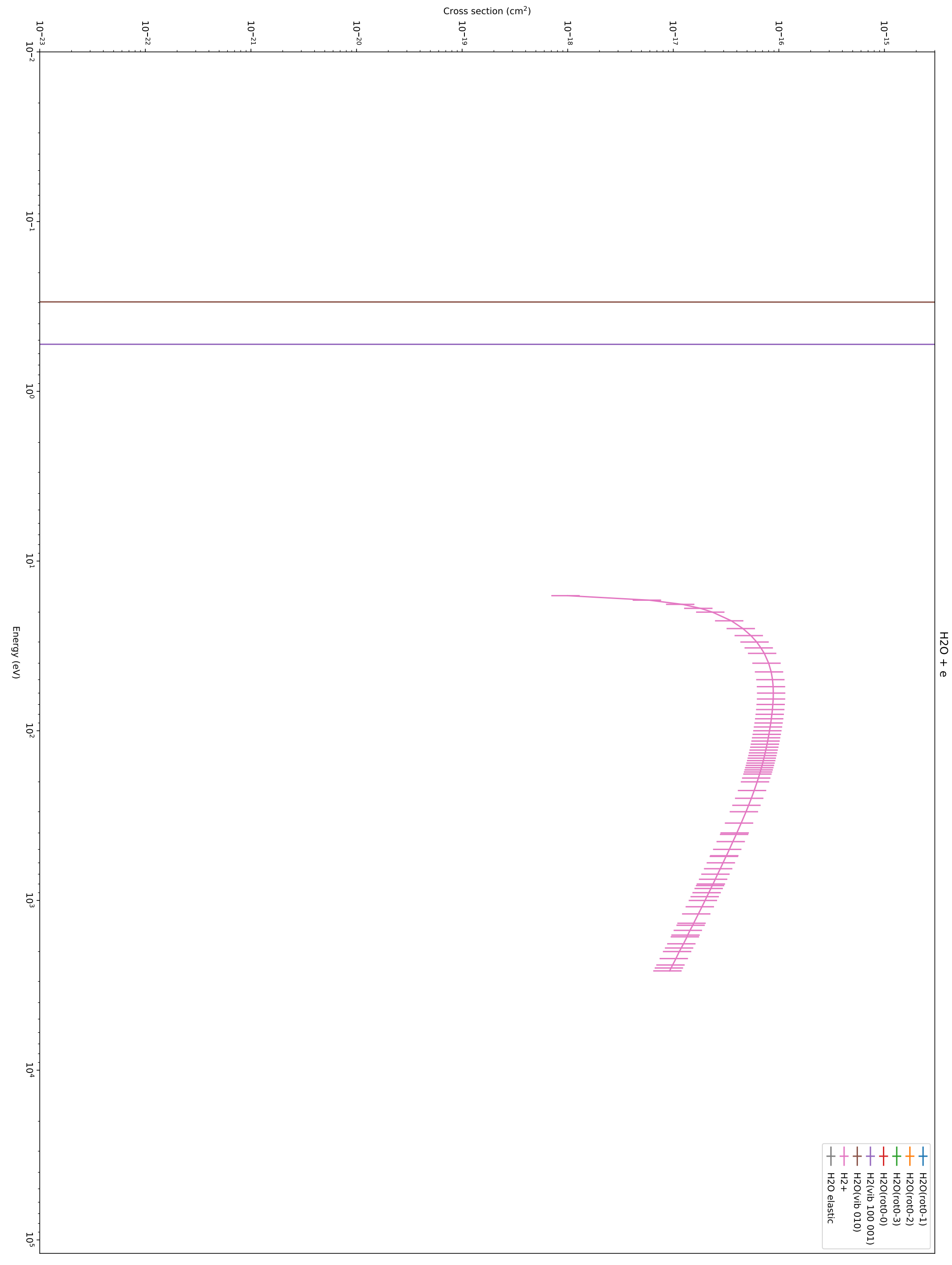

Figure 2.52: Cross sections for H2O + e

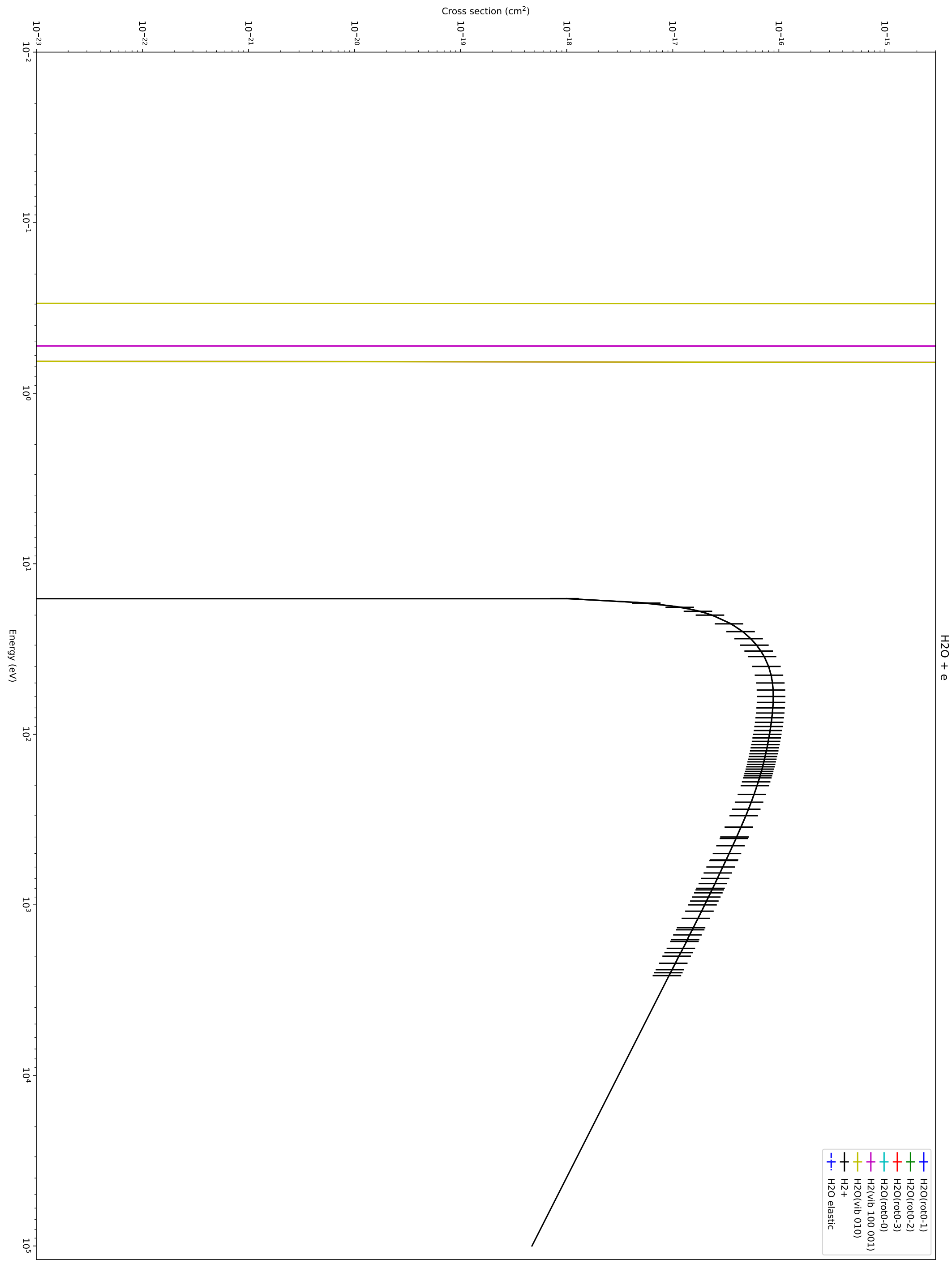

Figure 2.53: Cross sections for H2O + e (wavelength with extrapolation version)

Reference	Threshold	Range of energy	Uncertainty	Properties	Fig
Revi Nockel et al. 92	0	0:-1	30%	RUE	Fig. 2.55

Table 2.15: Elastic cross section for e impact on H_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$H_2 + e \rightarrow H^+$	Revi Yoon 2008	18.1	18.1:-1	7%		Fig. 2.56
	Revi Avakyan 1998	18.1	18.1:-1	15%		Fig. 2.56
$H_2 + e \rightarrow H_2^+$	Revi Yoon 2008	15.426	15.426:-1	7%		Fig. 2.54
	Revi Avakyan 1998	15.426	15.426:-1	15%		Fig. 2.54
	Meas Straub 1997	15.426	15.426:-1	5%		Fig. 2.54
	Revi Phelps	15.426	15.426:-1	20%		Fig. 2.54
	Meas Straub 1997	18.1	18.1:-1	5%		Fig. 2.56

Table 2.16: Ionization Cross section for e impact on H_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$H_2 + e \rightarrow H_2(rot)$	Adap Dalgarno 1999	0.001	0.001:-1	30%	RE	Fig. 2.57

Table 2.17: Excitation Cross section for e impact on H_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$H_2 + e \to H_2(v2)$	Adap Janev 1987	1	1:-1	30%	RE	Fig. 2.58 2.59
$H_2 + e \to$ Elastic	Revi Nockel et al. 92	0	0:-1	30%	RUE	Fig. 2.58 2.59
$H_2 + e \to H^+$	Adap Janev et al 87 + Yoon 08	18	18:-1	30%	RE	Fig. 2.58 2.59
$H_2 + e \to H_2(v1)$	Adap Janev 1987	.5	.5:-1	30%	RE	Fig. 2.58 2.59
$H_2 + e \to H_2$(Bprime)	Adap Dalgarno 99	19.5	19.5:-1	30%	RE	Fig. 2.58 2.59
$H_2 + e \to H_2$(Bseconde)	Adap Dalgarno 99	14.2	14.2:-1	30%	RE	Fig. 2.58 2.59
$H_2 + e \to H_2$(abc)	Adap Janev 1987	10	10:-1	30%	RE	Fig. 2.58 2.59
$H_2 + e \to H_2^+$	Adap Liu 2004	15.4	15.4:-1	30%	RE	Fig. 2.58 2.59
$H_2 + e \to H_2(D)$	Adap Dalgarno 99	13.6	13.6:-1	30%	RE	Fig. 2.58 2.59
$H_2 + e \to H_2$(C1Pu)	Adap Dalgarno 99	11.7	11.7:-1	30%	RE	Fig. 2.58 2.59
$H_2 + e \to H_2$(rot)	Adap Dalgarno 1999	0.001	0.001:-1	30%	RE	Fig. 2.58 2.59
$H_2 + e \to H_2$(EF)	Adap Dalgarno 99	12.2	12.2:-1	30%	RE	Fig. 2.58 2.59
$H_2 + e \to H(2p)$	Adap Ajello 91 APJ, 371, 422-431	14.67	14.67:-1	10%	RE	Fig. 2.58 2.59
$H_2 + e \to H_2$(Rydberg)	Adap Dalgarno 1999	15.5	15.5:-1	30%	RE	Fig. 2.58 2.59
$H_2 + e \to H_2$(Dprime)	Adap Dalgarno 99	14.3	14.3:-1	30%	RE	Fig. 2.58 2.59
$H_2 + e \to H_2$(B1Su)	Adap H_2(B 1S+u (2pS))Dalgarno 99	11.37	11.37:-1	30%	RE	Fig. 2.58 2.59

Table 2.18: Recommended Cross section for e impact on H_2

2.5 Cross section of e impact with H_2

2.5.1 Elastic Cross Section

2.5.2 Inelastic Cross Sections

Ionization Cross Sections

H_2 + e → H+

H_2 + e → H2+

Excitation Cross Sections

H_2 + e → H2(rot)

2.5.3 Recommended data set

H_2 + e → H2(v2)

H_2 + e → Elastic

H_2 + e → H+

H_2 + e → H2(v1)

H_2 + e → H2(Bprime)

H_2 + e → H2(Bseconde)

H_2 + e → H2(abc)

H_2 + e → H2+

H_2 + e → H2(D)

H_2 + e → H2(C1Pu)

H_2 + e → H2(rot)

H_2 + e → H2(EF)

H_2 + e → H(2p)

H_2 + e → H2(Rydberg)

H_2 + e → H2(Dprime)

H_2 + e → H2(B1Su)

Legend for the properties

R : Recommended cross section for the processus. It is used in the main file. The selection of the recommended cross section is based on the quality of

the data (e.g. errorbars, comparison with other experiments), the possibility of extrapolation, and the origin of the work, coupled with the consistency (sum of recommended cross sections Total cross section)

U : Estimated uncertainty: sometimes, the uncertainty is not given, because of theoretical work... The authors of the database have to estimate the uncertainty, but the quality of that estimation can be questionable. Moreover, when data from different sources have been adapted (e.g. for extrapolation), the uncertainty can be modified...

E : Validated for extrapolation: the extrapolation of these cross sections is plausible. For example, when an analytic function has been applied...

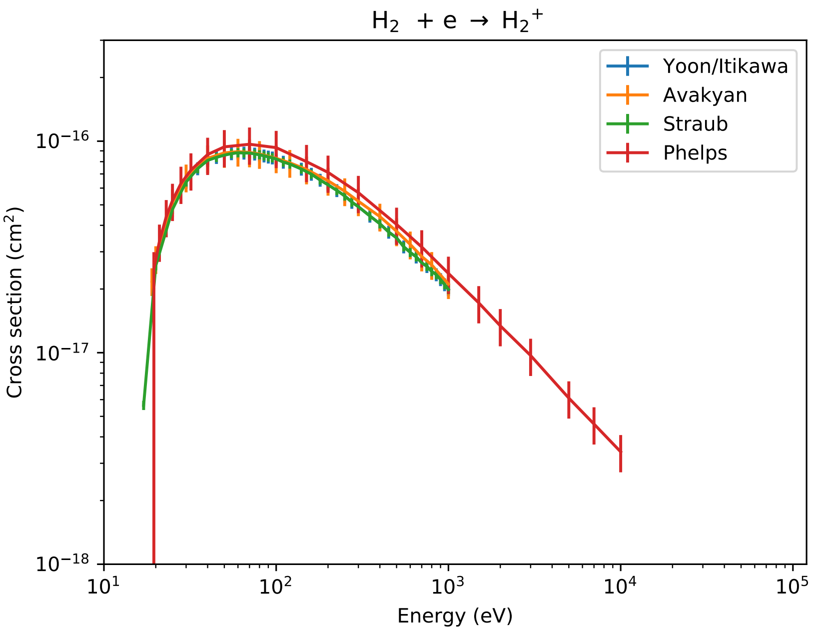

Figure 2.54: Cross sections for H_2 + e $\rightarrow$ $H_2{}^+$

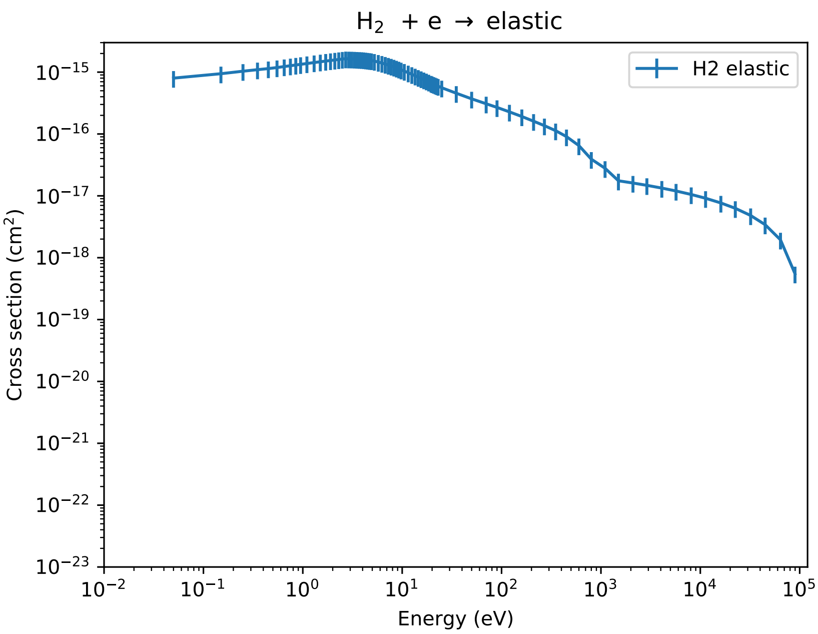

Figure 2.55: Cross sections for H_2 + e $\rightarrow$ elastic

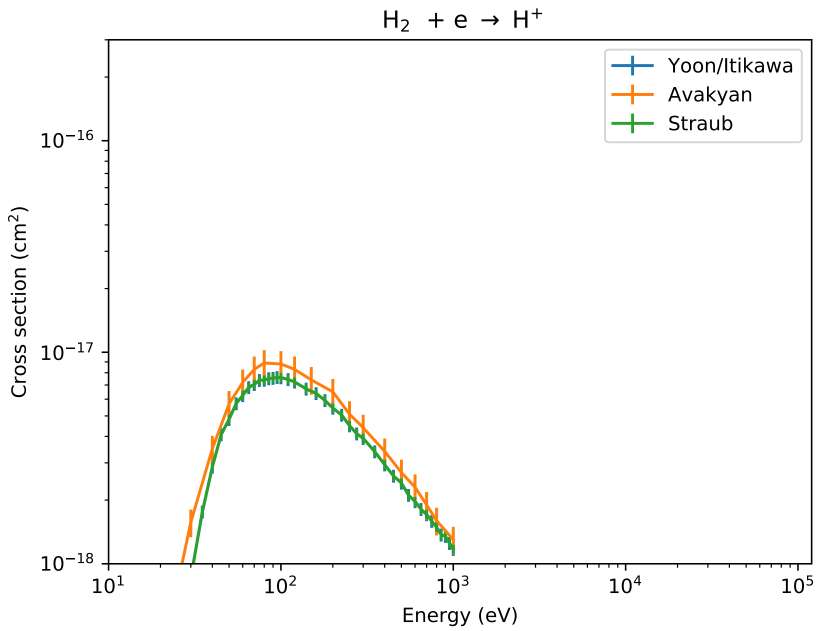

Figure 2.56: Cross sections for H_2 + e $\rightarrow$ H^+

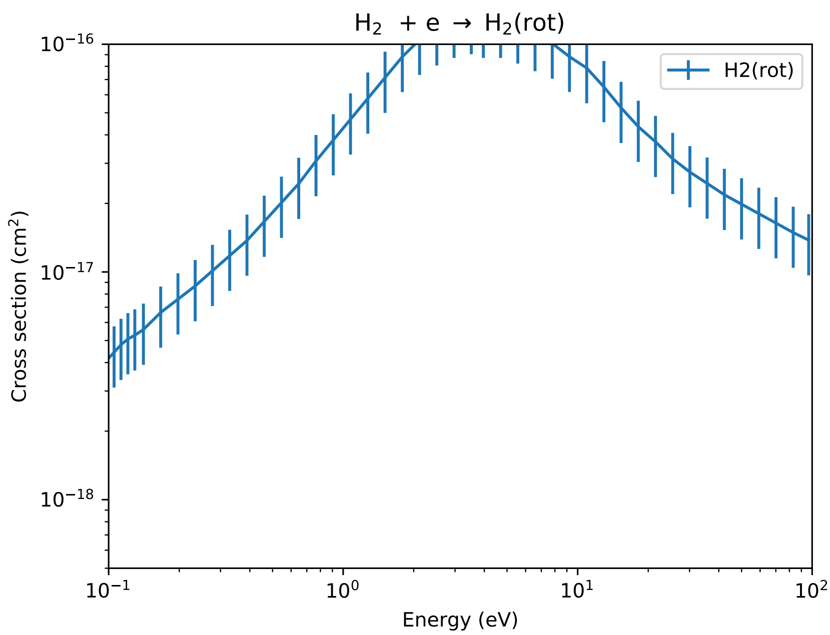

Figure 2.57: Cross sections for H_2 + e $\rightarrow$ H_2(rot)

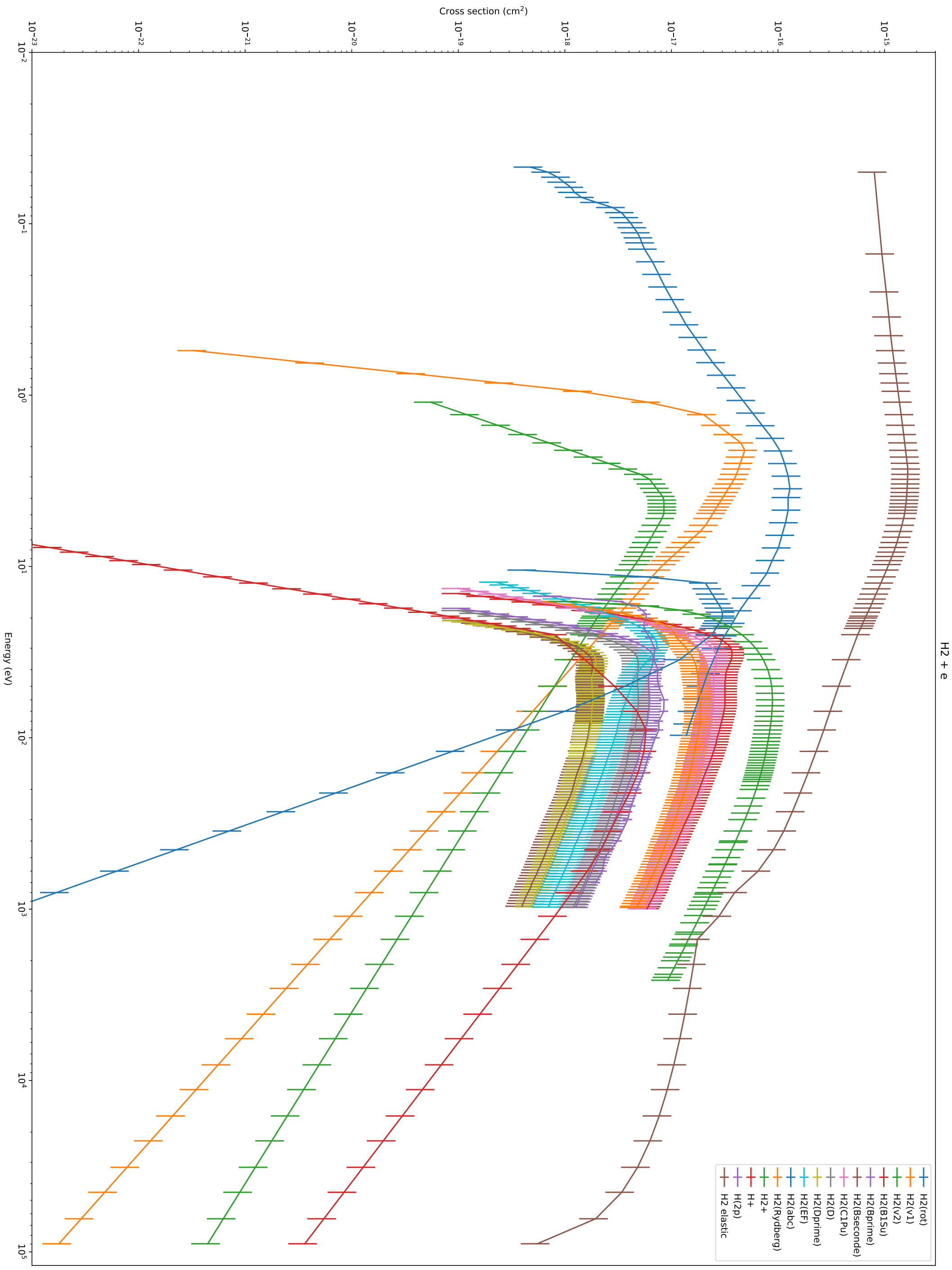

Figure 2.58: Cross sections for H2 + e

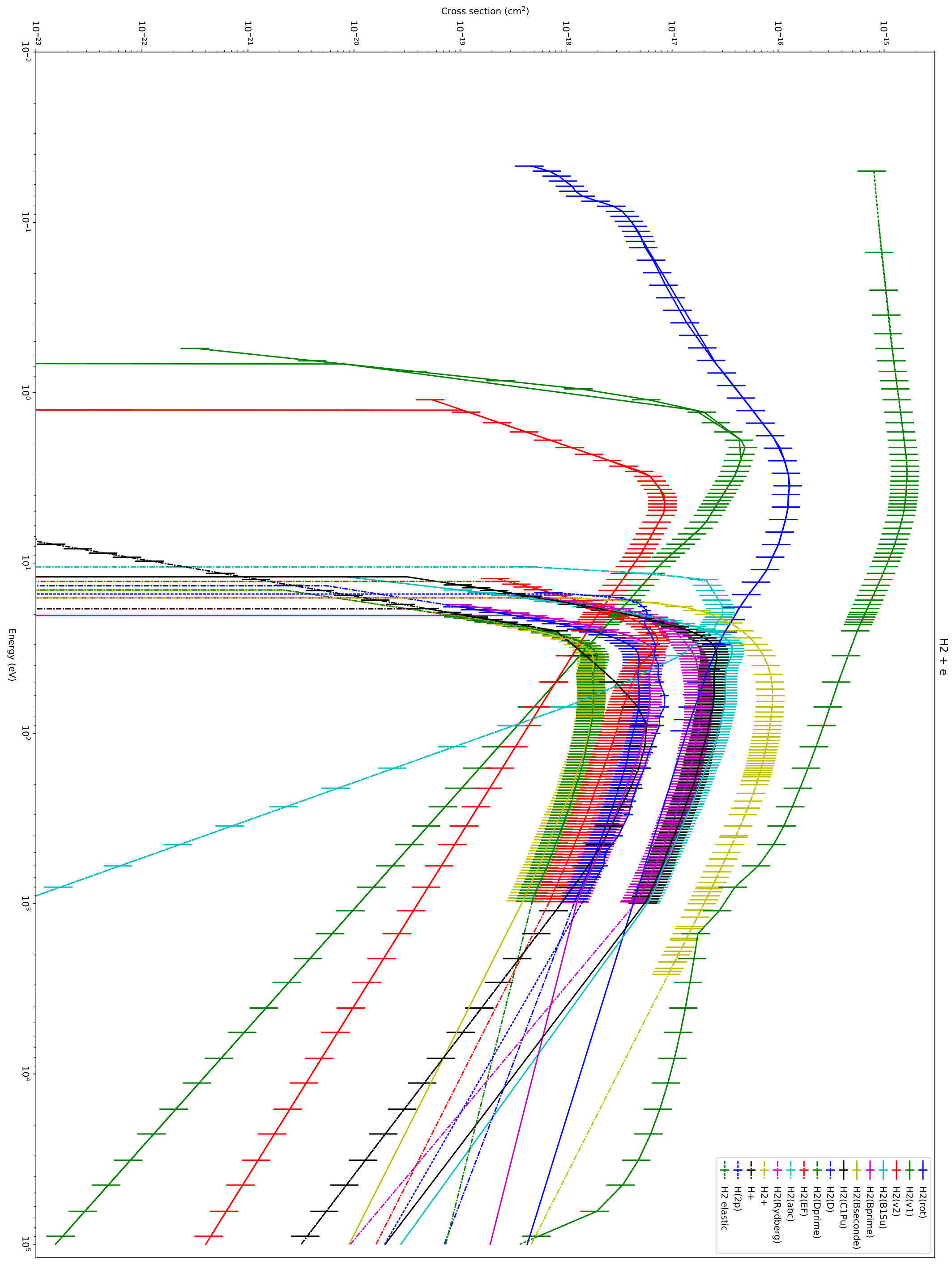

Figure 2.59: Cross sections for H2 + e (wavelength with extrapolation version)

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
He + e → He(3Pt)	Adap Ralchenko 2008	23.038	23.038:-1	15%	RE	Fig. 2.60 2.61
He + e → He(2Ps)	Adap Ralchenko 2008	21.247	21.247:-1	15%	RE	Fig. 2.60 2.61
He + e → He++	Adap Pindzola 2007	79	79:-1	40%	RE	Fig. 2.60 2.61
He + e → He(2St)	Adap Ralchenko 2008	19.847	19.847:-1	15%	RE	Fig. 2.60 2.61
He + e → He(3Ds)	Adap Ralchenko 2008	23.105	23.105:-1	15%	RE	Fig. 2.60 2.61
He + e → He(3Ss)	Adap Ralchenko 2008	22.951	22.951:-1	15%	RE	Fig. 2.60 2.61
He + e → He(2Pt)	Adap Ralchenko 2008	20.993	20.993:-1	15%	RE	Fig. 2.60 2.61
He + e → He(4St)	Adap Ralchenko 2008	23.626	23.626:-1	15%	RE	Fig. 2.60 2.61
He + e → He(4Ft)	Adap Ralchenko 2008	23.77	23.77:-1	15%	RE	Fig. 2.60 2.61
He + e → He(4Fs)	Adap Ralchenko 2008	23.77	23.77:-1	15%	RE	Fig. 2.60 2.61
He + e → He(4Ss)	Adap Ralchenko 2008	23.706	23.706:-1	15%	RE	Fig. 2.60 2.61
He + e → He(4Pt)	Adap Ralchenko 2008	23.74	23.74:-1	15%	RE	Fig. 2.60 2.61
He + e → Elastic	Revi Strickland 1989	0	0:-1	30%	RUE	Fig. 2.60 2.61
He + e → He(3St)	Adap Ralchenko 2008	22.749	22.749:-1	15%	RE	Fig. 2.60 2.61
He + e → He(3Dt)	Adap Ralchenko 2008	23.105	23.105:-1	15%	RE	Fig. 2.60 2.61
He + e → He(2Ss)	Adap Ralchenko 2008	20.63	20.63:-1	15%	RE	Fig. 2.60 2.61
He + e → He(4Ds)	Adap Ralchenko 2008	23.77	23.77:-1	15%	RE	Fig. 2.60 2.61
He + e → He(4Ps)	Adap Ralchenko 2008	23.77	23.77:-1	15%	RE	Fig. 2.60 2.61
He + e → He(3Ps)	Adap Ralchenko 2008	23.118	23.118:-1	15%	RE	Fig. 2.60 2.61
He + e → He+	Adap Ralchenko 2008	24.6	24.6:-1	15%	RE	Fig. 2.60 2.61
He + e → He(4Dt)	Adap Ralchenko 2008	23.77	23.77:-1	15%	RE	Fig. 2.60 2.61

Table 2.19: Recommended Cross section for e impact on He

2.6 Cross section of e impact with He

2.6.1 Inelastic Cross Sections

2.6.2 Recommended data set

He + e → He(3Pt)

He + e → He(2Ps)

He + e → He++

He + e → He(2St)

He + e → He(3Ds)

He + e → He(3Ss)

He + e → He(2Pt)

He + e → He(4St)

He + e → He(4Ft)

He + e → He(4Fs)

He + e → He(4Ss)

He + e → He(4Pt)

He + e → Elastic

He + e → He(3St)

He + e → He(3Dt)

He + e → He(2Ss)

He + e → He(4Ds)

He + e → He(4Ps)

He + e → He(3Ps)

He + e → He+

He + e → He(4Dt)

Legend for the properties

R : Recommended cross section for the processus. It is used in the main file. The selection of the recommended cross section is based on the quality of

the data (e.g. errorbars, comparison with other experiments), the possibility of extrapolation, and the origin of the work, coupled with the consistency (sum of recommended cross sections Total cross section)

U : Estimated uncertainty: sometimes, the uncertainty is not given, because of theoretical work... The authors of the database have to estimate the uncertainty, but the quality of that estimation can be questionable. Moreover, when data from different sources have been adapted (e.g. for extrapolation), the uncertainty can be modified...

E : Validated for extrapolation: the extrapolation of these cross sections is plausible. For example, when an analytic function has been applied...

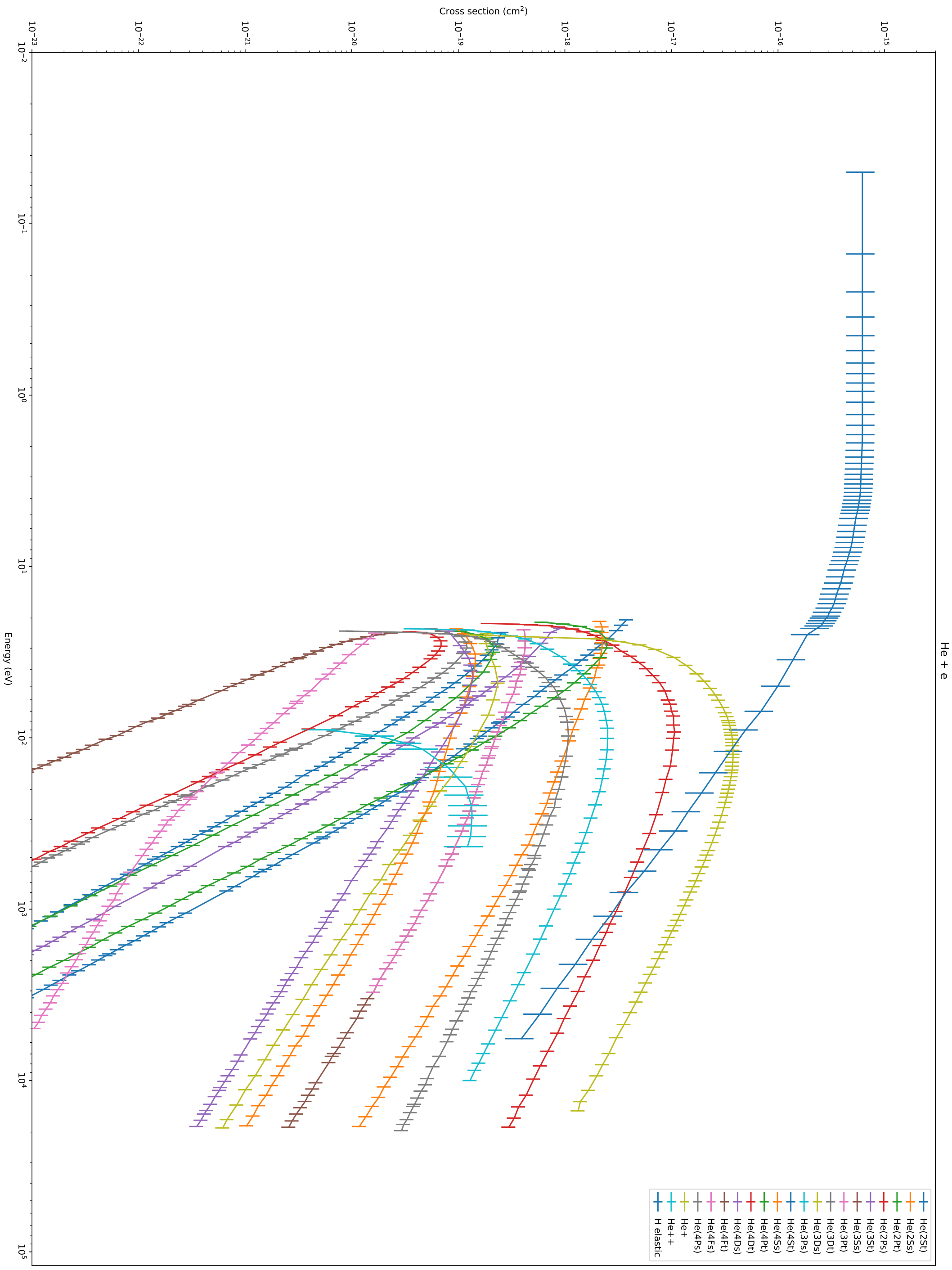

Figure 2.60: Cross sections for He + e

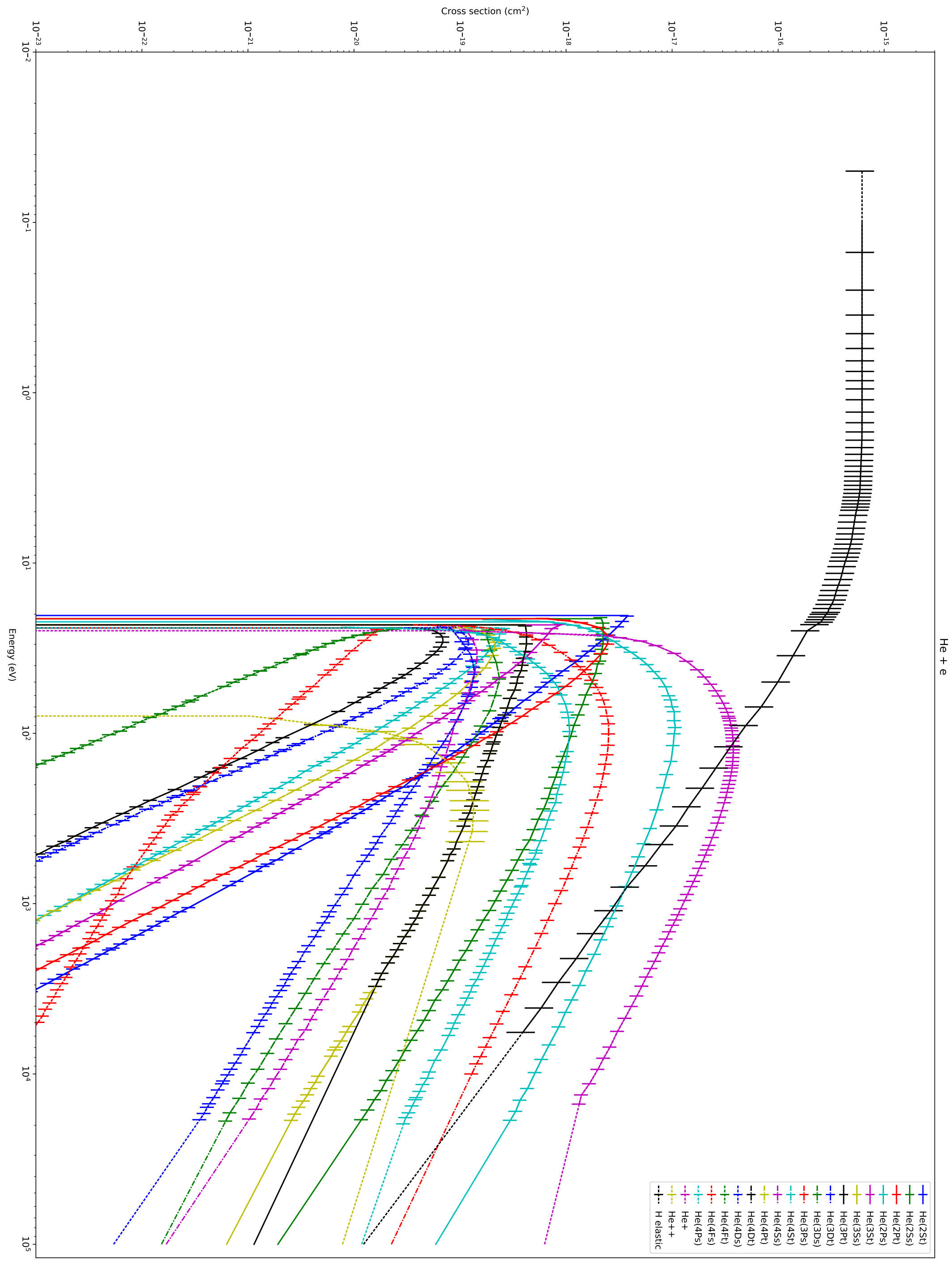

Figure 2.61: Cross sections for He + e (wavelength with extrapolation version)

2.7 Cross section of e impact with H

2.7.1 Inelastic Cross Sections

Ionization Cross Sections

H + e → H+

2.7.2 Recommended data set

H + e → Elastic

H + e → H(n=6)

H + e → H(n=4)

H + e → H(2p)

H + e → H(n=5)

H + e → H+

H + e → H(2s)

H + e → H(n=3)

Legend for the properties

R : Recommended cross section for the processus. It is used in the main file. The selection of the recommended cross section is based on the quality of the data (e.g. errorbars, comparison with other experiments), the possibility of extrapolation, and the origin of the work, coupled with the consistency (sum of recommended cross sections Total cross section)

U : Estimated uncertainty: sometimes, the uncertainty is not given, because of theoretical work... The authors of the database have to estimate the uncertainty, but the quality of that estimation can be questionable. Moreover, when data from different sources have been adapted (e.g. for extrapolation), the uncertainty can be modified...

E : Validated for extrapolation: the extrapolation of these cross sections is plausible. For example, when an analytic function has been applied...

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$H + e \rightarrow H+$	Revi Avakyan 1998	13.6	13.6:-1	15%	RE	Fig. 2.62
	Meas Shah 1987	13.6	13.6:-1	15%	E	Fig. 2.62

Table 2.20: Ionization Cross section for e impact on H

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$H + e \rightarrow$ Elastic	Revi Strickland 1989	0	0:-1	30%	RUE	Fig. 2.63 2.64
$H + e \rightarrow H(n=6)$	Adap Janev 1987	12.0875	12.0875:-1	50%	RE	Fig. 2.63 2.64
$H + e \rightarrow H(n=4)$	Adap Janev 1987	12.7485	12.7485:-1	50%	RE	Fig. 2.63 2.64
$H + e \rightarrow H(2p)$	Meas James 1997	10.1988	10.1988:-1	10%	RE	Fig. 2.63 2.64
$H + e \rightarrow H(n=5)$	Adap Janev 1987	13.0545	13.0545:-1	50%	RE	Fig. 2.63 2.64
$H + e \rightarrow H^+$	Revi Avakyan 1998	13.6	13.6:-1	15%	RE	Fig. 2.63 2.64
$H + e \rightarrow H(2s)$	Adap Janev 1987	10.1988	10.1988:-1	50%	RE	Fig. 2.63 2.64
$H + e \rightarrow H(n=3)$	Adap Janev 1987	12.0875	12.0875:-1	50%	RE	Fig. 2.63 2.64

Table 2.21: Recommended Cross section for e impact on H

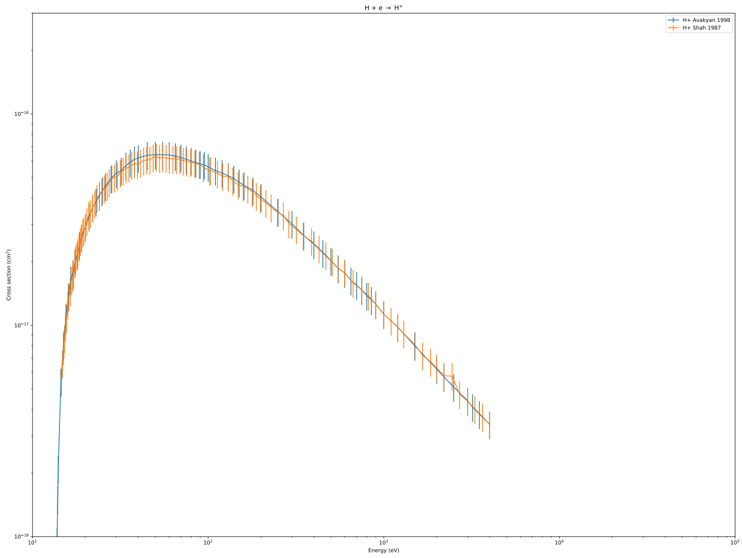

Figure 2.62: Cross sections for H + e $\rightarrow$ H^+

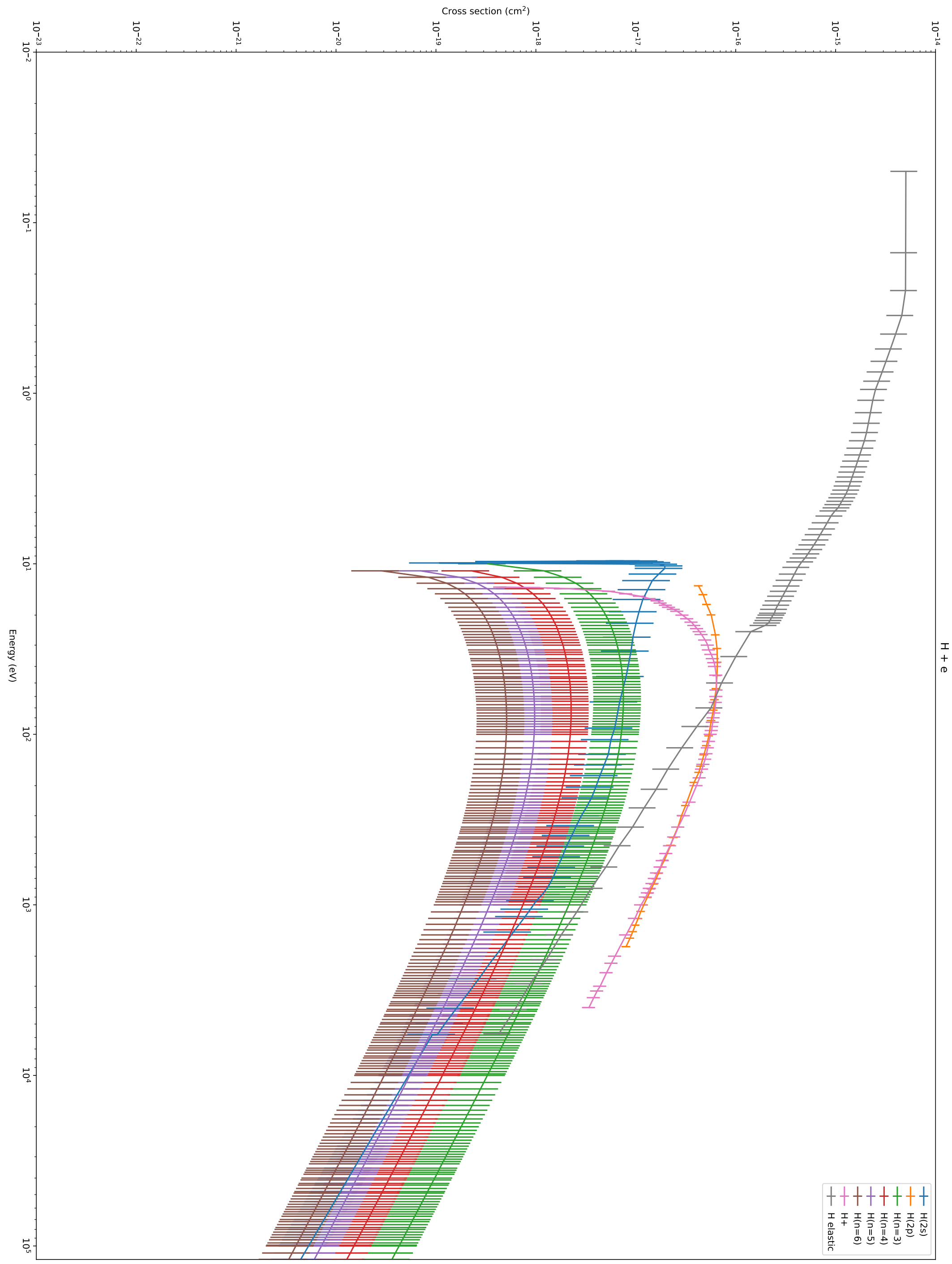

Figure 2.63: Cross sections for H + e

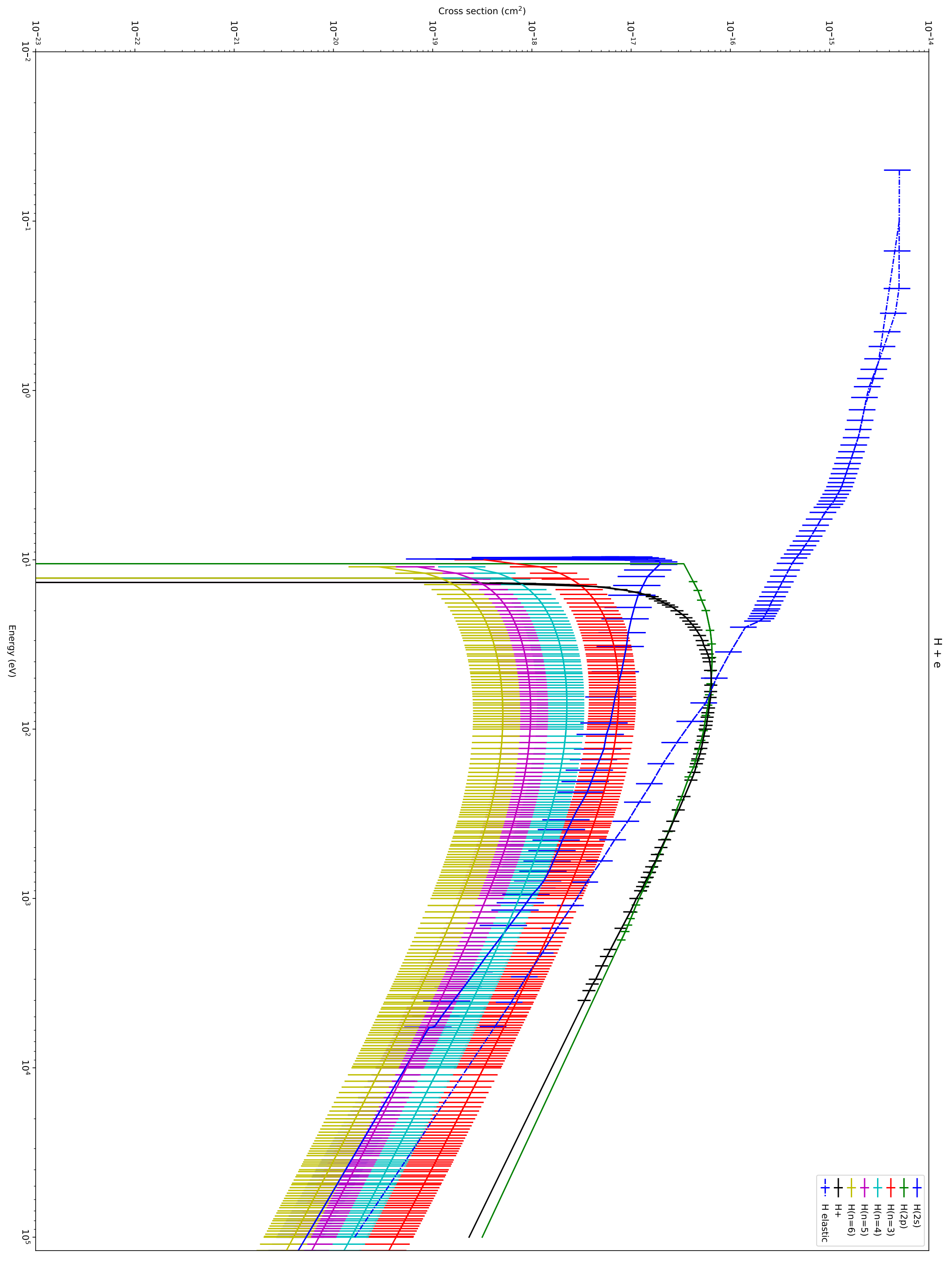

Figure 2.64: Cross sections for H + e (wavelength with extrapolation version)

2.8 Cross section of e impact with N_2

2.8.1 Elastic Cross Section

2.8.2 Inelastic Cross Sections

Ionization Cross Sections

N_2 + e → N2++(Auger)

Notes for N_2^{++} K-Shell ionization, Frémont + Tabata 2006 The K-Shell ionization of N_2 by electron impact has been studied in [?]. The ratio K-shell/simple ionization has been taken in that paper. The total cross section has been computed by multiplying this ratio by the recommended ionization cross section, coming from [5].

Reference	Threshold	Range of energy	Uncertainty	Properties	Fig
???? ? BDD	0	0:-1	???%	U	Fig. 2.66
Revi Itikawa 2009	0	0:-1	20%		Fig. 2.66
Revi Tabata2006	0	0.0514 : 5220.0	20%	E	Fig. 2.66
Adap Itikawa 2006+ Tabata 2006	0	0:-1	20%	RUE	Fig. 2.66

Table 2.22: Elastic cross section for e impact on N_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$N_2 + e \rightarrow N_2^{++}$(Auger)	Adap Fremont 2006 + Tabata 2006	400	400:-1	50%	RUE	Fig. 2.67
$N_2 + e \rightarrow N_2^{+}$	Revi Tabata2006	15.600000	17.0 : 1000.0	7%	E	Fig. 2.71
	Revi Itikawa 2009	15.580	15.580:-1	5%		Fig. 2.71
	???? ? BDD	15.58	15.58:-1	???%	U	Fig. 2.71
	Meas Straub 2004	15.58	15.58:-1	5%		Fig. 2.71
	Adap Straub 2004 + Tabata 2006	15.58	15.58:-1	5%	RUE	Fig. 2.71
$N_2 + e \rightarrow N^{+}$	Revi Itikawa 2009	30	30:-1	5%		Fig. 2.69
	Meas Straub 2004	30	30:-1	5%		Fig. 2.69
	Revi Tabata2006	24.300000	30.0 : 1000.0	8%	E	Fig. 2.69
	Adap Straub 2004 + Tabata 2006	30	30:-1	5%	RUE	Fig. 2.69
$N_2 + e \rightarrow N^{++}$	Revi Itikawa 2009	70	70:-1	6%		Fig. 2.65
	Meas Straub 2004	70	70:-1	6%		Fig. 2.65
	Revi Tabata2006	53.900000	70.0 : 1000.0	10%	E	Fig. 2.65
	Adap Straub 2004 + Tabata 2006	70	70:-1	6%	RUE	Fig. 2.65
$N_2 + e \rightarrow N_2^{++}$	???? ? BDD	43.0	43.0:-1	???%	U	Fig. 2.70
	Adap Straub 2004	43	43:-1	50%	RUE	Fig. 2.70

Table 2.23: Ionization Cross section for e impact on N_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$N_2 + e \rightarrow 2{*}N$	Revi Tabata2006	9.760000	12.0 : 200.0	25%	E	Fig. 2.73
	Revi Itikawa 2009	12	12:-1	25%		Fig. 2.73
	Adap Itikawa 2006+ Tabata 2006	12	12:-1	25%	RUE	Fig. 2.73

Table 2.24: Dissociation Cross section for e impact on N_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$N_2 + e \rightarrow N_2$(a'1Su-)	Revi Tabata2006	8.400000	11.0 : 1000.0	50%	E	Fig. 2.68
	Revi Itikawa 2009	8.399	8.399:-1	33%		Fig. 2.68
	Adap Itikawa 2006+ Tabata 2006	8.399	8.399:-1	33%	RUE	Fig. 2.68

Table 2.25: Excitation Cross section for e impact on N_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$N_2 + e \rightarrow N_2(391.4)$	Revi Itikawa 2006	18	18:-1	15%		Fig. 2.72
	Revi Tabata 2009	18.800000	19.0 : 10000.0	20%	U	Fig. 2.72
$N_2 + e \rightarrow N_2(470.9)$	Revi Tabata 2009	18.800000	20.5 : 399.0	20%	U	Fig. 2.72
$N_2 + e \rightarrow N_2(358.2)$	Revi Tabata 2009	19.000000	29.2 : 400.0	20%	U	Fig. 2.72
$N_2 + e \rightarrow N_2(427.8)$	Revi Tabata 2009	18.800000	20.5 : 399.0	20%	U	Fig. 2.72

Table 2.26: Emission Cross section for e impact on N_2

N_2 + e → N2+

N_2 + e → N+

N_2 + e → N++

N_2 + e → N2++

Dissociation Cross Sections

N_2 + e → 2*N

Excitation Cross Sections

N_2 + e → N2(a'1Su-)

2.8.3 Emission Cross Sections

N_2 + e → N2(391.4)

N_2 + e → N2(470.9)

N_2 + e → N2(358.2)

N_2 + e → N2(427.8)

2.8.4 Recommended data set

N_2 + e → N2++

N_2 + e → N2(vib)

N_2 + e → N(149.4)

N_2 + e → N2(W3Du)

N_2 + e → N2(a-X)

N_2 + e → N(120nm)

N_2 + e → N2(A3Su+)

N_2 + e → N2(B3Pg)

N_2 + e → N2+

N_2 + e → N2(a"1Sg+)

N_2 + e → Elastic

N_2 + e → N2++(Auger)

N_2 + e → N++

N_2 + e → N(124.3)

N_2 + e → N(108.4)

N_2 + e → N2(c'4-X)

N_2 + e → N2(a1Pg)

N_2 + e → N+

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
N_2 + e → N_2^{++}	???? ? BDD	43.0	43.0:-1	50%		Fig. 2.74 2.75
N_2 + e → N_2(vib)	Revi Itikawa 2009	0.5	0.5:-1	???%	U	Fig. 2.74 2.75
N_2 + e → N(149.4)	Revi Itikawa 2009	50	50:-1	???%	U	Fig. 2.74 2.75
N_2 + e → N_2(W3Du)	Revi Itikawa 2009	7.362	7.362:-1	40%		Fig. 2.74 2.75
N_2 + e → N_2(a-X)	Revi Itikawa 2009	10	10:-1	???%	U	Fig. 2.74 2.75
N_2 + e → N(120nm)	Revi Itikawa 2009	50	50:-1	???%	U	Fig. 2.74 2.75
N_2 + e → N_2(A3Su+)	Revi Itikawa 2009	6.169	6.169:-1	35%		Fig. 2.74 2.75
N_2 + e → N_2(B3Pg)	Revi Itikawa 2009	7.353	7.353:-1	35%		Fig. 2.74 2.75
N_2 + e → N_2^+	Adap Straub 2004 + Tabata 2006	15.58	15.58:-1	5%	RUE	Fig. 2.74 2.75
N_2 + e → N_2(a"1Sg+)	Revi Itikawa 2009	12.255	12.255:-1	33%		Fig. 2.74 2.75
N_2 + e → Elastic	Adap Itikawa 2006+ Tabata 2006	0	0:-1	20%	RUE	Fig. 2.74 2.75
N_2 + e → N_2^{++}(Auger)	Adap Fremont 2006 + Tabata 2006	400	400:-1	50%	RUE	Fig. 2.74 2.75
N_2 + e → N^{++}	Adap Straub 2004 + Tabata 2006	70	70:-1	6%	RUE	Fig. 2.74 2.75
N_2 + e → N(124.3)	Revi Itikawa 2009	50	50:-1	???%	U	Fig. 2.74 2.75
N_2 + e → N(108.4)	Revi Itikawa 2009	50	50:-1	???%	U	Fig. 2.74 2.75
N_2 + e → N_2(c'4-X)	Revi Itikawa 2009	10	10:-1	???%	U	Fig. 2.74 2.75
N_2 + e → N_2(a1Pg)	Revi Itikawa 2009	8.549	8.549:-1	25%		Fig. 2.74 2.75
N_2 + e → N^+	Adap Straub 2004 + Tabata 2006	30	30:-1	5%	RUE	Fig. 2.74 2.75
N_2 + e → N_2(C-B)	Revi Itikawa 2009	10	10:-1	???%	U	Fig. 2.74 2.75
N_2 + e → N_2(J)	Revi Itikawa 2009	0.0015	0.0015:-1	20%		Fig. 2.74 2.75
N_2 + e → N(113.4)	Revi Itikawa 2009	60	60:-1	???%	U	Fig. 2.74 2.75
N_2 + e → N_2(E3Sg+)	Revi Itikawa 2009	11.875	11.875:-1	40%		Fig. 2.74 2.75
N_2 + e → N_2(427.8)	Revi Tabata 2009	18.800000	20.5 : 399.0	20%	U	Fig. 2.74 2.75
N_2 + e → N_2(B'3Su-)	Revi Itikawa 2009	8.165	8.165:-1	30%		Fig. 2.74 2.75
N_2 + e → N_2(391.4)	Revi Itikawa 2009	18	18:-1	???%	U	Fig. 2.74 2.75
	Revi Tabata 2009	18.800000	19.0 : 10000.0	20%	U	Fig. 2.74 2.75
N_2 + e → N_2(C3Pu)	Revi Itikawa 2009	11.032	11.032:-1	33%		Fig. 2.74 2.75
N_2 + e → N_2(a'1Su-)	Adap Itikawa 2006+ Tabata 2006	8.399	8.399:-1	33%	RUE	Fig. 2.74 2.75
N_2 + e → N_2(W1Du)	Revi Itikawa 2009	8.890	8.890:-1	33%		Fig. 2.74 2.75
N_2 + e → 2*N	Adap Itikawa 2006+ Tabata 2006	12	12:-1	25%	RUE	Fig. 2.74 2.75

Table 2.27: Recommended Cross section for e impact on N_2

the data (e.g. errorbars, comparison with other experiments), the possibility of extrapolation, and the origin of the work, coupled with the consistency (sum of recommended cross sections   Total cross section)

U   : Estimated uncertainty: sometimes, the uncertainty is not given, because of theoretical work... The authors of the database have to estimate the uncertainty, but the quality of that estimation can be questionable. Moreover, when data from different sources have been adapted (e.g. for extrapolation), the uncertainty can be modified...

E   : Validated for extrapolation: the extrapolation of these cross sections is plausible. For example, when an analytic function has been applied...

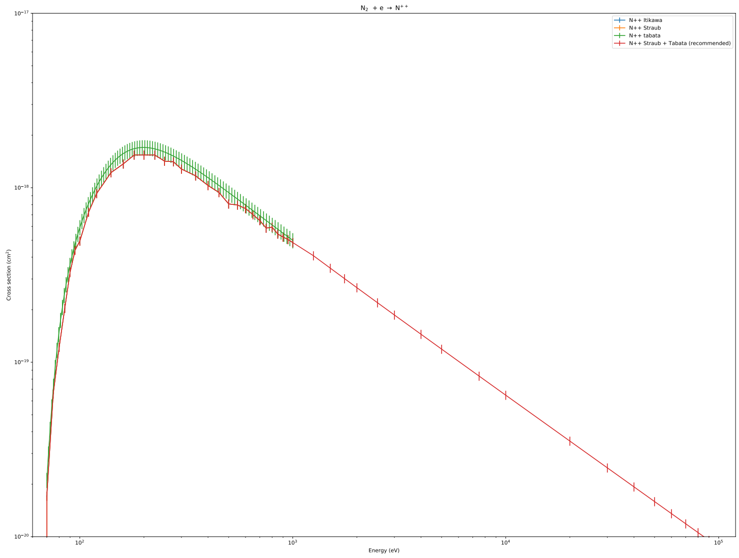

Figure 2.65: Cross sections for N_2 + e → N^{++}

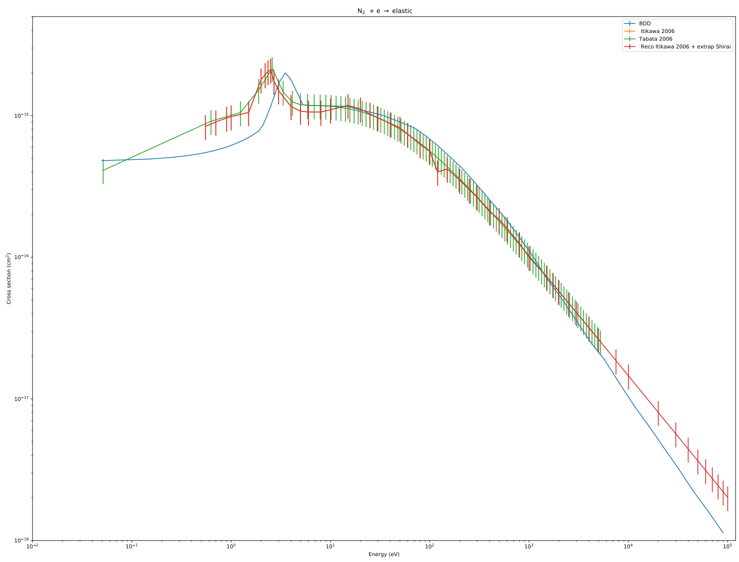

Figure 2.66: Cross sections for N_2 + e → elastic

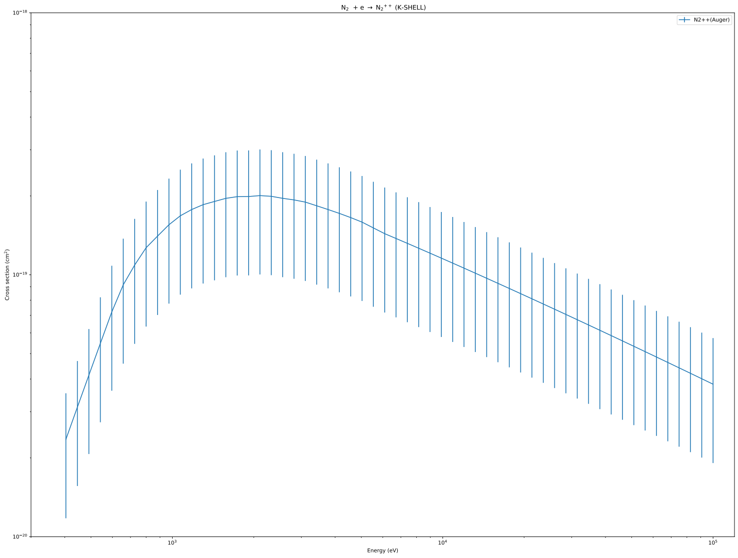

Figure 2.67: Cross sections for N_2 + e → $N_2{}^{++}$ (K-SHELL)

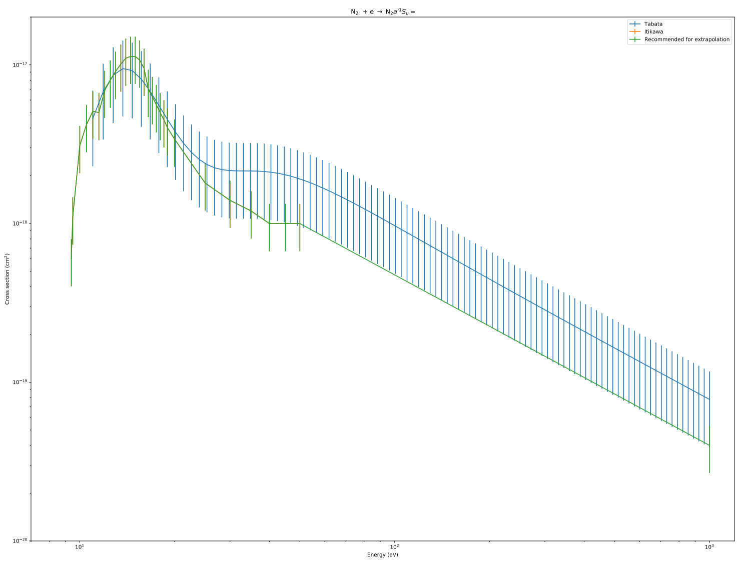

Figure 2.68: Cross sections for N_2 + e → $N_2 a'^1 S_u -$

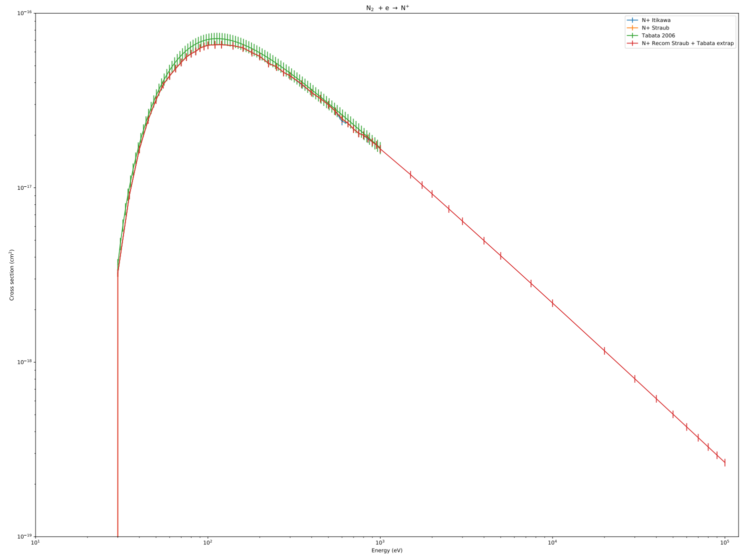

Figure 2.69: Cross sections for N_2 + e → N^+

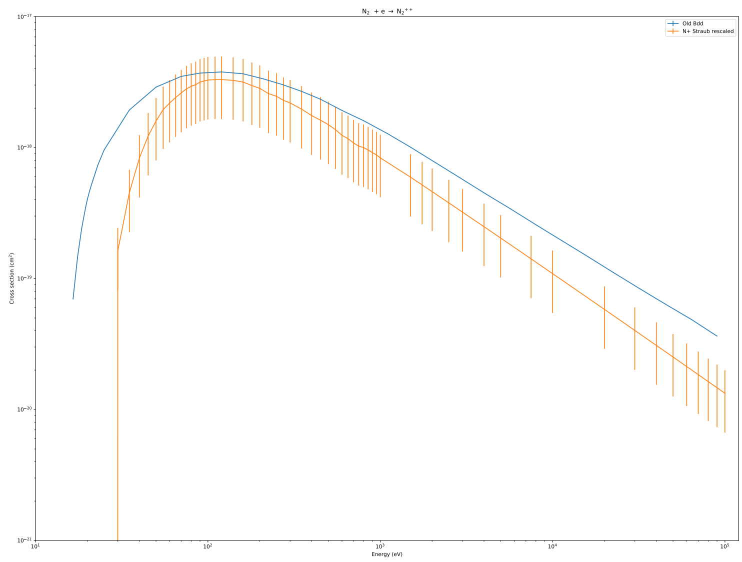

Figure 2.70: Cross sections for N_2 + e → $N_2{}^{++}$

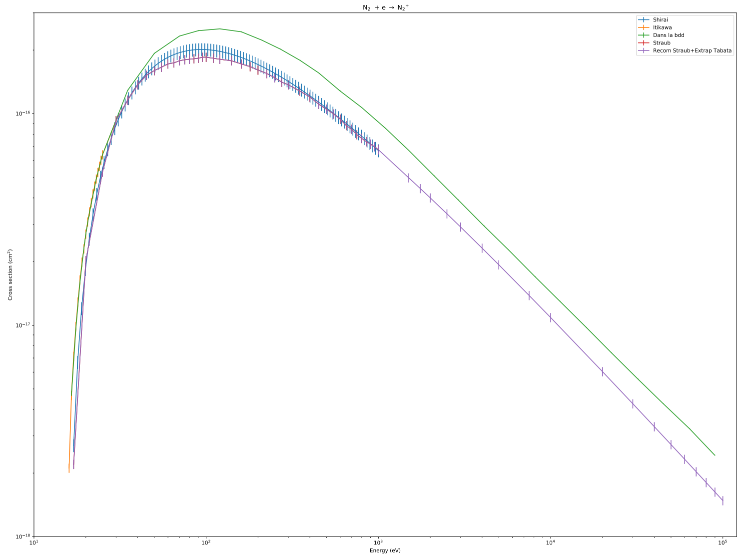

Figure 2.71: Cross sections for N_2 + e → $N_2{}^+$

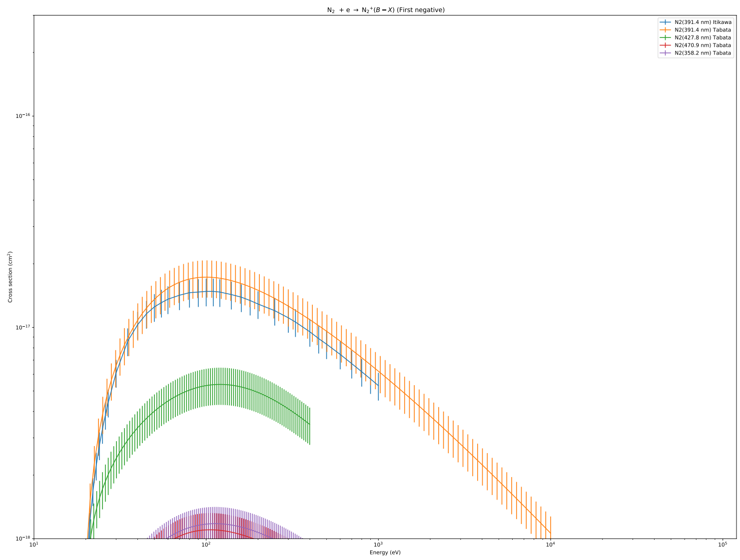

Figure 2.72: Cross sections for N_2 + e → $N_2{}^+(B-X)$ (First negative)

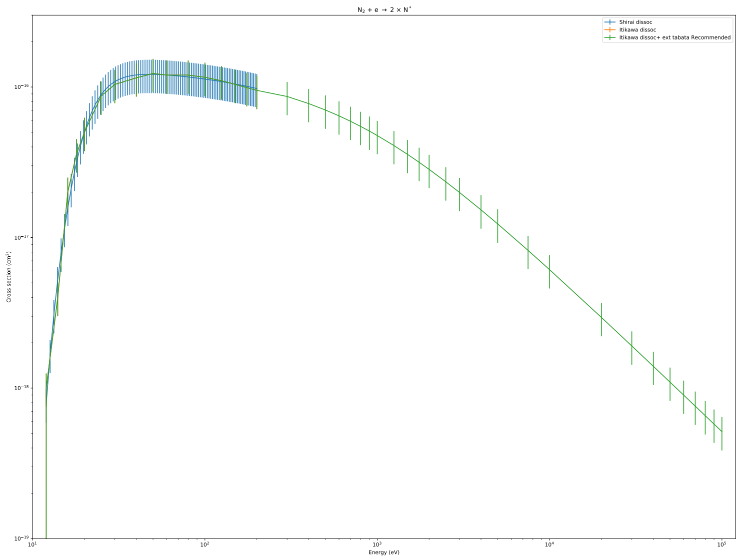

Figure 2.73: Cross sections for $N_2 + e \rightarrow 2 \times N^*$

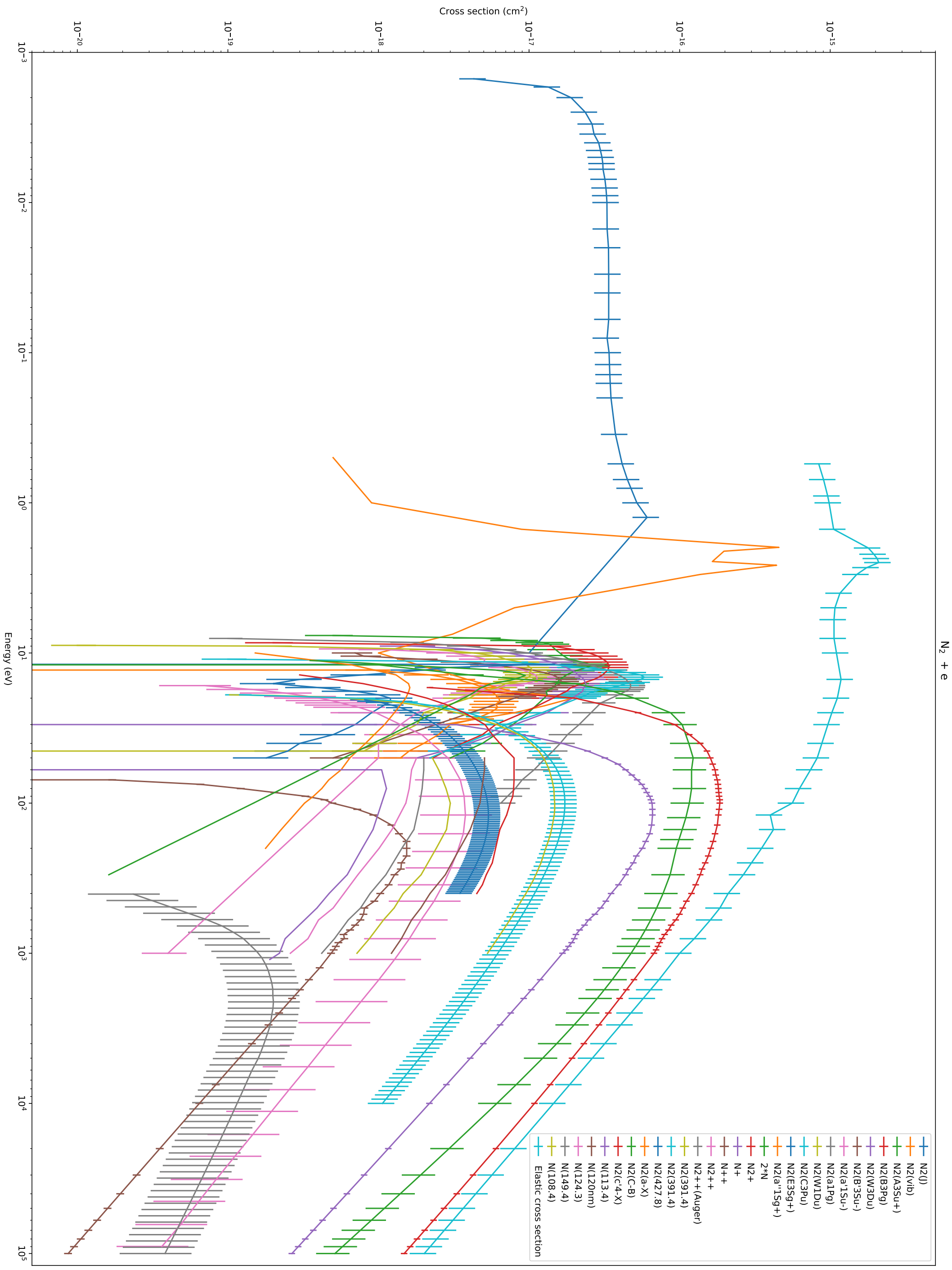

Figure 2.74: Cross sections for N_2 + e

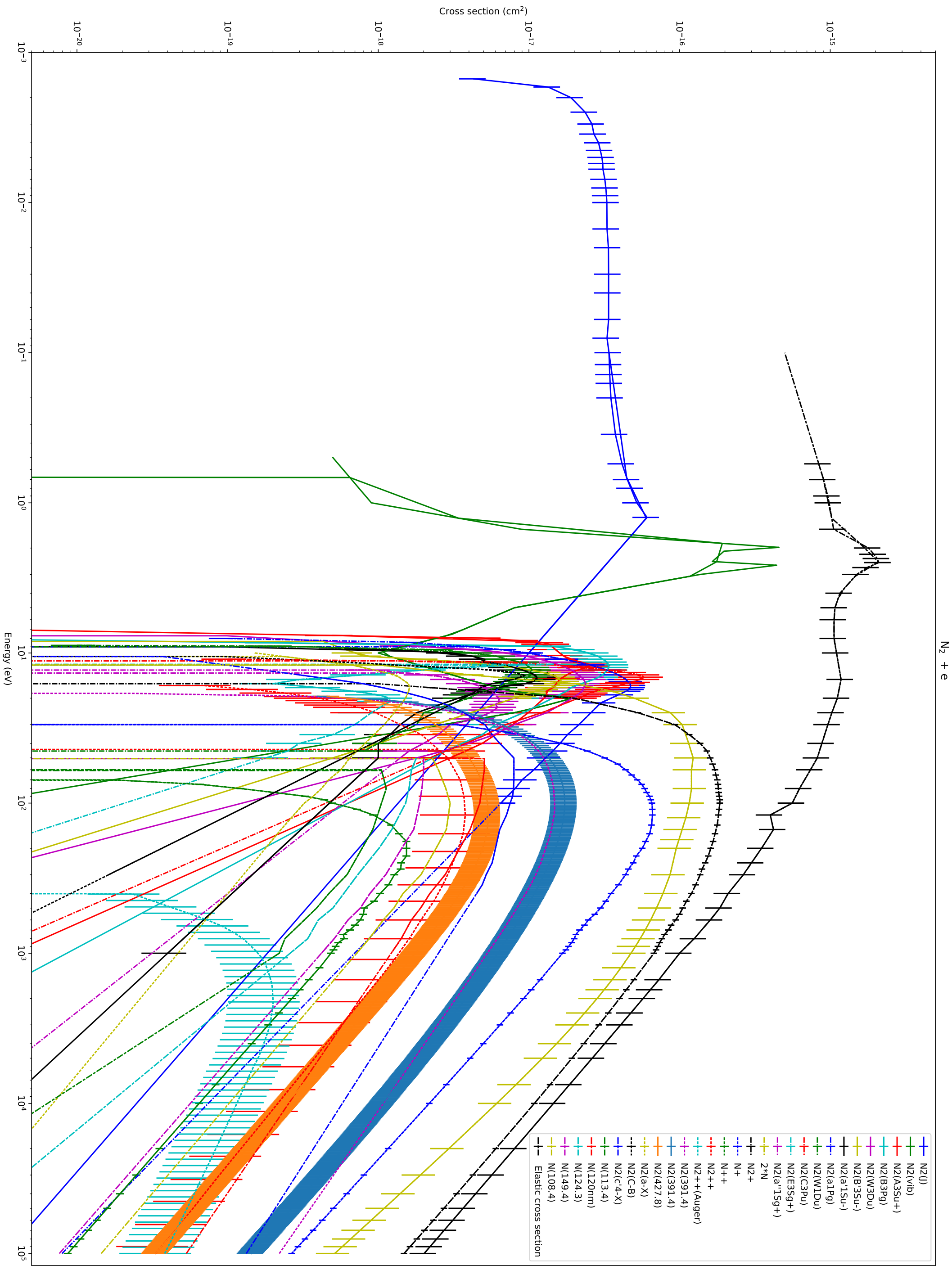

Figure 2.75: Cross sections for N_2 + e (wavelength with extrapolation version)

2.9 Cross section of e impact with O_2

2.9.1 Elastic Cross Section

2.9.2 Inelastic Cross Sections

Ionization Cross Sections

O_2 + e → O++

O_2 + e → O2+

O_2 + e → O+

O_2 + e → O2++(Auger)

Notes for O_2^{++} K-Shell ionization, Frémont 2006 + Straub2004 The K-Shell ionization of O by electron impact has not been studied in [**?**], but we assumed that the K-Shell/single ionization ratio is close to the O_2 one which is used here. The total cross section has been computed by multiplying this ratio by the recommended ionization cross section, coming from [**?**].

Reference	Threshold	Range of energy	Uncertainty	Properties	Fig
Revi Itikawa 2009	0	0:-1	20%	R	Fig. 2.80
???? ? BDD	0	0:-1	???%	U	Fig. 2.80

Table 2.28: Elastic cross section for e impact on O_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$O_2 + e \rightarrow O^{++}$	Meas Straub 2004	73.	73.:-1	6%		Fig. 2.79
	Revi Itikawa 2009	73.	73.:-1	6%		Fig. 2.79
	Adap Straub 2004	73.	73.:-1	6%	RU	Fig. 2.79
$O_2 + e \rightarrow O_2^+$	Revi Itikawa 2009	12.8	12.8:-1	5%		Fig. 2.84
	Meas Straub 2004	12.8	12.8:-1	5%	R	Fig. 2.84
	???? ? BDD	12.8	12.8:-1	???%	U	Fig. 2.84
$O_2 + e \rightarrow O^+$	Meas Straub 2004	23.	23.:-1	5%		Fig. 2.82
	Adap Straub 2004	23.	23.:-1	5%	RU	Fig. 2.82
	Revi Itikawa 2009	23.	23.:-1	5%		Fig. 2.82
	???? ? BDD	23.	23.:-1	???%	U	Fig. 2.82
$O_2 + e \rightarrow O_2^{++}$(Auger)	Adap Fremont 2006 + Straub 2004	539	539:-1	20%	RUE	Fig. 2.81
$O_2 + e \rightarrow O_2^{++}$	???? ? BDD	36.13	36.13:-1	???%	U	Fig. 2.83
	Adap Straub 2004	36.13	36.13:-1	40%		Fig. 2.83

Table 2.29: Ionization Cross section for e impact on O_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
O_2 + e → 2 O(*)	Revi Itikawa 2009	13	13:-1	34%		Fig. 2.76

Table 2.30: Dissociation Cross section for e impact on O_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
O_2 + e → O_2(vib0-3)	???? ? BDD	0.3	0.3:-1	???%	U	Fig. 2.85
O_2 + e → v1	Revi Itikawa 2009	0.3	0.3:-1	???%	U	Fig. 2.85
O_2 + e → v2	Revi Itikawa 2009	0.3	0.3:-1	???%	U	Fig. 2.85
O_2 + e → v3	Revi Itikawa 2009	6	6:-1	???%	U	Fig. 2.85
O_2 + e → O_2(vib3-4)	???? ? BDD	.630	.630:-1	???%	U	Fig. 2.85

Table 2.31: Excitation Cross section for e impact on O_2

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$O_2 + e \rightarrow 777.4nm$	Meas Erdman 1987	19	19:-1	15%		Fig. 2.87
$O_2 + e \rightarrow O_2^+$	Revi Itikawa 2009	19	19:-1	24%		Fig. 2.77
	Revi Itikawa 2009	18	18:-1	24%		Fig. 2.78
$O_2 + e \rightarrow O(^1S)$	Meas LeClair 1993	16.	16.:-1	18%	RE	Fig. 2.86

Table 2.32: Emission Cross section for e impact on O_2

O_2 + e → O2++

Dissociation Cross Sections

O_2 + e → 2 O(*)

Excitation Cross Sections

O_2 + e → O2(vib0-3)

O_2 + e → v1

O_2 + e → v2

O_2 + e → v3

O_2 + e → O2(vib3-4)

2.9.3 Emission Cross Sections

O_2 + e → 777.4nm

O_2 + e → O2+

O_2 + e → O(1S)

2.9.4 Recommended data set

O_2 + e → b1Sg+

O_2 + e → B3Su - LB

O_2 + e → O+

O_2 + e → O2++(Auger)

O_2 + e → O2+(A2Pu)

O_2 + e → O2++

O_2 + e → O++

O_2 + e → v1

O_2 + e → v2

O_2 + e → v3

O_2 + e → B3Su

O_2 + e → A3Su A'3Du c1Su

O_2 + e → O(1S)

O_2 + e → B3Su - 2B

O_2 + e → 2 O(*)

O_2 + e → 777.4nm

O_2 + e → Elastic

O_2 + e → O2+

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
O_2 + e → b1Sg+	Revi Itikawa 2009	1.627	1.627:-1	18%		Fig. 2.88 2.89
O_2 + e → B3Su - LB	Revi Itikawa 2009	6.120	6.120:-1	20%		Fig. 2.88 2.89
O_2 + e → O^+	Adap Straub 2004	23.	23.:-1	5%	RU	Fig. 2.88 2.89
O_2 + e → O_2^{++}(Auger)	Adap Fremont 2006 + Straub 2004	539	539:-1	20%	RUE	Fig. 2.88 2.89
O_2 + e → O_2^+(A2Pu)	Revi Itikawa 2009	18	18:-1	24%		Fig. 2.88 2.89
O_2 + e → O_2^{++}	Adap Straub 2004	36.13	36.13:-1	40%		Fig. 2.88 2.89
O_2 + e → O^{++}	Adap Straub 2004	73.	73.:-1	6%	RU	Fig. 2.88 2.89
O_2 + e → v1	Revi Itikawa 2009	0.3	0.3:-1	???%	U	Fig. 2.88 2.89
O_2 + e → v2	Revi Itikawa 2009	0.3	0.3:-1	???%	U	Fig. 2.88 2.89
O_2 + e → v3	Revi Itikawa 2009	6	6:-1	???%	U	Fig. 2.88 2.89
O_2 + e → B3Su	Revi Itikawa 2009	6.120	6.120:-1	20%		Fig. 2.88 2.89
O_2 + e → A3Su A'3Du c1Su	Revi Itikawa 2009	4.2	4.2:-1	50%		Fig. 2.88 2.89
O_2 + e → O(^{1}S)	Meas LeClair 1993	16.	16.:-1	18%	RE	Fig. 2.88 2.89
O_2 + e → B3Su - 2B	Revi Itikawa 2009	6.120	6.120:-1	23%		Fig. 2.88 2.89
O_2 + e → 2 O(*)	Revi Itikawa 2009	13	13:-1	34%		Fig. 2.88 2.89
O_2 + e → 777.4nm	Meas Erdman 1987	19	19:-1	15%		Fig. 2.88 2.89
O_2 + e → Elastic	Revi Itikawa 2009	0	0:-1	20%	R	Fig. 2.88 2.89
O_2 + e → O_2^+	Meas Straub 2004	12.8	12.8:-1	5%	R	Fig. 2.88 2.89
	Revi Itikawa 2009	19	19:-1	24%		Fig. 2.88 2.89
	Revi Itikawa 2009	18	18:-1	24%		Fig. 2.88 2.89
O_2 + e → O_2^+(B4Sg)	Revi Itikawa 2009	18	18:-1	24%		Fig. 2.88 2.89
O_2 + e → A1Dg	Revi Itikawa 2009	0.977	0.977:-1	16%		Fig. 2.88 2.89

Table 2.33: Recommended Cross section for e impact on O_2

the data (e.g. errorbars, comparison with other experiments), the possibility of extrapolation, and the origin of the work, coupled with the consistency (sum of recommended cross sections   Total cross section)

U : Estimated uncertainty: sometimes, the uncertainty is not given, because of theoretical work... The authors of the database have to estimate the uncertainty, but the quality of that estimation can be questionable. Moreover, when data from different sources have been adapted (e.g. for extrapolation), the uncertainty can be modified...

E : Validated for extrapolation: the extrapolation of these cross sections is plausible. For example, when an analytic function has been applied...

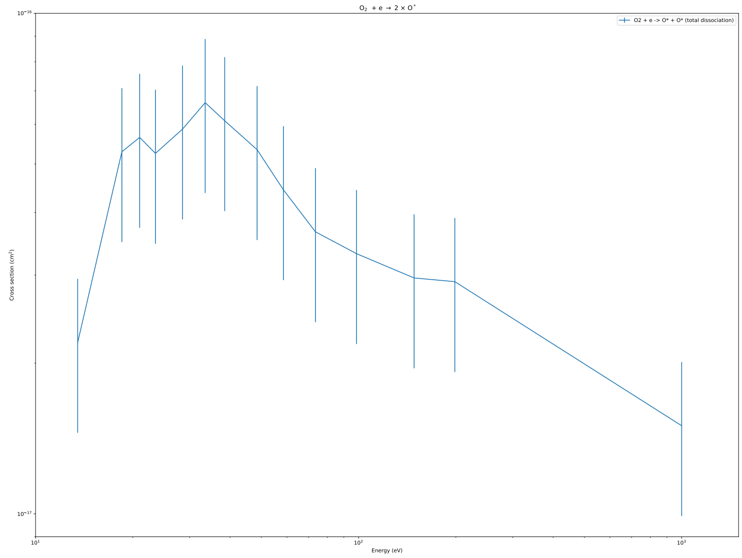

Figure 2.76: Cross sections for O_2 + e $\rightarrow$ 2 $\times$ O^*

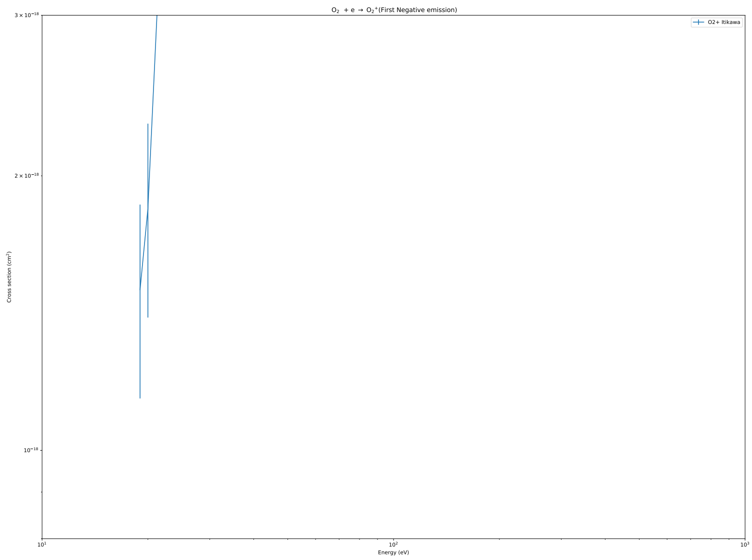

Figure 2.77: Cross sections for O_2 + e $\rightarrow$ O_2^+(First Negative emission)

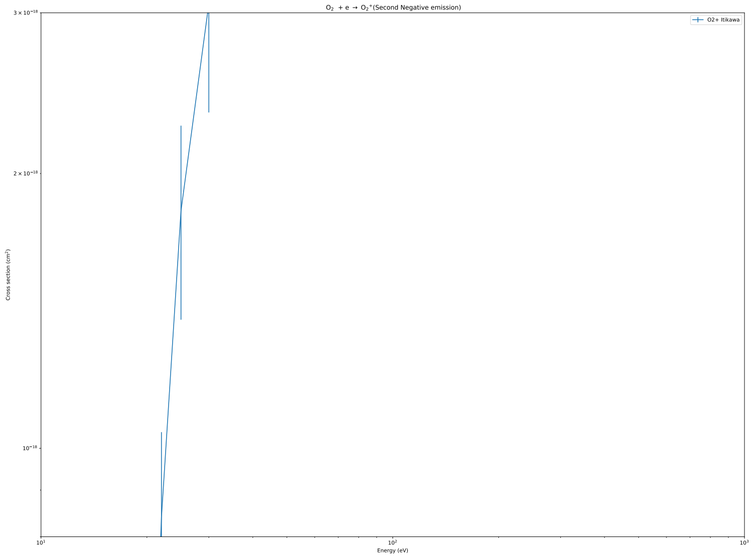

Figure 2.78: Cross sections for O_2 + e → O_2^+(Second Negative emission)

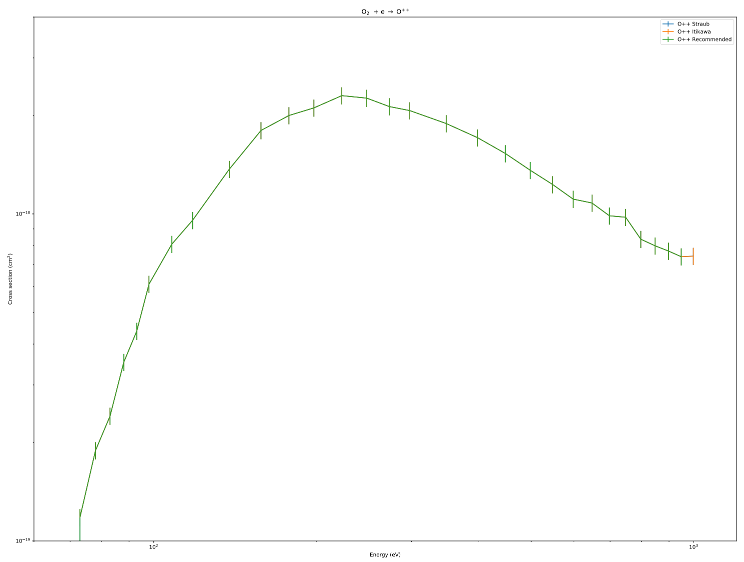

Figure 2.79: Cross sections for O_2 + e → O^{++}

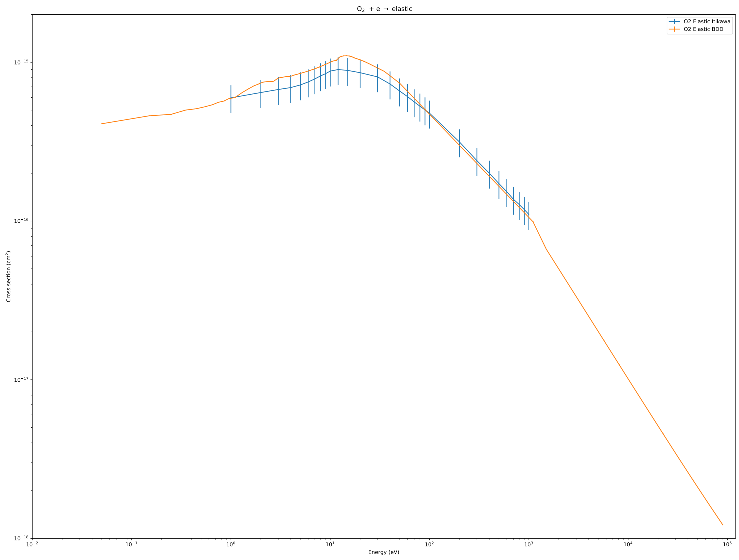

Figure 2.80: Cross sections for O_2 + e → elastic

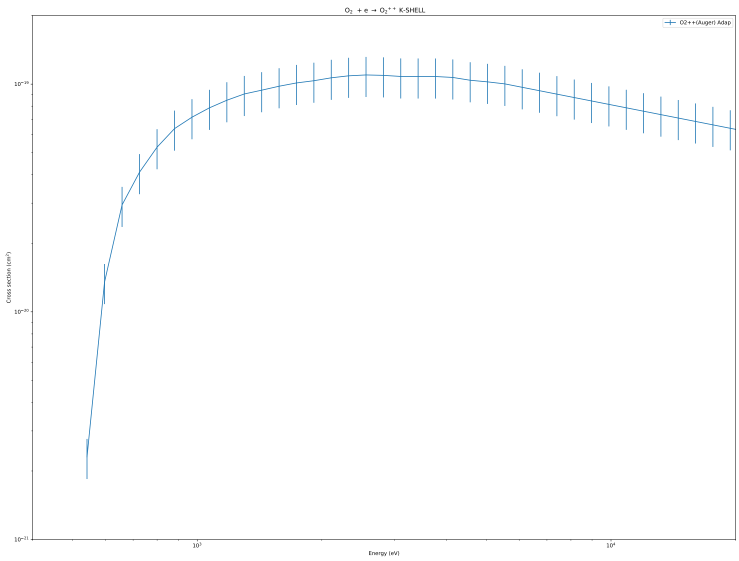

Figure 2.81: Cross sections for O_2 + e → O_2^{++} K-SHELL

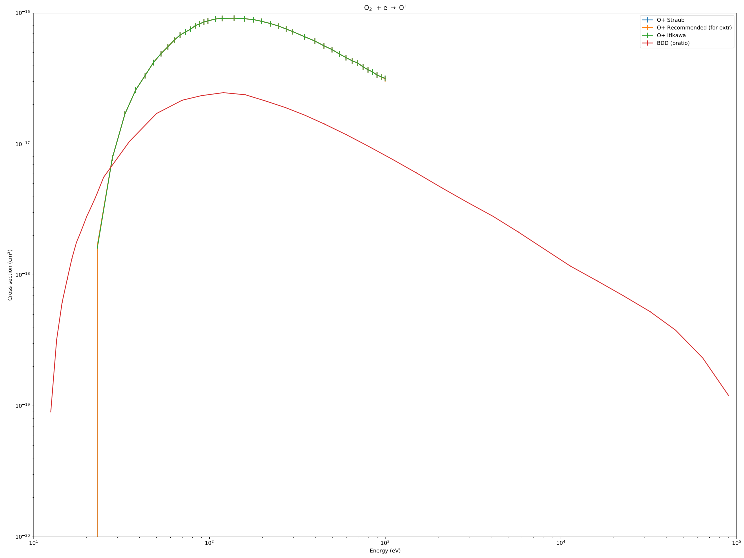

Figure 2.82: Cross sections for $O_2 + e \rightarrow O^+$

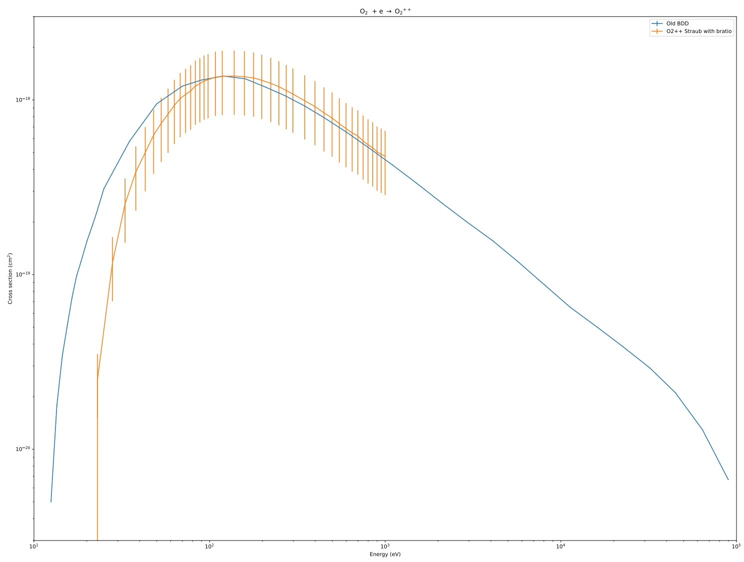

Figure 2.83: Cross sections for $O_2 + e \rightarrow {O_2}^{++}$

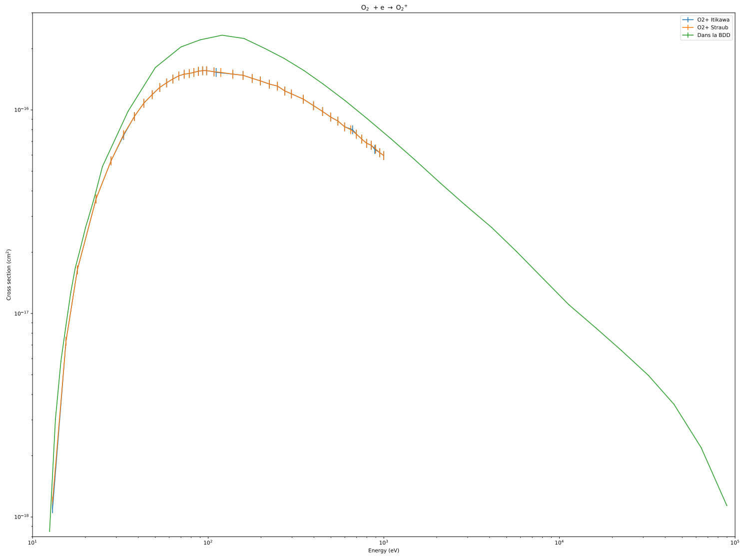

Figure 2.84: Cross sections for O_2 + e $\rightarrow$ $O_2{}^+$

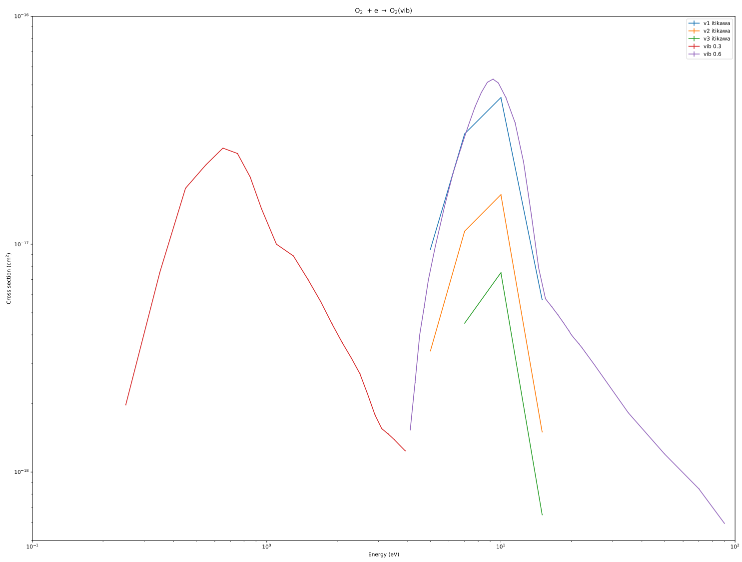

Figure 2.85: Cross sections for O_2 + e $\rightarrow$ O_2(vib)

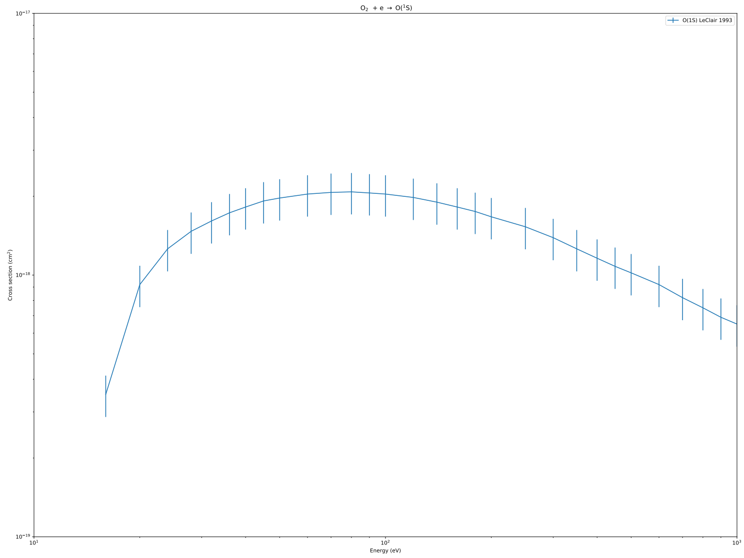

Figure 2.86: Cross sections for $O_2 + e \rightarrow O(^1S)$

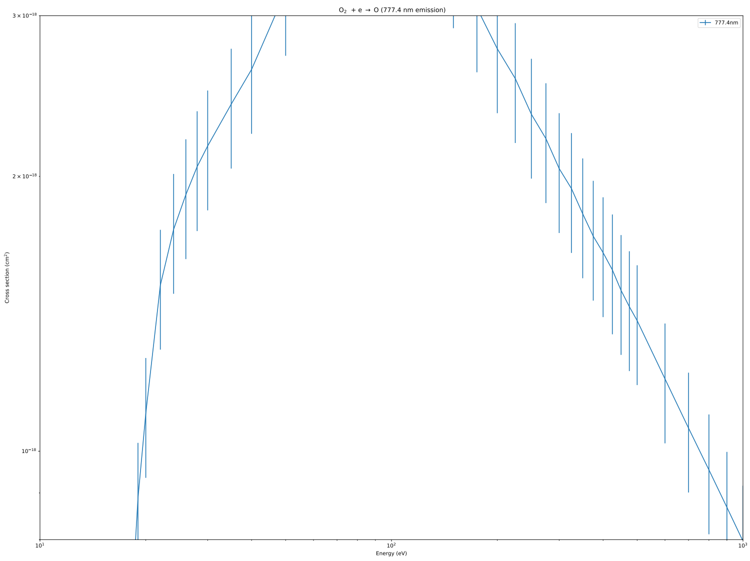

Figure 2.87: Cross sections for $O_2 + e \rightarrow O$ (777.4 nm emission)

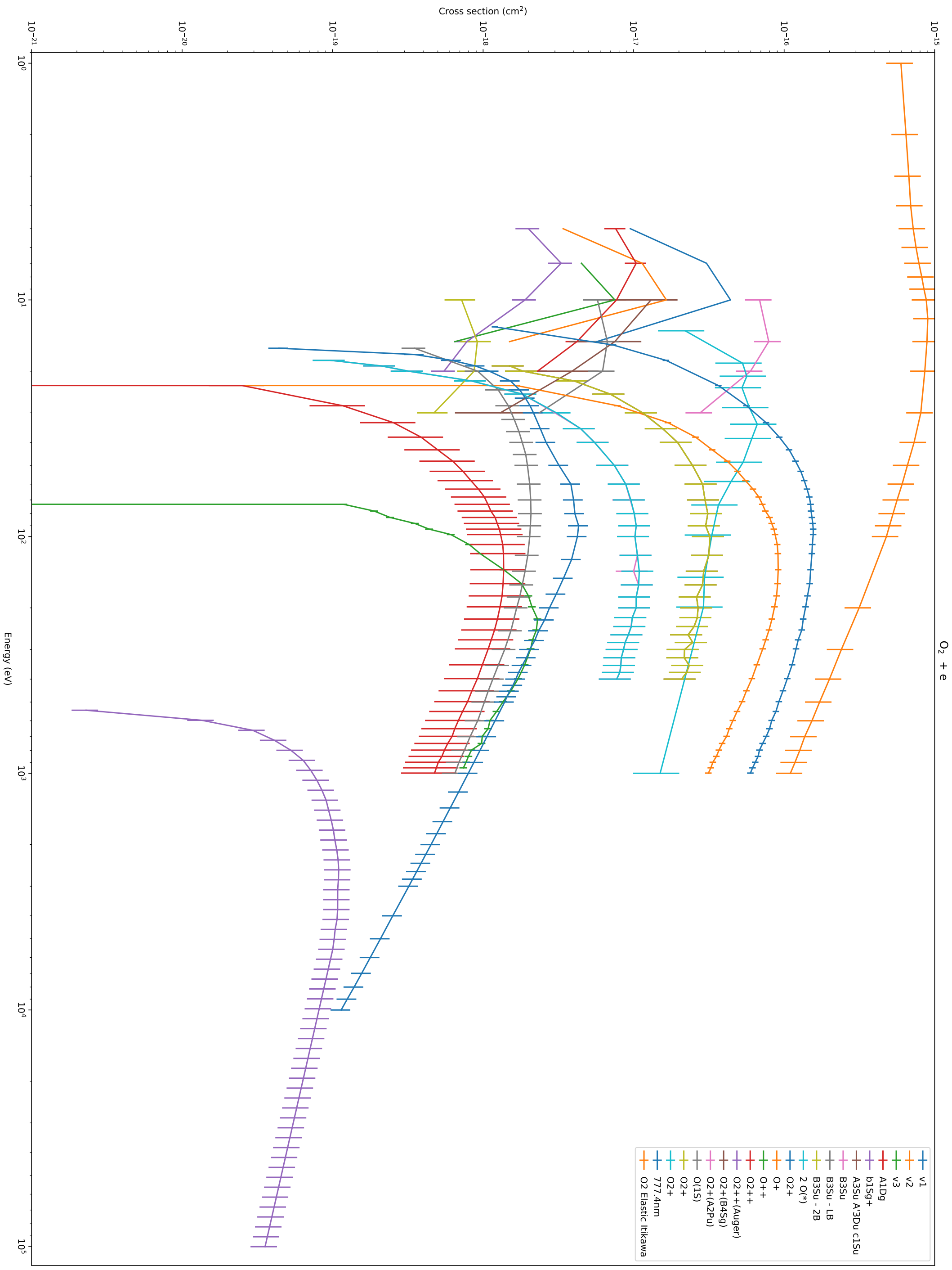

Figure 2.88: Cross sections for O_2 + e

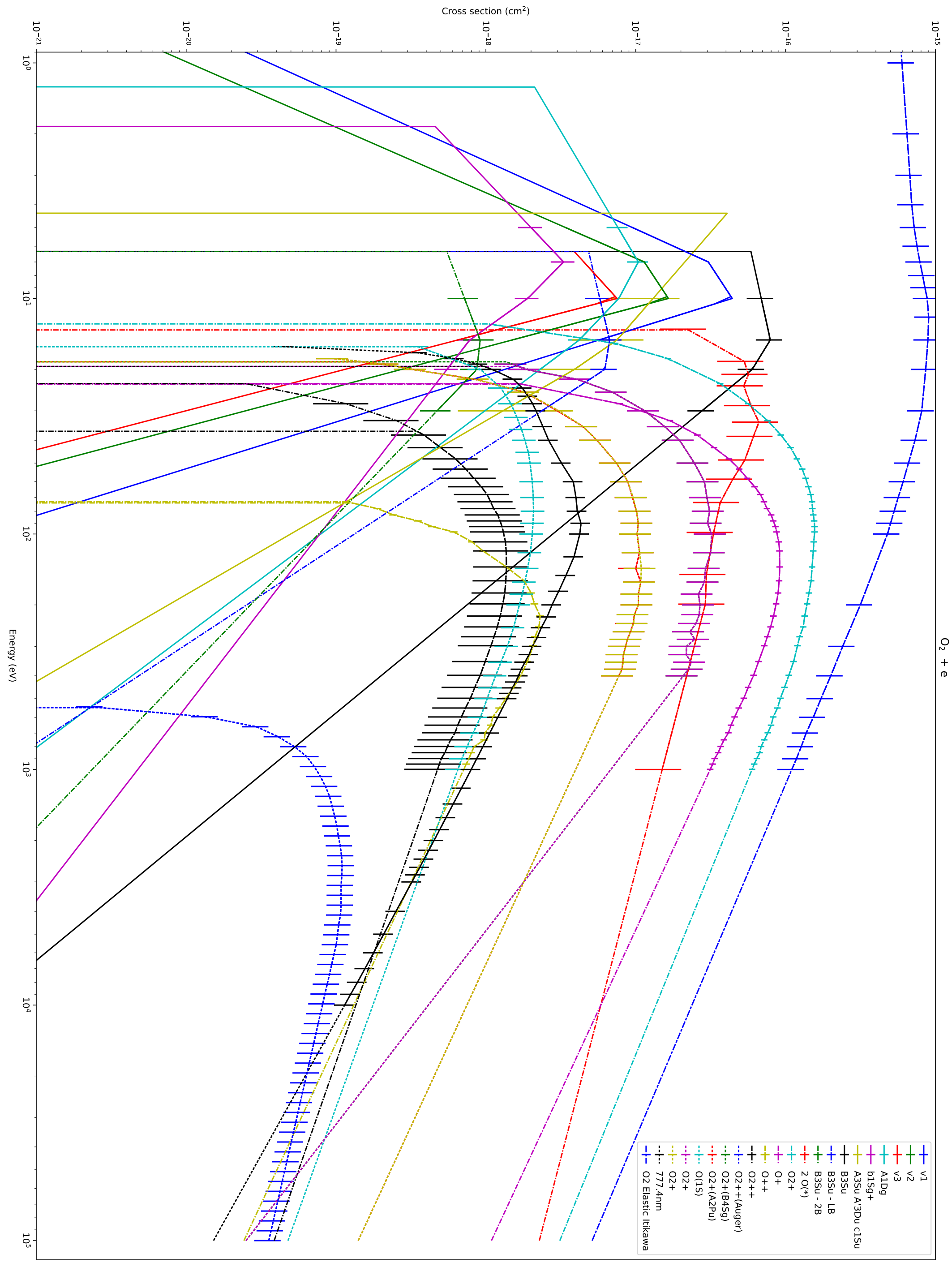

Figure 2.89: Cross sections for O_2 + e (wavelength with extrapolation version)

2.10 Cross section of e impact with O

2.10.1 Elastic Cross Section

2.10.2 Inelastic Cross Sections

Ionization Cross Sections

O + e → O+

Notes for O^+ BDD That ionization source comes from the old database (BDD), probable from Rees. It is adapted for extrapolation, but the uncertainty is unknown.

Notes for O^+ Thompson 1995 That ionization source comes from the measurements of Thompson 1995. These measurements are the latest, and have been taken in consideration in other sources (like Avakyan 98). The claimed uncertainty is 10%.

Notes for O^+ Avakyan 1998 The cross section, from Avakyan 1998, comes from the measurements of Thompson 1995, smoothed, and adapted for extrapolation. The claimed uncertainty is 10%. This is the currently **recommended** cross section for that process.

Notes for O^+ Laher 1995 The cross section, was adapted from the disponible bibliography at that time. The claimed uncertainty was close to 10%, but probably more important.

O + e → O++

O + e → O++(Auger)

Notes for O^{++} K-Shell ionization, Glupe 1967 The K-Shell ionization of O by electron impact has been studied in [2]. It has been extrapolated here.

Reference	Threshold	Range of energy	Uncertainty	Properties	Fig
???? ? BDD	0	0:-1	30%		Fig. 2.95
Revi Itikawa 1990	0	0:-1	30%	U	Fig. 2.95
Adap Itikawa 1990+Williams	0	0:-1	30%	UE	Fig. 2.95
Adap Itikawa 1990+Williams+High E estimation	0	0:-1	30%	RUE	Fig. 2.95

Table 2.34: Elastic cross section for e impact on O

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
$O + e \rightarrow O^{+}$	???? ? BDD	13.61	13.61:-1	???%	U	Fig. 2.104
	Meas Thompson 1995	13.61	13.61:-1	10%		Fig. 2.104
	Revi Avakyan 1998	13.61	13.61:-1	10%	RE	Fig. 2.104
	Revi Laher 90	13.61	13.61:-1	10%		Fig. 2.104
$O + e \rightarrow O^{++}$	???? ? BDD	48.74	48.74:-1	???%	U	Fig. 2.107
	Meas Thompson 1995	48.74	48.74:-1	15%		Fig. 2.107
	Adap Thompson 1995+extrapolation	48.74	48.74:-1	15%	RUE	Fig. 2.107
$O + e \rightarrow O^{++}$(Auger)	Meas Glupe Mehlhorn 1967	539	539:-1	15%	RE	Fig. 2.96

Table 2.35: Ionization Cross section for e impact on O

Excitation Cross Sections

O + e → O(4d-3D)

O + e → O(3p-3P)

O + e → O(3S)

O + e → O(Rydberg)

O + e → O(2p5-3P)

O + e → O((3S)1D)

O + e → O((3S)3D)

O + e → O(1S)

O + e → O(5d-3D)

O + e → O(3s”-3P)

O + e → O(1D)

O + e → O(3p-5P)

O + e → O(3d-3D)

O + e → O(5S)

O + e → O(4d-3P)

O + e → O(finestr)

2.10.3 Emission Cross Sections

O + e → O(3S)

O + e → O(5P)

O + e → O((3S)3D)

2.10.4 Recommended data set

O + e → O(4d-3D)

O + e → O(3p-3P)

O + e → O(3d-3D)

O + e → O(Rydberg)

O + e → O(2p5-3P)

O + e → O(5P)

O + e → Elastic

O + e → O((3S)3D)

O + e → O(3p-5P)

O + e → O+

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
O + e → O(4d-3D)	Revi Majeed 95	12.8	12.8:-1	???%	U	Fig. 2.100
O + e → O(3p-3P)	Meas Gulcicek 1988	10.99	10.99:-1	50%		Fig. 2.105
	Revi Laher 90	10.98	10.98:-1	50%		Fig. 2.105
	Revi Majeed 95	10.98	10.98:-1	50%	R	Fig. 2.105
O + e → O(^{3}S)	???? ? BDD	10.	10.:-1	???%	U	Fig. 2.109
	Revi Johnson 05	10.	10.:-1	20%	R	Fig. 2.109
	Revi Majeed 95	10.	10.:-1	50%		Fig. 2.109
O + e → O(Rydberg)	Revi Majeed 95	11	11:-1	50%	U	Fig. 2.98
O + e → O(2p5-3P)	Revi Majeed 95	15.65	15.65:-1	25%		Fig. 2.97
	Revi Laher 90	15.65	15.65:-1	25%	R	Fig. 2.97
O + e → O((3S)1D)	???? ? BDD	14.5	14.5:-1	???%	U	Fig. 2.102
	Revi Laher 90	12.53	12.53:-1	???%	U	Fig. 2.102
O + e → O((3S)3D)	???? ? BDD	15.	15.:-1	???%	U	Fig. 2.94
	Revi Majeed 95	12.53	12.53:-1	???%	RU	Fig. 2.94
	Revi Laher 90	15.	15.:-1	???%	U	Fig. 2.94
O + e → O(^{1}S)	???? ? BDD	4.	4.:-1	54%		Fig. 2.108
	Revi Laher 90	4.18	4.18:-1	54%	R	Fig. 2.108
	Revi Majeed 95	4.18	4.18:-1	54%		Fig. 2.108
O + e → O(5d-3D)	Revi Majeed 95	13.	13.:-1	???%	U	Fig. 2.90
O + e → O(3s"-3P)	Revi Majeed 95	14.	14.:-1	???%	U	Fig. 2.91
O + e → O(^{1}D)	Adap Itikawa 90	2.1	2.1:-1	50%	RE	Fig. 2.101
	Revi Laher 90	1.96	1.96:-1	50%		Fig. 2.101
	Revi Majeed 95	1.96	1.96:-1	50%		Fig. 2.101
O + e → O(3p-5P)	Revi Laher 90	10.73	10.73:-1	50%	R	Fig. 2.99
	Revi Majeed 95	10.73	10.73:-1	50%		Fig. 2.99
O + e → O(3d-3D)	Revi Majeed 95	12.1	12.1:-1	???%	U	Fig. 2.106
O + e → O(^{5}S)	???? ? BDD	10	10:-1	???%	U	Fig. 2.92
	Revi Laher 90	9.14	9.14:-1	50%	R	Fig. 2.92
	Revi Majeed 95	9.14	9.14:-1	???%	U	Fig. 2.92
	Meas Doering and Gulcicec	9.14	9.14:-1	40%		Fig. 2.92
	Meas Avakyan	9.14	9.14:-1	50%		Fig. 2.92
O + e → O(4d-3P)	Revi Majeed 95	13.	13.:-1	???%	U	Fig. 2.103
O + e → O(finestr)	???? ? BDD	0.0178	0.0178:-1	???%	U	Fig. 2.110
	Revi Itikawa 1990	0.0178	0.0178:-1	50%	RU	Fig. 2.110
	Revi Itikawa 1990	0.0178	0.0178:-1	50%	RU	Fig. 2.110

Table 2.36: Excitation Cross section for e impact on O

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	Plots
O + e → O(^{3}S)	???? ? BDD	10.	10.:-1	???%	U	Fig. 2.9
	Revi Johnson 05	10.	10.:-1	20%	R	Fig. 2.9
O + e → O(5P)	Adap Johnson 05 and Julienne 1976 and Lanchester 2009	10.	10.:-1	20%	R	Fig. 2.9
O + e → O((3S)3D)	Meas Zipf Erdman 85	15.	15.:-1	???%	U	Fig. 2.9

Table 2.37: Emission Cross section for e impact on O

Process	Reference	Threshold	Range of energy	Uncertainty	Properties	
O + e → O(4d-3D)	Revi Majeed 95	12.8	12.8:-1	???%	U	Fig.
O + e → O(3p-3P)	Revi Majeed 95	10.98	10.98:-1	50%	R	Fig.
O + e → O(3d-3D)	Revi Majeed 95	12.1	12.1:-1	???%	U	Fig.
O + e → O(Rydberg)	Revi Majeed 95	11	11:-1	50%	U	Fig.
O + e → O(2p5-3P)	Revi Laher 90	15.65	15.65:-1	25%	R	Fig.
O + e → O(5P)	Adap Johnson 05 and Julienne 1976 and Lanchester 2009	10.	10.:-1	20%	R	Fig.
O + e → Elastic	Adap Itikawa 1990+Williams+High E estimation	0	0:-1	30%	RUE	Fig.
O + e → O((3S)3D)	Revi Majeed 95	12.53	12.53:-1	???%	RU	Fig.
O + e → O(3p-5P)	Revi Laher 90	10.73	10.73:-1	50%	R	Fig.
O + e → O^{+}	Revi Avakyan 1998	13.61	13.61:-1	10%	RE	Fig.
O + e → O(5d-3D)	Revi Majeed 95	13.	13.:-1	???%	U	Fig.
O + e → O(3s"-3P)	Revi Majeed 95	14.	14.:-1	???%	U	Fig.
O + e → O^{++}(Auger)	Meas Glupe Mehlhorn 1967	539	539:-1	15%	RE	Fig.
O + e → O(^{1}D)	Adap Itikawa 90	1.96	1.96:-1	50%	RE	Fig.
O + e → O(^{1}S)	Revi Laher 90	4.18	4.18:-1	54%	R	Fig.
O + e → O(^{3}S)	Revi Johnson 05	10.	10.:-1	20%	R	Fig.
O + e → O^{++}	Adap Thompson 1995+extrapolation	48.74	48.74:-1	15%	RUE	Fig.
O + e → O(^{5}S)	Revi Laher 90	9.14	9.14:-1	50%	R	Fig.
O + e → O(4d-3P)	Revi Majeed 95	13.	13.:-1	???%	U	Fig.
O + e → O(finestr)	Revi Itikawa 1990	0.0178	0.0178:-1	50%	RU	Fig.
	Revi Itikawa 1990	0.0178	0.0178:-1	50%	RU	Fig.

Table 2.38: Recommended Cross section for e impact on O

the data (e.g. errorbars, comparison with other experiments), the possibility of extrapolation, and the origin of the work, coupled with the consistency (sum of recommended cross sections   Total cross section)

U   : Estimated uncertainty: sometimes, the uncertainty is not given, because of theoretical work... The authors of the database have to estimate the uncertainty, but the quality of that estimation can be questionable. Moreover, when data from different sources have been adapted (e.g. for extrapolation), the uncertainty can be modified...

E   : Validated for extrapolation: the extrapolation of these cross sections is plausible. For example, when an analytic function has been applied...

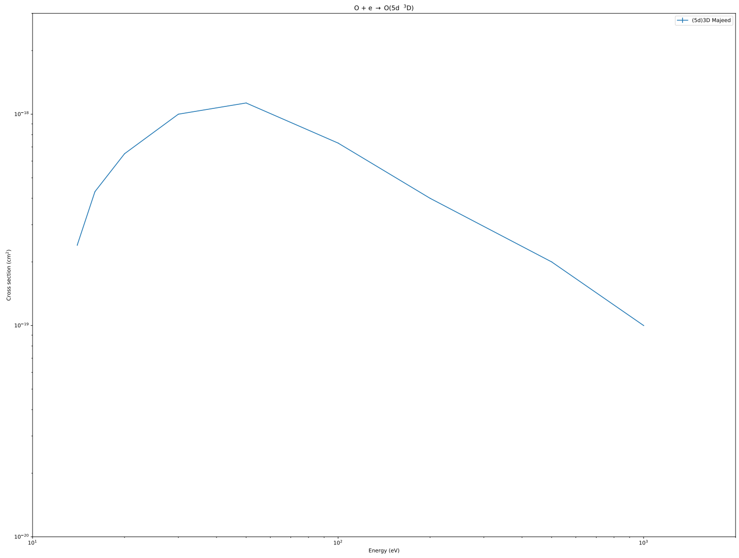

Figure 2.90: Cross sections for O + e $\rightarrow$ O(5d ^{3}D)

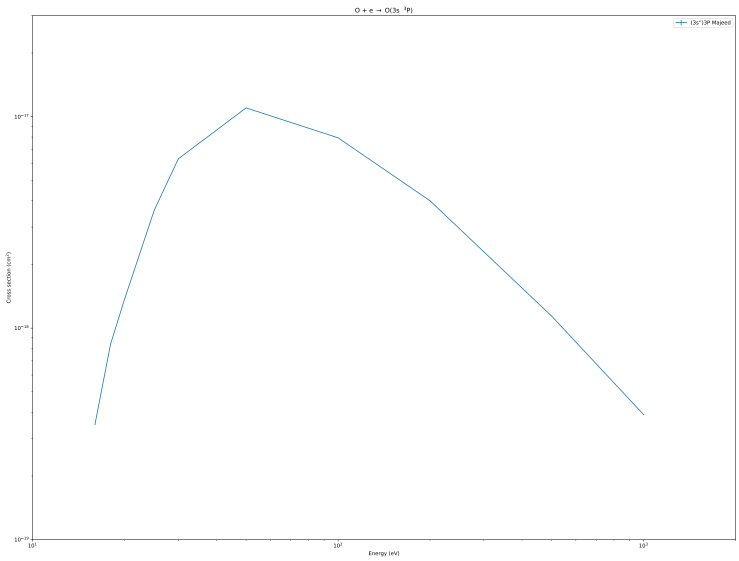

Figure 2.91: Cross sections for O + e $\rightarrow$ O(3s ^{3}P)

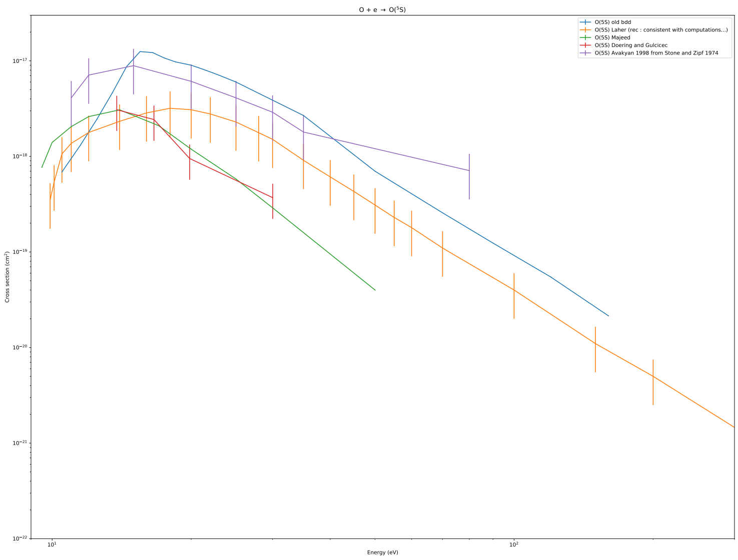

Figure 2.92: Cross sections for O + e → O(^{5}S)

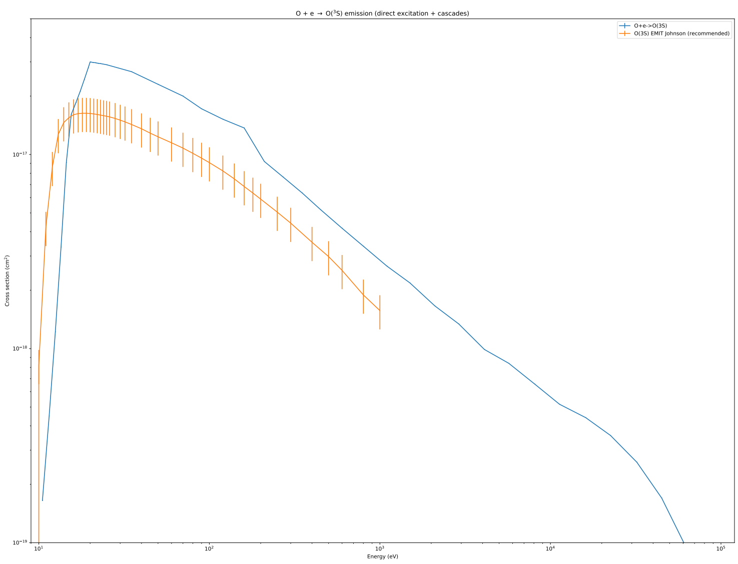

Figure 2.93: Cross sections for O + e → O(^{3}S) emission (direct excitation + cascades)

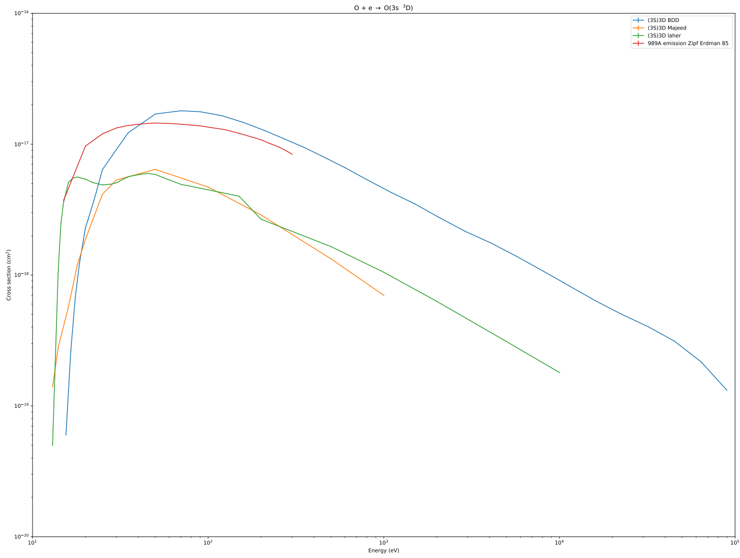

Figure 2.94: Cross sections for O + e → O(3s ^{3}D)

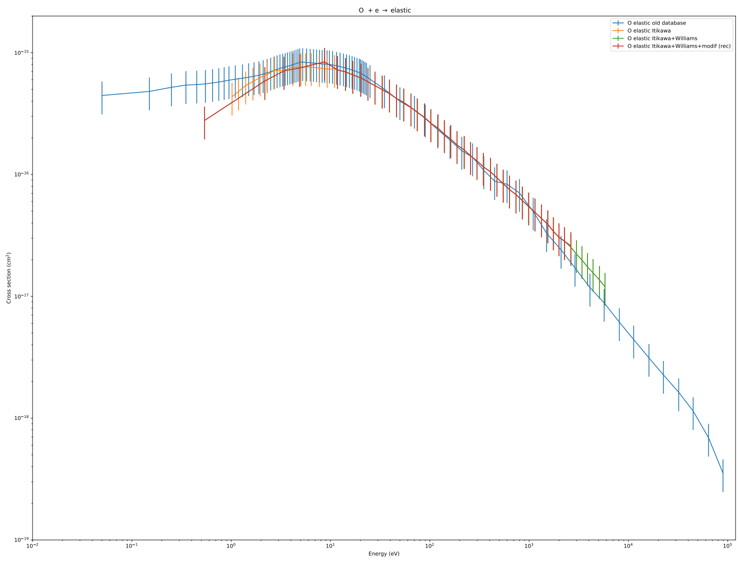

Figure 2.95: Cross sections for O + e → elastic

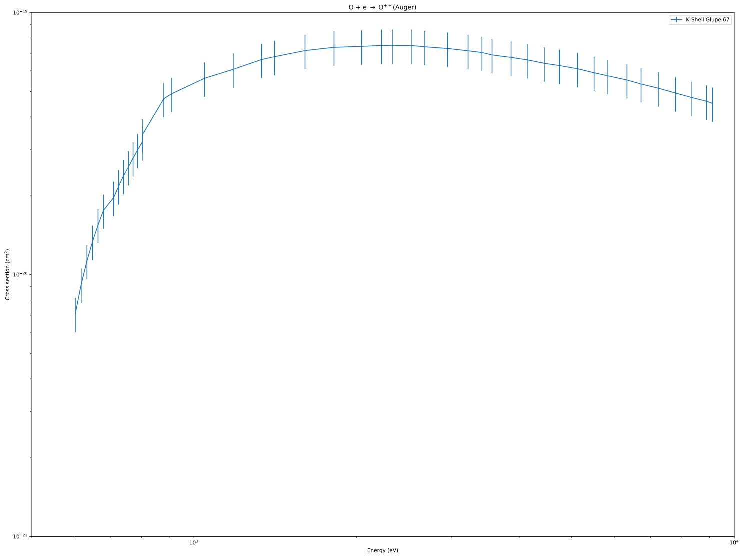

Figure 2.96: Cross sections for O + e $\rightarrow$ O^{++}(Auger)

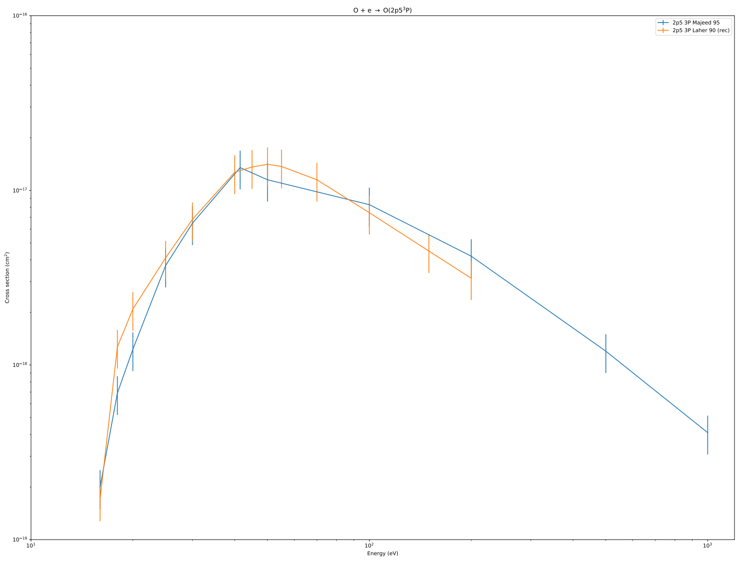

Figure 2.97: Cross sections for O + e $\rightarrow$ O(2p5^{3}P)

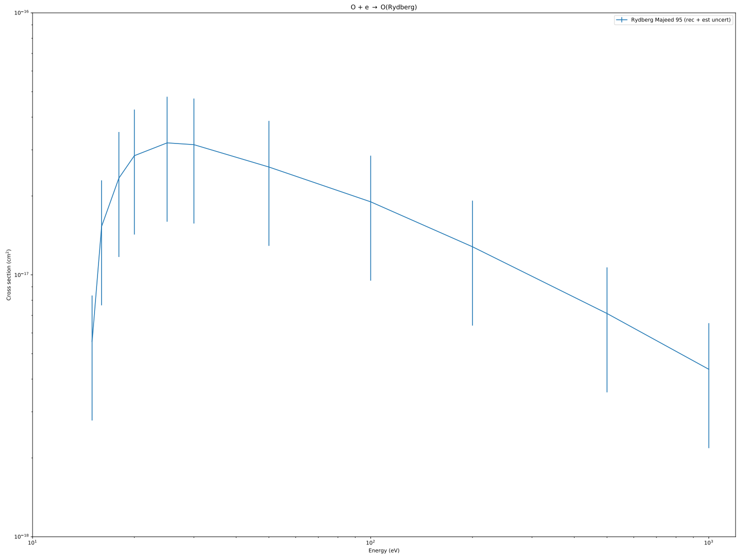

Figure 2.98: Cross sections for O + e → O(Rydberg)

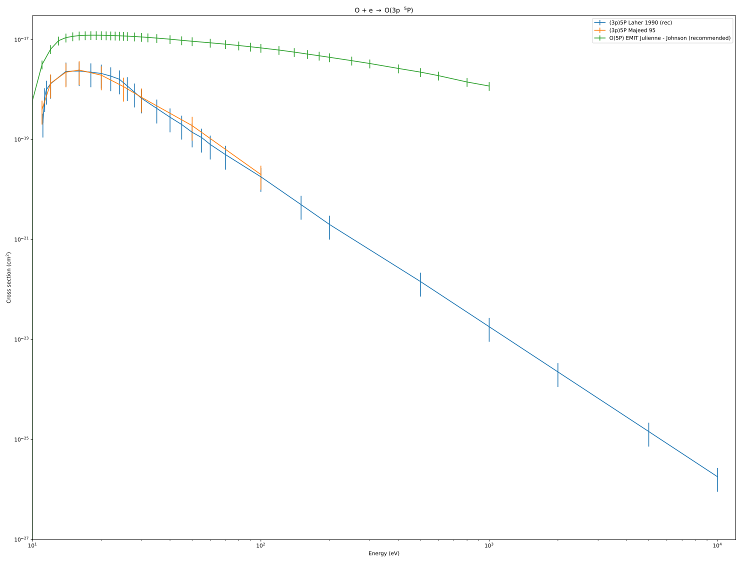

Figure 2.99: Cross sections for O + e → O(3p ^{5}P)

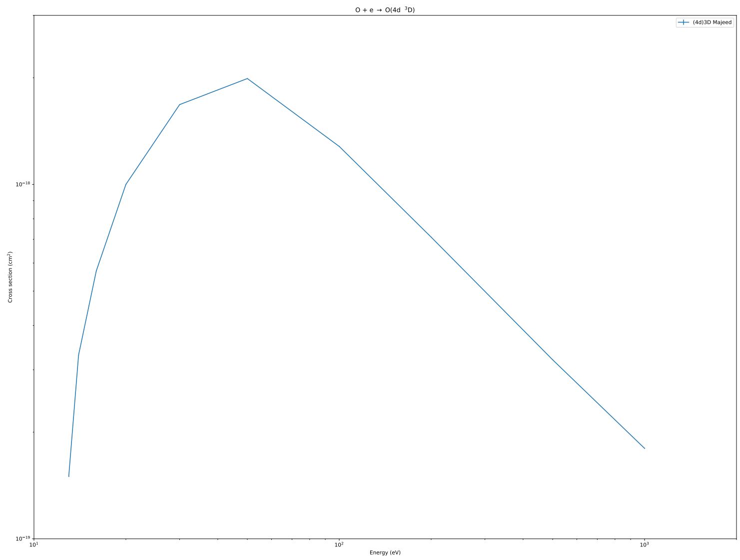

Figure 2.100: Cross sections for O + e → O(4d ^{3}D)

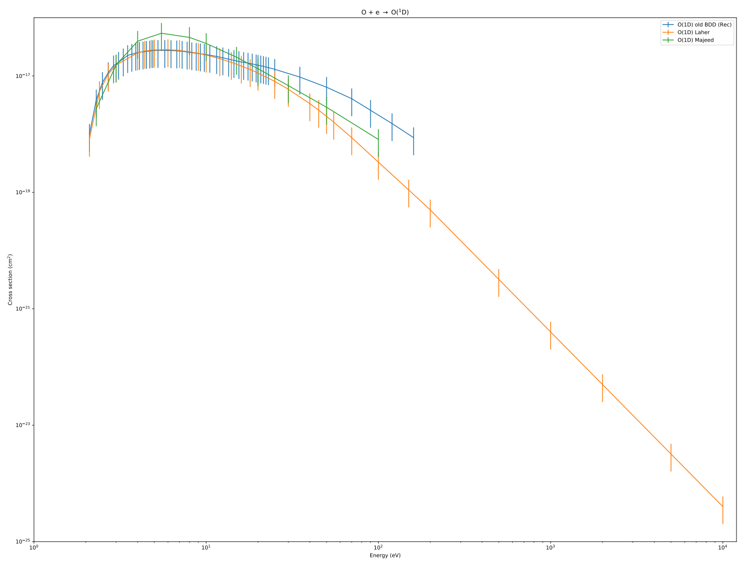

Figure 2.101: Cross sections for O + e → O(^{1}D)

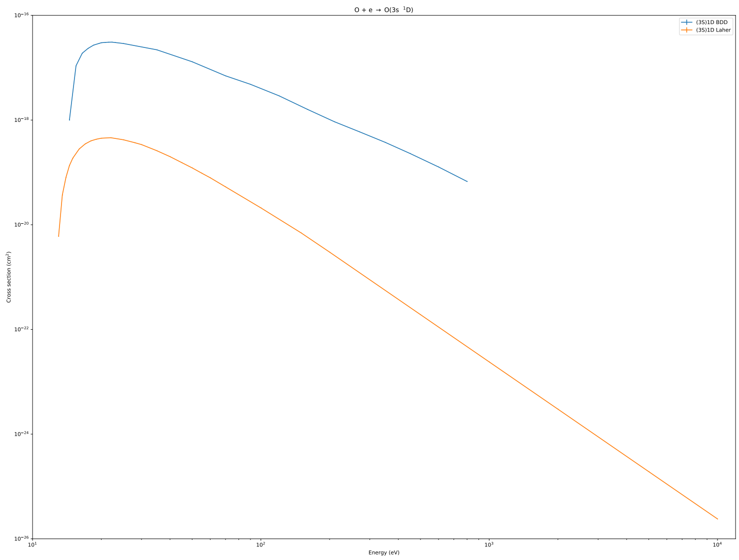

Figure 2.102: Cross sections for O + e → O(3s ^{1}D)

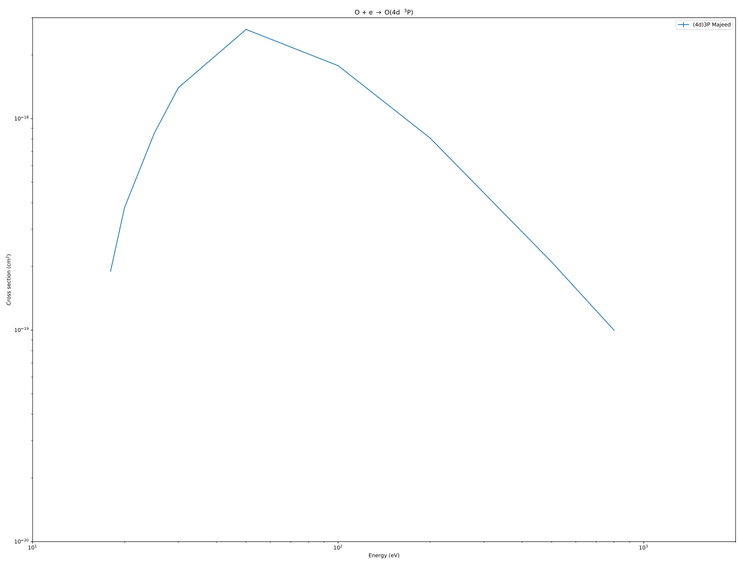

Figure 2.103: Cross sections for O + e → O(4d ^{3}P)

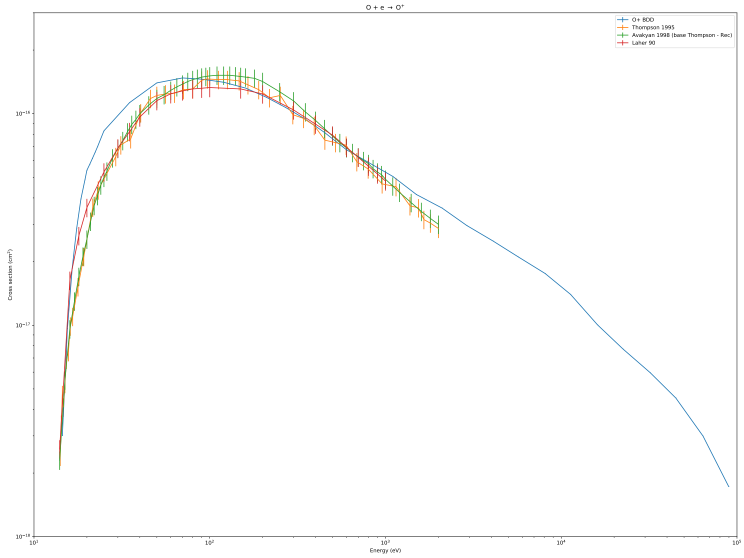

Figure 2.104: Cross sections for O + e $\rightarrow$ O^+

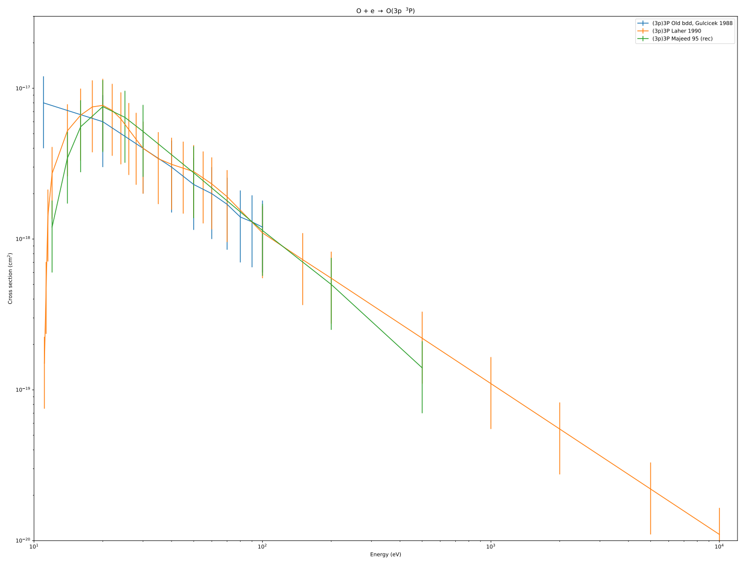

Figure 2.105: Cross sections for O + e $\rightarrow$ O(3p ^{3}P)

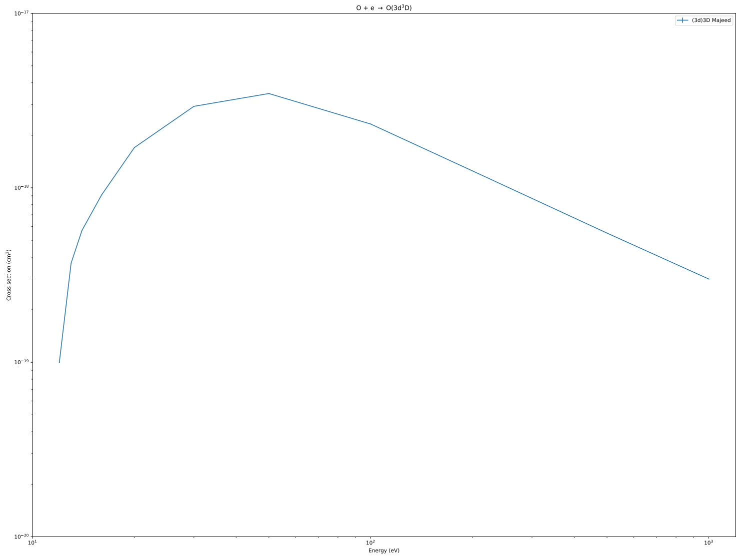

Figure 2.106: Cross sections for O + e → O(3d^{3}D)

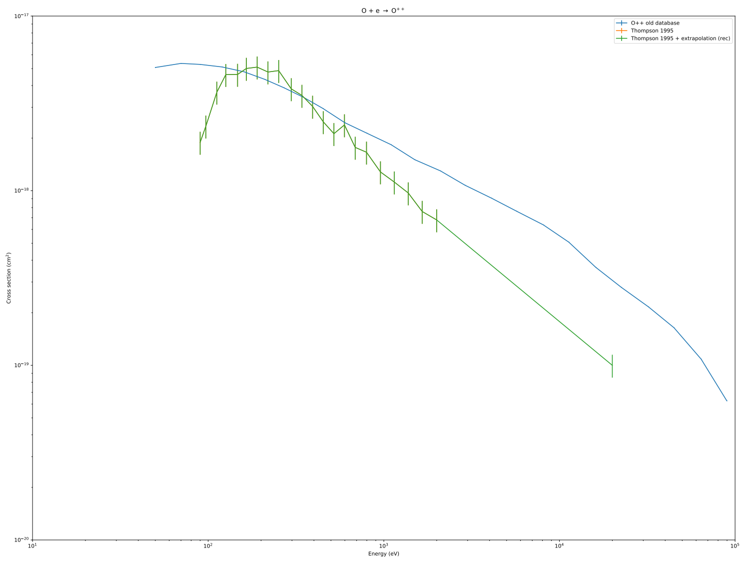

Figure 2.107: Cross sections for O + e → O^{++}

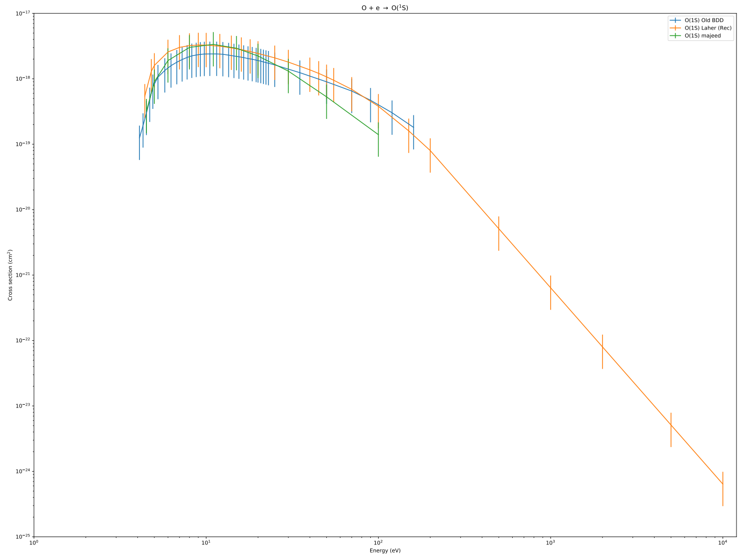

Figure 2.108: Cross sections for O + e $\rightarrow$ O(^{1}S)

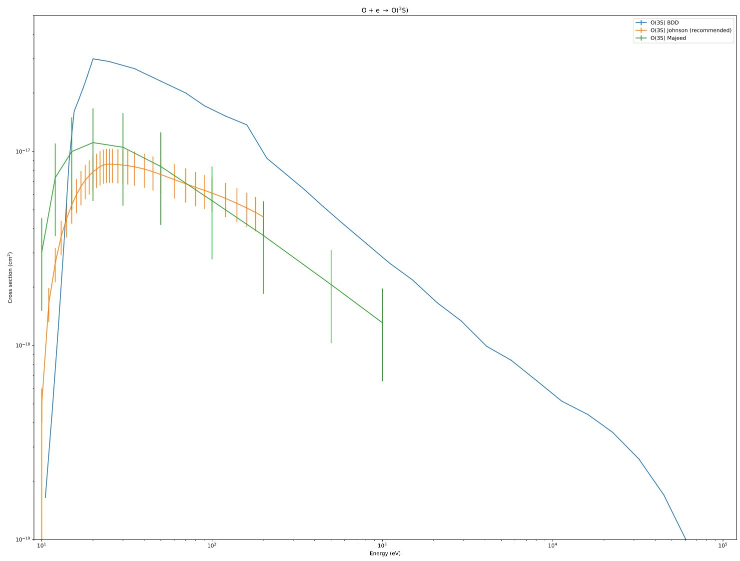

Figure 2.109: Cross sections for O + e $\rightarrow$ O(^{3}S)

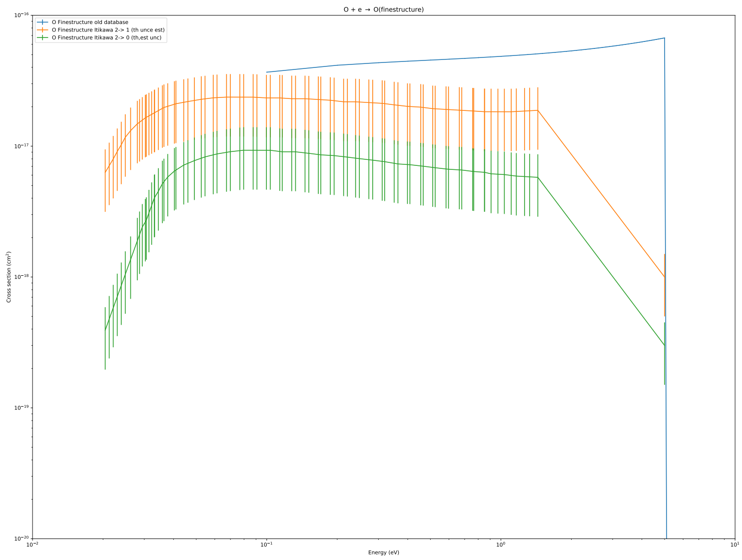

Figure 2.110: Cross sections for O + e → O(finestructure)

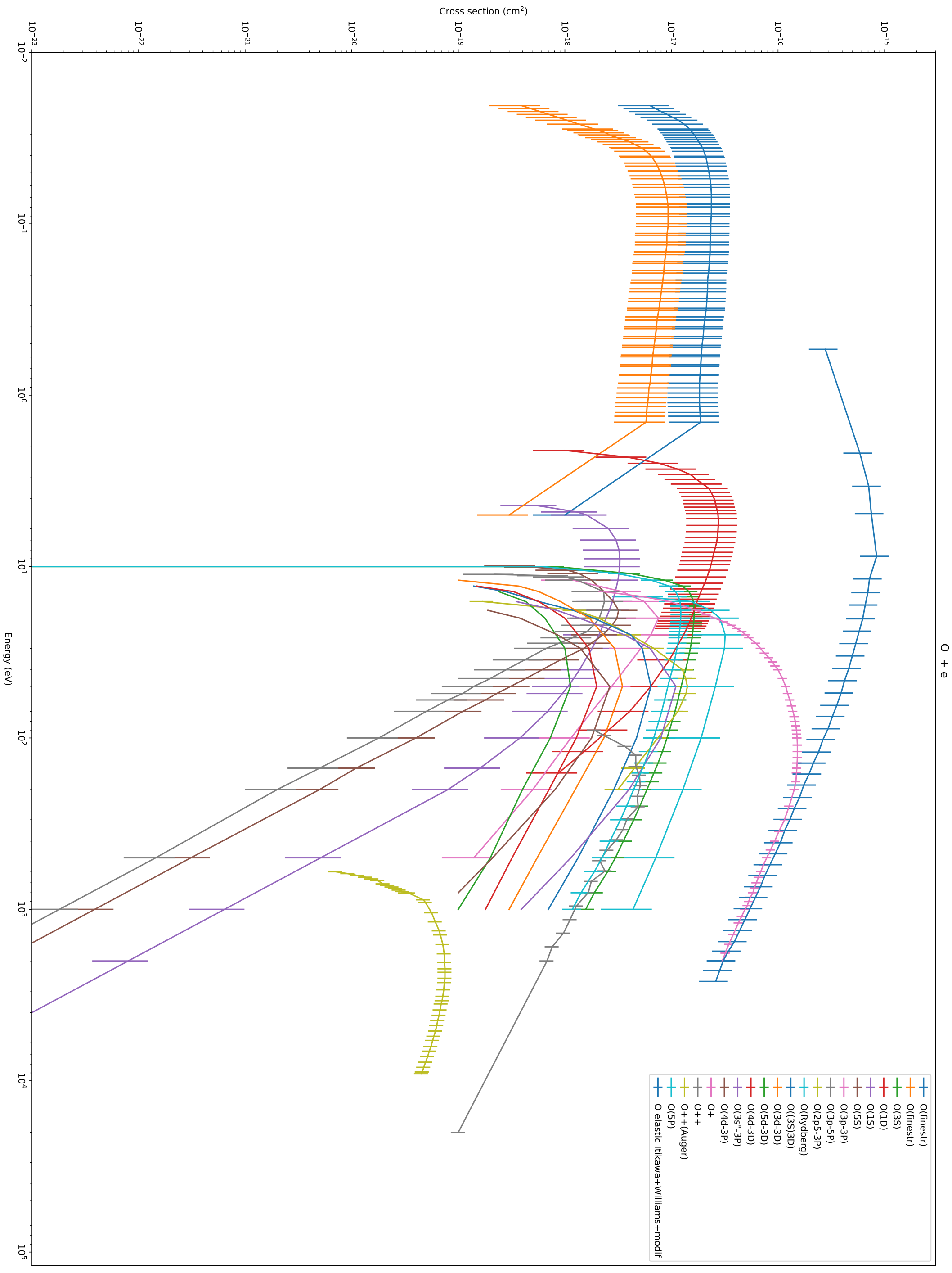

Figure 2.111: Cross sections for O + e

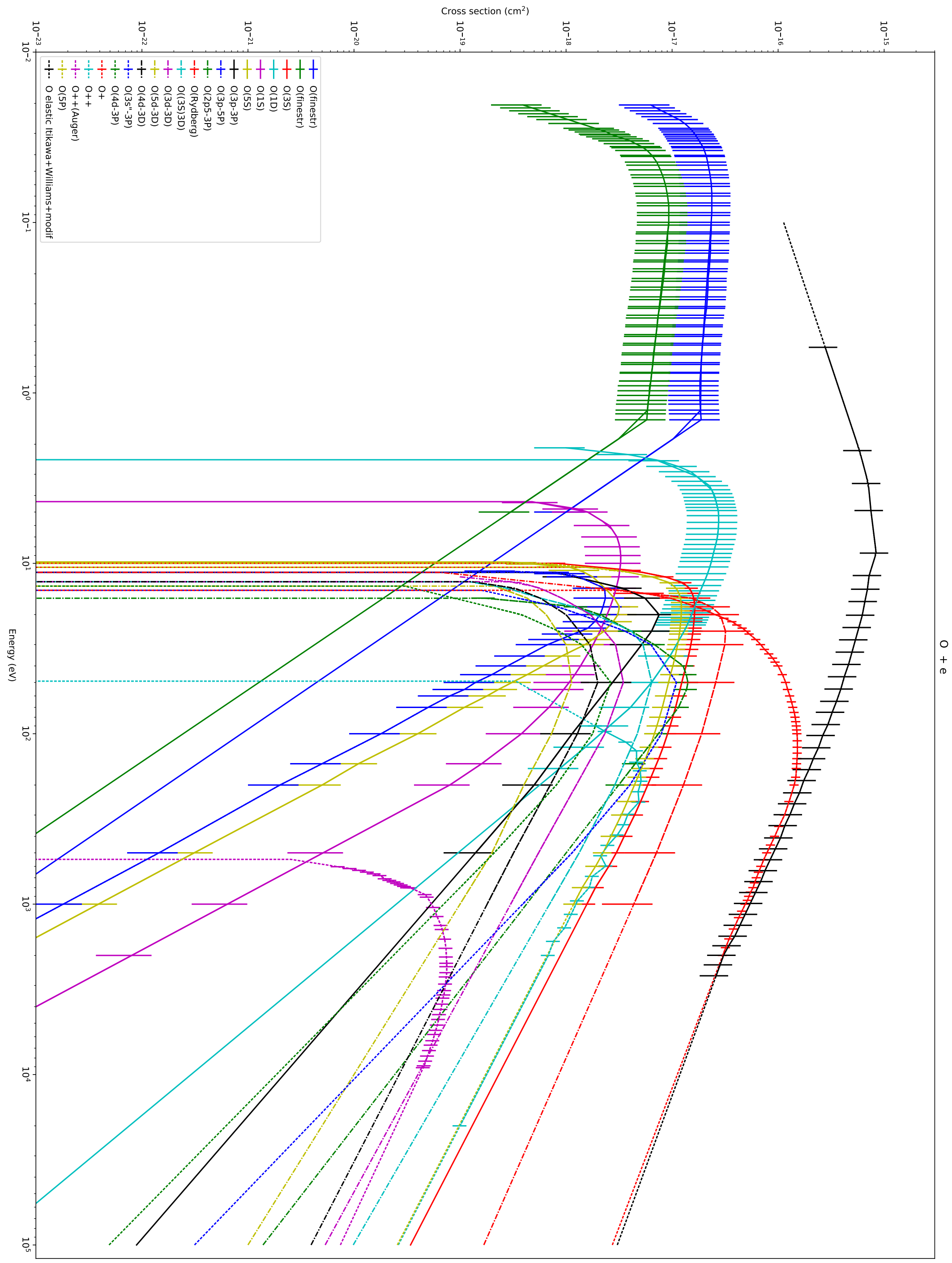

Figure 2.112: Cross sections for O + e (wavelength with extrapolation version)

Chapter 3

Sources for specific state or ions

3.1 Automatic computation of the list

The list can be automatically generated from the different files, or the recommended cross section file.

For consistency reasons, the following list was generated from the recommended set of data. The main reason lies in the non-recommended files: sometimes, the authors cannot discriminate between two species with their experiment, and then, gives the production for the two species (example: O_2^{++} and O^+ cannot be discriminated in standard ion mass spectrometer). It is stated in the specie list for that cross section in the non-recommended set, while in the recommended one, we tried to extract the species producted).

Chapter 4

Conclusion

The **AtMoCiad** database, presented here, will soon be released on internet, with free access. Contrarily to older databases, the design, presented in the appendixes, was developed for frequent modification and updates. Moreover, it is intended to be extended and completed for the scientific community, by the scientific community.

More than an useful tool for each user, **AtMoCiad** is also the basis for comparing the different codes developed by the modelers, along with a reference for the experimental community, and especially the laboratory that measure these cross sections.

Appendix A

The XML files

A.1 Working with XML files

XML is a kind of standardized ASCII file. It looks like HTML, but strict (markup should be closed, no bracing like $< a >< b >< /a >< /b >$ but $< a >< b >< /b >< /a >$). It is well suited for defining configuration, especially for communication between different softwares. Unfortunately for scientific purpose, it does not explicitly defines the notion of array (some specific files format, like hdf, are more suited when dealing with very large data files): list of numbers are used as array for the following.

Several advantages can be found in XML files:

1. Flexibility: you can make a lot of commentaries: reading XML files does not depend on the position of your data (contrary to the typical interface file in Fortran, for which the number of value to read has to be stated).

2. Size of data: you don't have to declare the size of your arrays, it is computed automatically.

3. Position of your information: you can put the information wherever you want! For example AeroPlanets uses a XPath wrapper to read the file: it depends on the hierarchy and the name of the markup.

4. Possibility to duplicate markup. Typically the output of selected species production! You can select different species...

5. Mixing strings and numbers! This allows REALLY flexible softwares. Typically in this case, you define the species, and its cross section.

Therefore, the addition of a new species can be straightforward[1].

6. Widely used formating system. It is easy to write

Of course, when implementing a full support of XML files, you have to take into account several points:

- XML is not a real user-computer interface. But editors exists, and it is the best format if you plan to add a web-based interface.
- XML is not dedicated to large dataset. When dealing with very big files, you should consider using HDF (binary, but without endianness problems).
- For the present database, the need for flexibility (frequent modifications), for interfacing (plot, python, C++), and for ease of integration into a system dedicated for several planets, oriented us toward the direct use of XML files[2]

As you can see, the authors of this documents highly encourage the use of the XML (and HDF) file format.

Anyway, to have a comprehensive XML file, i.e. really flexible and usable in your model, several concepts needs to be understood.

A.1.1 Hierarchy

The hierarchy of the markup is very important. Hierarchy means dependence. It is well suited for large set of options. Example, to define the mass and the ground state of CO2, the XML way could be:

```
<!-- The XML comment are inside this king of strange brackets! -->
<CO2>
<!-- Mass in amu -->
<mass>44.00995</mass>

<!-- List of possible states, beginning with the ground state -->
<states>
X
```

[1]It is especially true in AeroPlanets , you can define a new species in your database, then add its atmospheric model in the configuration file! In other terms, you can add a specie in a planet model without modifying the source code and so without recompilation.

[2]For people considering using other file format, the best solution is to use python-elementtree to create a conversion software.

```
</states>
<!-- ... -->
</CO2>
```

Here, state and mass are hierarchically inferior to CO2. (Note the way we write commentaries $<! - - \; - - >$). Such writing allows to define several species, with the same template[3] .

In the following, the hierarchy for the options will be written in a XPATH-style.

It means that the "mass" option in the precedent example will be presented as /CO2/mass.

A.1.2 Markup keys

Sometimes[4], we can use a key inside the markup $< truc\ key =' 42' > bla < /truc >$. We use this option to add simple statements, like model type:

```
<!-- altitude grid -->
<alt_grid>
<!--
use_model type:
0 : standard grid
1 : data
-->
<use_model type="0"/>
<!--
If we use a standard grid, the options are:
type 0 : exp decrease
type 1 : power law decrease
type 2 : constant width
-->
<st_grid type="0">
<altmin>120</altmin>
<altmax>300</altmax>
<number>50</number>
</st_grid>

<altdata></altdata>
```

[3]Note to developers: XPath defines nodes to work with such templates.

[4]Strictly speaking, use of keys can be avoided in XML: it could be replaced by the use of a hierarchically inferior markup. Anyway, we sometimes prefer not to write the closing markup: understandable names are sometimes very long. . .

```
</alt_grid>
```

This facility is really powerful when we work with uncertainties:

```
<Cross unit="cm2" uncertainty="30%">
...
```

We can define the uncertainty for an array really easily.

A.1.3 Numerical values

Two key are very important for the database, the “fact” and “uncertainty” keys.

These are used a lot in the definition, and bad interpretation of the database could come from the misuse of these keys.

The “fact” key

The numerical values can be modified thanks to the “fact” key. For example:

```
<a fact='12'>1</a>
```

will give a result of 12 if it is treated as a numerical value.

The “uncertainty” key

As explained before, this key is used to define the uncertainty of the dataset. If used with a % sign, it is perceived as a percentage. If not, it should be taken as the 1-σ difference.

A.2 The cross section files

The cross section XML files are the core of the database. They can easily be modified, transformed into other kind of files, or automatically plotted with the specific tools.

These standardized files also contains information to automatically create the web and pdf interfaces to the database. The photoionization cross sections files are the simplest, because more information are needed for the electron files. Therefore, we will describe the photon files before the improvements in the electron files.

The recommended cross section files are the dataset that should be used in the different softwares. In AeroPlanets , these XML files are directly used as inputs.

A.2.1 The heading of the cross section files

To ensure the validity of the documents, it start and ends with the "<crs>/</crs>" markup. The cross sections, should be put in the valid format inside a SPECIE markup. For example, for a file with CO_2 and O^+ cross sections, the file should look like:

```
<crs>
...
<CO2>
...
</CO2>
...

<O_PLUS>
...
</O_PLUS>
</crs>
```

Because the '+' character is not allowed inside the XML markup name, it has to be transformed into _PLUS in the database.

Strictly speaking, the cross section files are meant to describe only one species, and only one kind of interaction.

This allows an automatic plot and some other automatic interactions, by putting some markup specific to that file.

For example, if one file contains the cross sections for one process, from different sources. We could define a specific title, limits for an automatic plot, plotname...

/crs/Name : The name of the species that reacts. (*)[5]

/crs/Collider : The name of the particle that impact with the species (ph for photons, e for electrons, and soon p for protons). (*)

/crs/RecommendedFile : If the RecommendedFile markup is present, the system knowns that it is likely to be the whole set for the different cross sections. It is notably used inside the plotting system to plot the name of the process for each cross section, and not the extended legend.

[5](*) stands for mandatory options.

/crs/title : Title of the cross section file, typically written in latex: the pylab library is able to transform formulae for the title of the plots. (*)

/crs/Emin : For plotting: lower energy boundary. (*)

/crs/Emax : For plotting: upper energy boundary. (*)

/crs/Cmin : For plotting: lower cross section boundary. (*)

/crs/Cmax : For plotting: upper cross section boundary. (*)

/crs/plotname : The name of the standard plot (no extrapolation, abscissa unit is energy in eV). (*)

/crs/lambplotname : If present, creates a plot against wavelength (no extrapolation, abscissa unit is in angstrom).

/crs/explotname : If present, extrapolates the standard plot (extrapolation, abscissa unit is energy in eV)

/crs/exlambplotname : If present, extrapolates the wavelength plot (extrapolation, abscissa unit is in angstrom).

Example: the header for the recommended $CO_2 + \lambda$ cross section file

```
<crs>
<Name>CO2</Name>
<Collider>ph</Collider>
<RecommendedFile/>
<title> CO$_2$  + $\lambda$</title>
<Emin>5</Emin>
<Emax>1E5</Emax>
<Cmax>1E-15</Cmax>
<Cmin>1E-28</Cmin>
<plotname>seff_CO2_ph_recommended.pdf</plotname>
<lambplotname>seff_CO2_ph_recommended_lambda.pdf</lambplotname>
<explotname>seff_CO2_ph_recommendedex.pdf</explotname>
<exlambplotname>seff_CO2_ph_recommended_lambdaex.pdf</exlambplotname>
<CO2>
```

```
...
</CO2>
</crs>
```

A.2.2 The photoionization cross section file (cross section basic file)

The cross sections works like the species file concerning the name (except that the highest markup[6] is “crs”.

/crs/species The species markup. Highest markup for the real definition.

/crs/species/TotalCrs This markup allows to define the total cross section. Very useful when we know it: it is really more precise than sum up ionization cross section.

The typical use of this markup is :

```
<TotalCrs>
<Egrid unit="eV">
</Egrid>
<Cross unit="cm2">
</Cross>
</TotalCrs>
```

Typically, the unit can have the uncertainty key:

```
<Cross unit="cm2"  uncertainty="30%">
<Cross unit="cm2"  uncertainty="0.1">
```

You can define an 1σ uncertainty in percentage: very useful when your cross section varies on a huge range of parameters! But you can also give a relative uncertainty, in the example, 0.1 stands for ± 0.1.

In both sub-markup, a “unit” key is defined. It is not used in AeroPlanets now[7], but:

- It is better when you check your data.
- It allows to be used of the standard units for the code.
- It can really be useful when used with other sources.

[6] All the files will have an highest markup now: it allows to look at the XML file with firefox, and therefore to allows firefox to detect the XML errors!

[7] Boost has a unit module...

Now, the only accepted units are "eV" for the energy grid and "cm2" for the cross sections.

Of course, you could use the "fact" option to modify the global value, this is the best way to transform Barn into cm^2...

/crs/species/TotalCrsIsTheSum As stated in the main document, for photoionization, it is better to have a total absorption cross section, instead of adding the other cross sections, because the uncertainty of the flux would be decoupled from the uncertainties of each processes which can be variable. Anyway, if you do not have a total cross section, just add

```
<TotalCrsIsTheSum/>
```

it allows to define that the total cross section is the sum of the other.

/crs/species/Process keys: name of the process, number of electrons, and threshold. It is also possible to add ions, very useful when double ionization. Note that the number of ions of electrons are floating point values[8]!

The number of electrons could be 0 even if there is an ionization. This is a technique used to take into account one excited state of an ion while the total ionization is computed through a more precise cross section.

```
<Process name="" electrons="" threshold="">
<!-- also possible:
<Process name="" electrons="" threshold="" ions="">
-->
<Species>
<Specie name="" state=""/>
<Specie name="" state="" number=""/>
</Species>
<Egrid unit="eV">
</Egrid>
<Cross unit="cm2">
</Cross>
</Process>
```

/crs/species/Process/Species The Species defines a list of species created through the process.

[8]Useful when the produced species are determined with a branching ratio.

/crs/species/Process/Species/Specie One of the created species (you can have several species, or 0! -but it is not really useful unless this is necessary for total crs sum-). The key for the species is its name and its state. The state can be X. It allows to compute the production of excited states! One of the very important point for the species state is the possibility to add "-NOTOT" at the end of the state. It defines that the state created for the species has already been counted in the total species production.

For example, the electron production for CO_2^+ can be computed without taking into account the different states. But if we need the A state, we have to add the Itikawa 2002 cross section. If we need both total production (accurate) and A state production, we just need to add -NOTOT at the end of the state name like in this example.

If we do not have the precision for the state computed, typically for an ion, the best way is to define the excited state as "Total".

```
<!--  Itikawa 2002  for CO2+(A)-->
<Process name="CO2+e -> CO2+(A) " electrons="0" threshold="17.32">
<Species>
<Specie name="CO2+" state="A-NOTOT"/>
</Species>
<!-- The ionization is not taken
into account, because
it is a subproduct of the total ionization
-->
...
</Process>
```

On the contrary, some processes defines the production of the X, A, B,...states. But not the total production. In that case, we do not add the -NOTOT at the end, and, by detecting that fact, we know that we must add each processes to get the total production.

The addition of -NOTOT is therefore specific to the recommended file, and depends on the whole set of cross sections.

Concerning the electron production

The electron production is computed by adding the electron production of all processes, thanks to the number of electrons parameters. If you want to define a subprocess, you must let the number of electron produced at 0!

Shirai cross sections

The electron cross sections from Shirai et al. [3, 4], Tabata et al. [5] can also be included (if one day, this kind of parametrisation of cross section is done for photoionisation, it could be adapted too).

/crs/species/Process/Shirai To define that we are using the Shirai/Tabata cross sections. An example of the interface for these cross sections files could be seen in the section **??**.

/crs/species/Process/Emin The minimum energy where it is defined (For non-Shirai system, it is the energy of the first non-zero data point. It can be automatically determined there.)

/crs/species/Process/Emax The maximum energy where it is defined (For non-Shirai system, it is the energy of the last non-zero data point. When the system is extrapolated, it could be a point defined for having a good shape, or the point where the extrapolation is expected to be valid It can be automatically determined there.). .

/crs/species/Process/Equation Gives the type of the equation, and the article id (and the number in the article, but not used).

/crs/species/Process/params Gives the parameters for the cross section.

```
<Process name=''CO2+e -> O + C'' electrons=''0'' threshold=''11.100000''>
<Shirai/><!--Shirai et al 2001 analytic cross section -->
<Species>
<Specie name=''C'' state=''X''/>
<Specie name=''O'' state=''X'' number=''2''/>
</Species>
<Emin> 13.5 </Emin>
<Emax> 199.0 </Emax>
<Equation type=''1'' article_id=''CO2'' article_number=''36''/>
<params>
7.040000e-01   1.084000e+00   2.680000e-02   5.700000e-01
</params>
</Process>
```

A.2.3 The Electron cross section file (extends the standard cross section!)

The electron cross section is basically the same file as the photoionization cross section[9] . The main difference is that the total cross section is not used. So, we generally define it as TotalCrsIsTheSum.

The total cross section is replaced by elastic, ionization and excitation cross sections (ionization and excitation are the inelastic cross sections, these cross sections have technically almost no differences, except being computed separately).

/crs/species/ElasticCrs Elastic cross section, defined like every other cross sections.

/crs/species/ExcitationCrs, /crs/species/IonizationCrs Allows to define total excitation and ionization cross sections. These options are NOT RECOMMENDED. Because energy conservation for electron impact is computed by using thresholds: energy conservation is not computed in that case!

We recommend to use Excitation and Ionization!

/crs/species/Process/Excitation Allows to specify that this is an excitation process that should be use to compute the total excitation cross section.

/crs/species/Process/Ionization Allows to specify that this is an ionization process that should be use to compute the total excitation cross section.

Concerning the total electron production

The total electron production is computed by adding the ionization process results (computed by the number of electrons). Therefore, if you use a subprocess (of a previously defined process), you should consider that its ionization is already taken into account. If you defines that this sub-process creates also an electron, if the first process creates an electron, the result will be a double-ionization (probably not what you want in that case).

When more than one electron are created in the process, the electrons production is correctly stored, but for the electron flux, all the energy is put inside one electron.

[9]Heritage in C++! A fantastic concept!

When there is an Auger process, the Auger electron is correctly put in the flux.

Auger electron computation

The Auger electron process is taken into account in AeroPlanets . The principle is simple: a suborbit is ionized (creates one electrons) and one electron of an upper orbits falls to that orbit, creating a photon that is absorbed by the species itself; therefore, creating another ionization. This leads to a double ionization, with a second electron very specific: it has the energy of the transition; it is an auger electron.

In the **photoionization** and **electron impact** cross section, you can add the Auger process simply by defining a cross section, and adding the Auger markup:

/crs/species/Process/Auger Allows to define the Auger process, and the Auger electron energy:

```
<Auger energy="500"/>
```

Several Auger electrons can be created in one process, with different efficiency, you can simply do:

```
<Auger energy="500" fact="0.5"/>
<Auger energy="800" fact="0.5"/>
```

If no efficiency is defined, it is considered to be one.

A.2.4 The recommended data set cross section

The recommended data set cross section works technically like the other files. The main difference is the "/crs/RecommendedFile" in its heading. This markup could be used for discriminating against the other types, for example by displaying the process and not the sources when plotting.

The recommended data set is not automatically created from the other files right now. This may become true in the future, and, in that case, people writing the database should not care about the consistency between the other files and the recommended data set.

Nomenclature

AeroPlanets Software developed by G. Gronoff on the basis of the Trans* codes. It is an upper atmosphere of the earth and planet model, for computing ionization, dissociation and excitation. It has several modules for computing the emissions, for retrieval... It is the first model using the **AtMoCiad** database, and its development was useful for determining the necessary parameters of the database xml files.

AMOP Photoionization cross sections database compiled by the AMOP group: `http://amop.space.swri.edu/`.

AtMoCiad The Atomic and Molecular Cross sections for ionization and air-glow database. The database descripted in the present document.

BDD Old database. The database used in the very old versions of the Trans* codes. Typically used as a reference when actual references are lost.

XML eXtensible Markup Language: document format based on Markup. To simplify, it is a text (ASCII/UTF8....) document containing markups to define its structure, and the relations between the several parts of the text.

XPath Set of techniques to easily navigate in a XML document. The basic concept is to follow the 'roots' to the 'leaves' of the document, by giving all the nodes. An example can be found in A.1.1. Thanks to the wide use of XML, notably in web-based technology, XPath techniques are implemented in several programming languages. For example, python has the ElementTree module, extensively used in the plotting and transforming examples.

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