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STARK BROADENING OF STRONTIUM ION Sr V SPECTRAL LINES IN HOT WHITE DWARF ATMOSPHERES

Research team

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The Aims of This study

➢The Aims of the present work is to perform the calculations of Stark broadening for ten Sr V lines recently discovered in the UV spectrum of the hot white dwarf RE 0503-289, which have never been detected before in hot white dwarfs

Plan

- Introduction
- Strontium plasma study
- Computational procedure
- Results and discussion
- Conclusions

Introduction

Line strengths S

Radiative decay rates A_{ij}

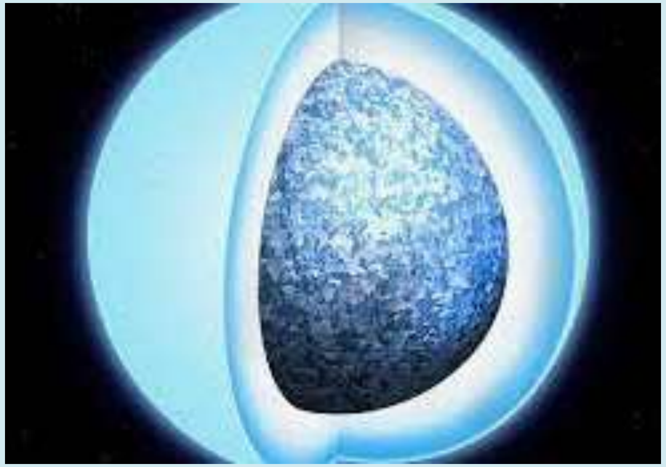
Atomic data
(E, S, gf and A_{ij})

Line broadening parameters

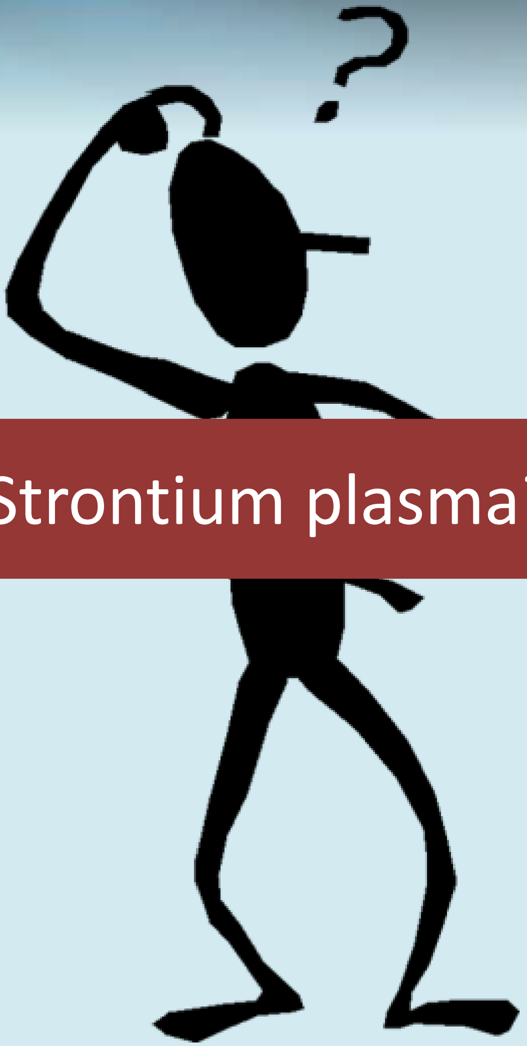
Energy levels E

Weighted oscillator strengths gf

White dwarf star collects planet Debris



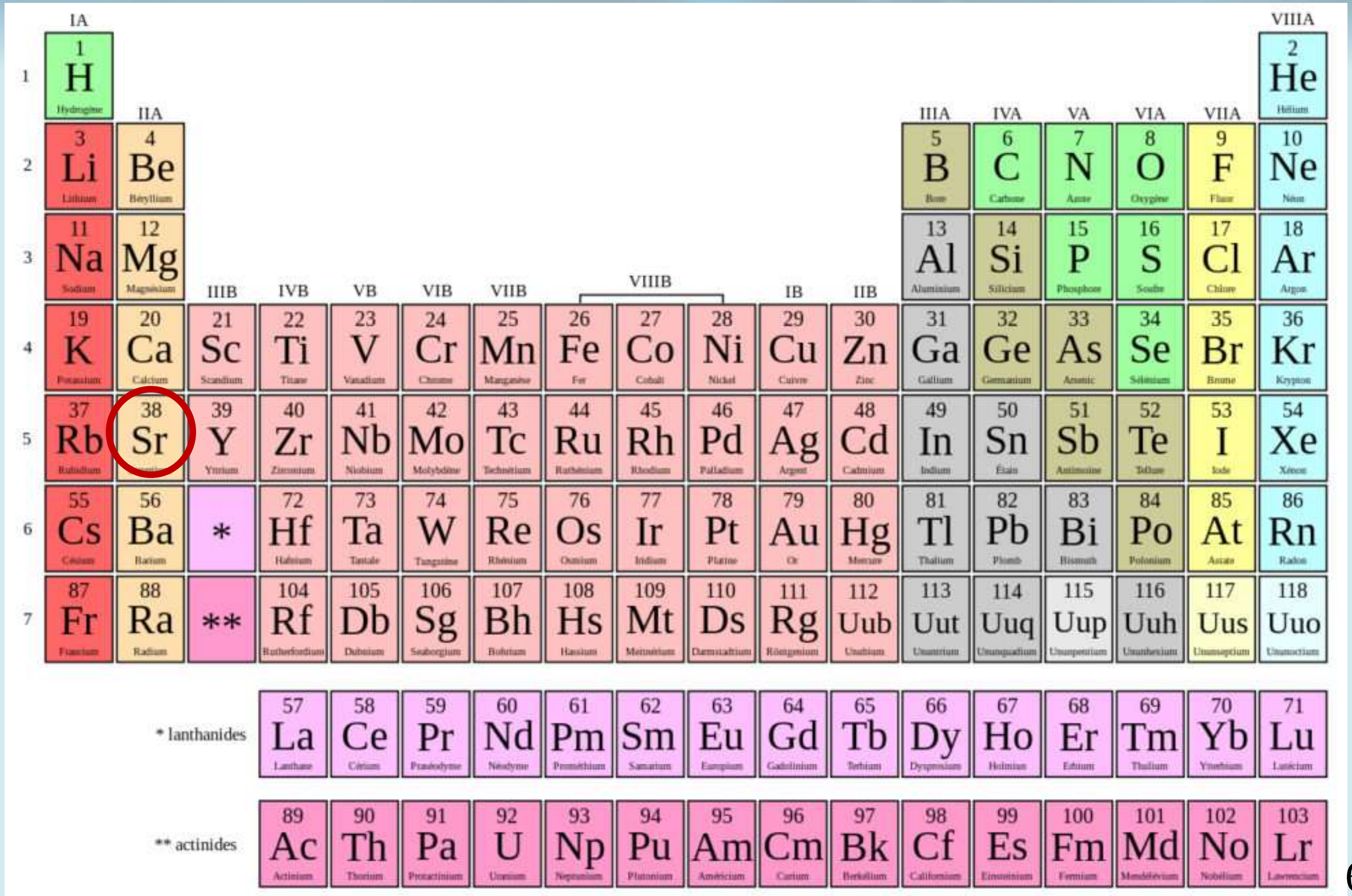
White dwarf atmospheres



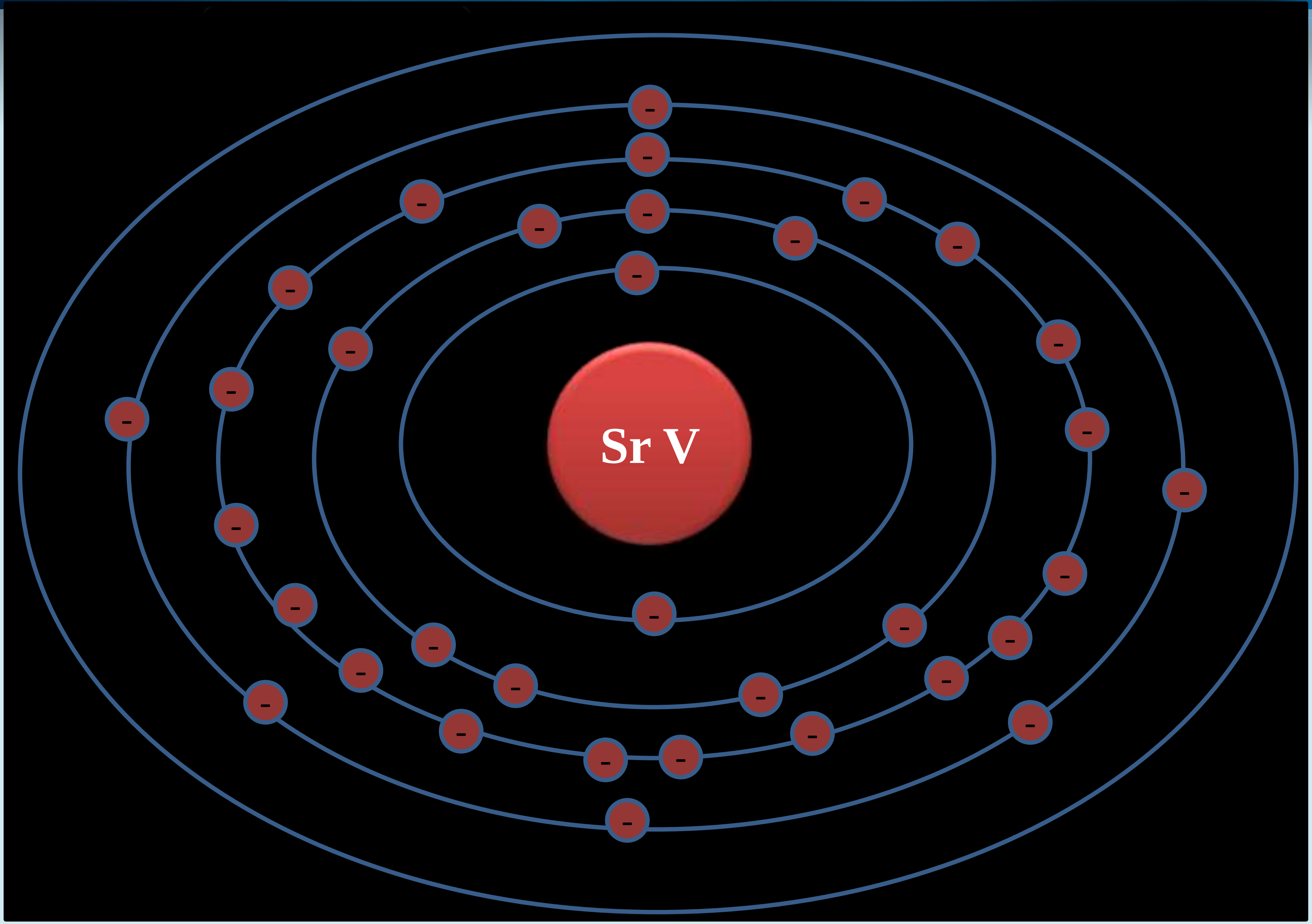
Strontium plasma?

Atomic Properties of Stontium atom

Atomic properties
Sr Atomic number 38
[Kr]5s^2
Family: Alkaline earth metals
Group :2, Period :5, Block :5
Atomic radius = 219 pm
Crystal system: face-centered cubic
Electrons by energy level 2/8/18/8/2

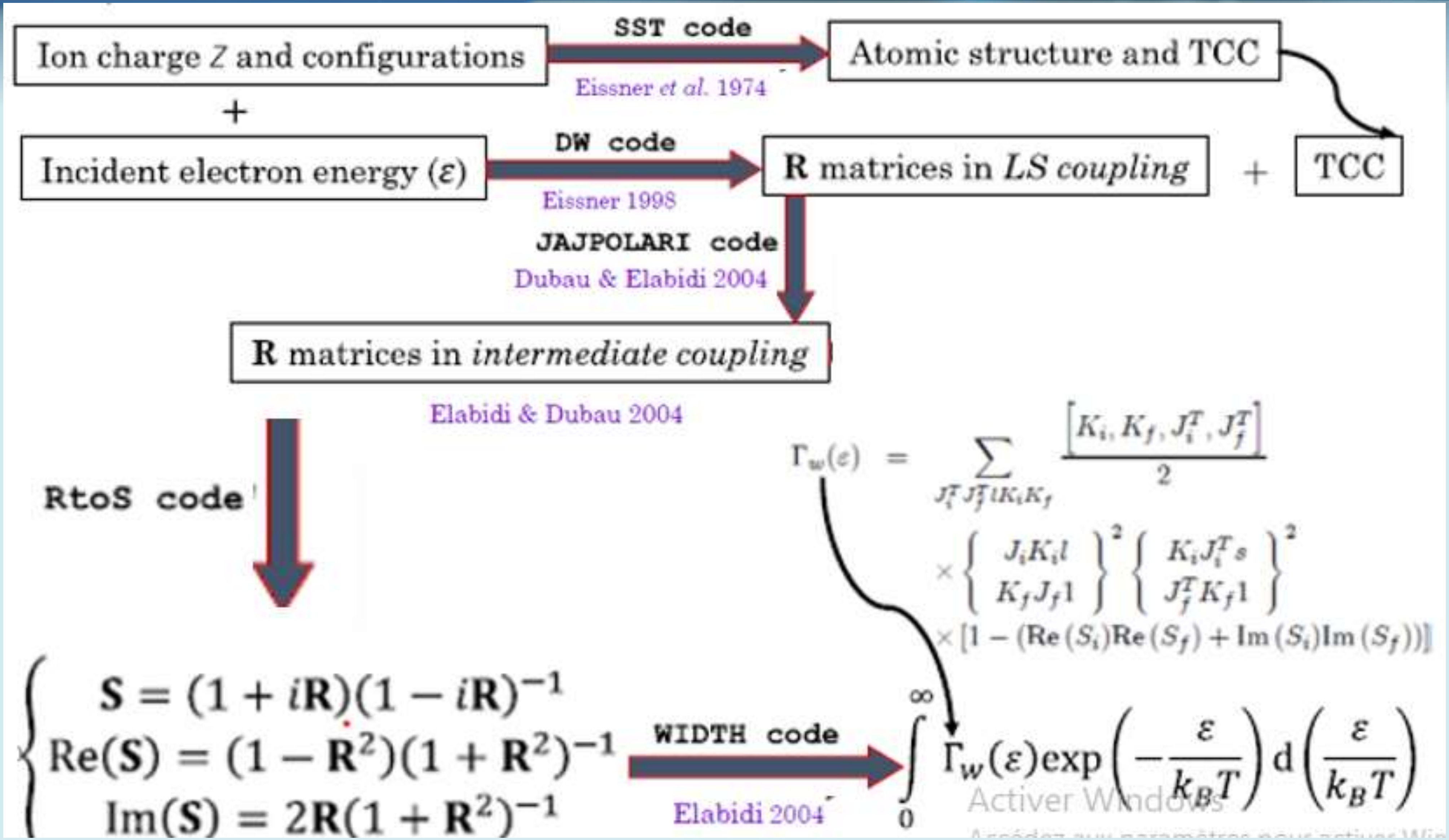


Sr V (Selenium-like)



- $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 2p^4$
- Astrophysical interest
- White dwarf atmospheres

Description of the numerical procedure



Atomic data **:** Present Sr V fine structure energy levels for the first ten levels compared with those of NIST results.

i	Conf.	Present (cm^{-1})	NIST	ΔE_{NIST} %
1	$4s^2 4p^4\ ^3P_2$	0.0	0.0	0.0
2	$4s^2 4p^4\ ^3P_1$	8166.	8308.	1.74
3	$4s^2 4p^4\ ^3P_0$	9085.	8718.	4.04
4	$4s^2 4p^4\ ^1D_2$	23172.	20311.	12.35
5	$4s^2 4p^4\ ^1S_0$	50557.	44050.	12.87
6	$4s4p^5\ ^3P°_2$	149729.	154032.	2.87
7	$4s4p^5\ ^3P°_1$	155821.	160018.	2.69
8	$4s4p^5\ ^3P°_0$	159642.	164016.	2.74
9	$4s4p^5\ ^1P°_1$	193987.	193319.	0.34
10	$4s^2 4p^3(^3S°)4d\ ^5D°_0$	198843.	202129.	1.65

The average errors between our calculations and NIST results are less than 2%

Atomic data **:** Present radiative decay rates A_{ij}, line strengths S and weighted oscillator strengths gf for Sr V allowed transitions involving the first level 1

i–j	A_{ij} (S^{-1})	S	gf
6 − 1	9.670E+08	0.71093	3.233E−01
7 − 1	6.419E+08	0.25121	1.189E−01
9 − 1	9.627E+07	0.01953	1.151E−02
11 − 1	5.427E+07	0.01021	6.168E−03
12 − 1	6.535E+07	0.02046	1.237E−02
13 − 1	3.129E+07	0.01370	8.282E−03
15 − 1	1.472E+08	0.03683	2.399E−02
16 − 1	9.960E+07	0.03402	2.235E−02
17 − 1	3.735E+07	0.00540	3.562E−03

These radiative parametrs for Sr V are the first to be published, so no comparisons have been performed for them

Stark line widths **:** Present quantum Stark widths ***W*** for 10 Sr V lines at electron density $N_e = 10^{17}$ cm^{-3} for different temperatures ***T***(10^4 K), the wavelengths are taken from (SST)

5 configurations :

3d^{10} (4s^{2}4p^4, 4s4p^5, 4s^{2}4p^{3}4d, 4s^{2}4p^{3}5s and 4s^{2}4p^{3}5p)

Transition	T (10^4 K)	W (Å)	Transition	W (Å)
	1	1.141E−01		1.186E−01
$4p^3(^2P^o)4d\ ^3D^o_3–4p^3(^2P^o)5p\ ^1D_2$	2	7.703E−02	$4p^3(^2D^o)4d\ ^3D^o_2–4p^3(^4S^o)5p\ ^3P_1$	8.024E−02
λ = 904.67 Å	4	4.604E−02	λ = 1040.35 Å	4.915E−02
34–83	6	3.515E−02	18–59	3.863E−02
	8	2.950E−02		3.331E−02
	10	2.585E−02		2.996E−02
	1	9.015E−02		1.982E−01
$4p^3(^2D^o)4d\ ^3G^o_4–4p^3(^2D^o)5p\ ^3F_3$	2	6.019E−02	$4p^3(^2P^o)4d\ ^1F^o_3–4p^3(^2P^o)5p\ ^3P_2$	1.143E−01
λ = 928.36 Å	4	3.486E−02	λ = 1040.43 Å	6.254E−02
23–70	6	2.586E−02	38–84	4.644E−02
	8	2.127E−02		3.841E−02
	10	1.839E−02		3.336E−02
	1	1.444E−01		5.891E−01
$4p^3(^2P^o)4d\ ^3F^o_4–4p^3(^2P^o)5p\ ^3D_3$	2	8.620E−02	$4p^3(^2P^o)4d\ ^1F^o_3–4p^3(^2P^o)5p\ ^1D_2$	2.432E−01
λ = 937.68 Å	4	4.673E−02	λ = 1042.05 Å	9.569E−02
33–80	6	3.391E−02	38–83	5.847E−02
	8	2.742E−02		4.340E−02
	10	2.333E−02		3.546E−02
	1	7.893E−02		2.294E−01
$4p^3(^2D^o)4d\ ^3D^o_3–4p^3(^4S^o)5p\ ^3P_2$	2	5.329E−02	$4p^3(^2P^o)4d\ ^3D^o_2–4p^3(^2D^o)5p\ ^3F_2$	1.463E−01
λ = 974.52 Å	4	3.219E−02	λ = 1168.01 Å	8.543E−02
16–61	6	2.500E−02	29–67	6.511E−02
	8	2.143E−02		5.458E−02
	10	1.925E−02		4.777E−02
	1	2.018E−01		3.215E−01
$4p^3(^2P^o)4d\ ^3D^o_1–4p^3(^2D^o)5p\ ^3D_1$	2	1.650E−01	$4p^3(^2P^o)4d\ ^3D^o_2–4p^3(^4S^o)5p\ ^3P_2$	1.878E−01
λ = 1181.28 Å	4	1.121E−01	λ = 1482.52 Å	1.118E−01
27–64	6	8.688E−02	29–61	8.891E−02
	8	7.267E−02		7.655E−02
	10	6.343E−02		6.822E−02

Fig. a : Stark ***W***Stark and Doppler ***W***Doppler widths for the Sr V line **4p^3(^{2}D°)4d ^{3}D°$_3$** – **4p^3(^{4}S°)5p ^{3}P$_2$** (λ=97.452 nm) for the atmospheric models Wesemael (1981) with effective temperatures T_{eff} = 70 000–100 000 K and log g = 8 as a function of atmospheric layer temperatures

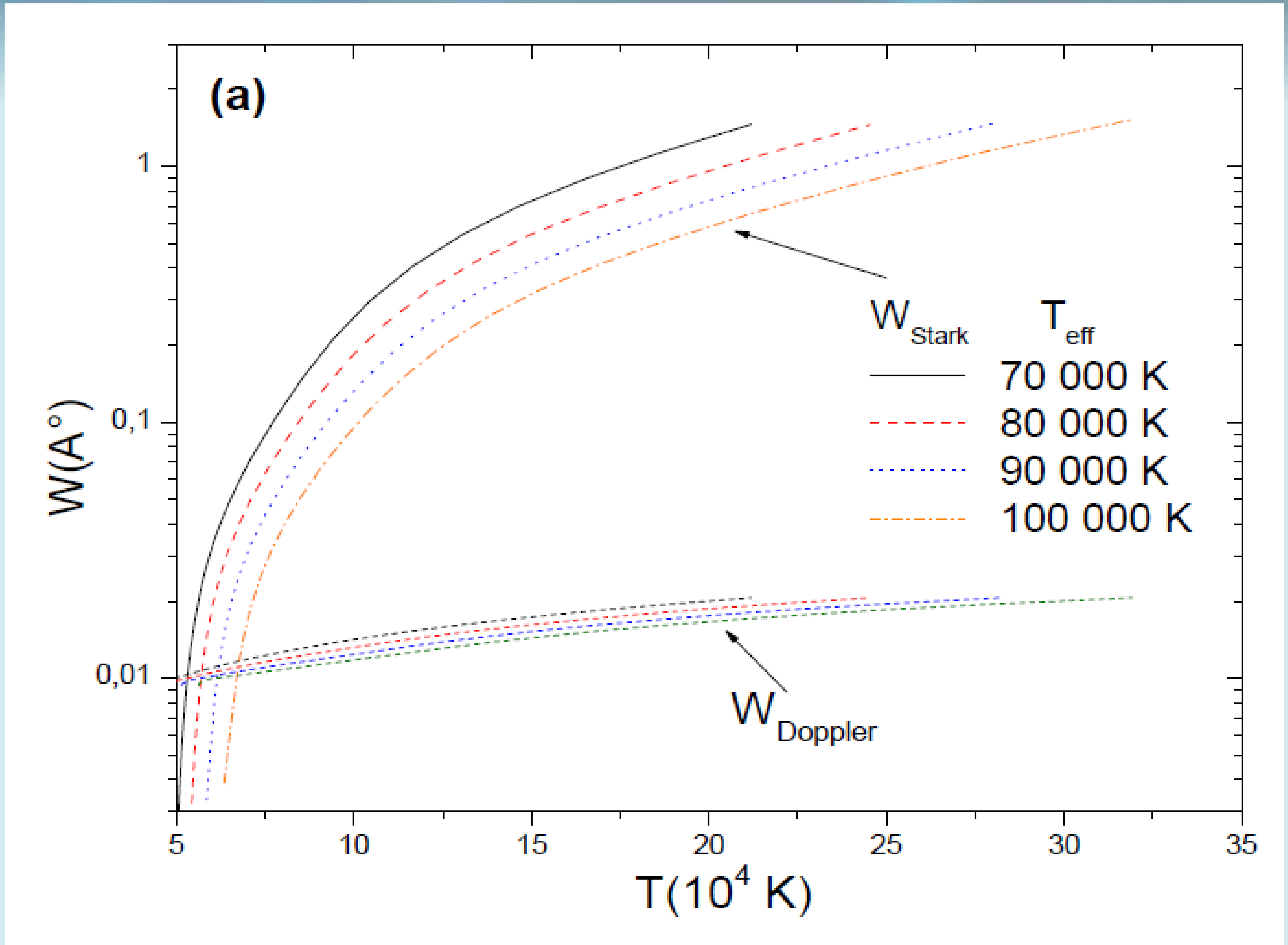


Fig. b : Stark $\boldsymbol{W}_{\text{Stark}}$ and Doppler $\boldsymbol{W}_{\text{Doppler}}$ widths for the Sr V line **4p^3(^{2}D°)4d ^{3}D°$_3$ – 4p^3(^{4}S°)5p ^{3}P$_2$** (λ=97.452 nm) for the atmospheric models of Wesemael (1981) with effective temperatures $\boldsymbol{T}_{\text{eff}}$ = 70 000–100 000 K and log g = 8 as a function of the Rosseland optical depth

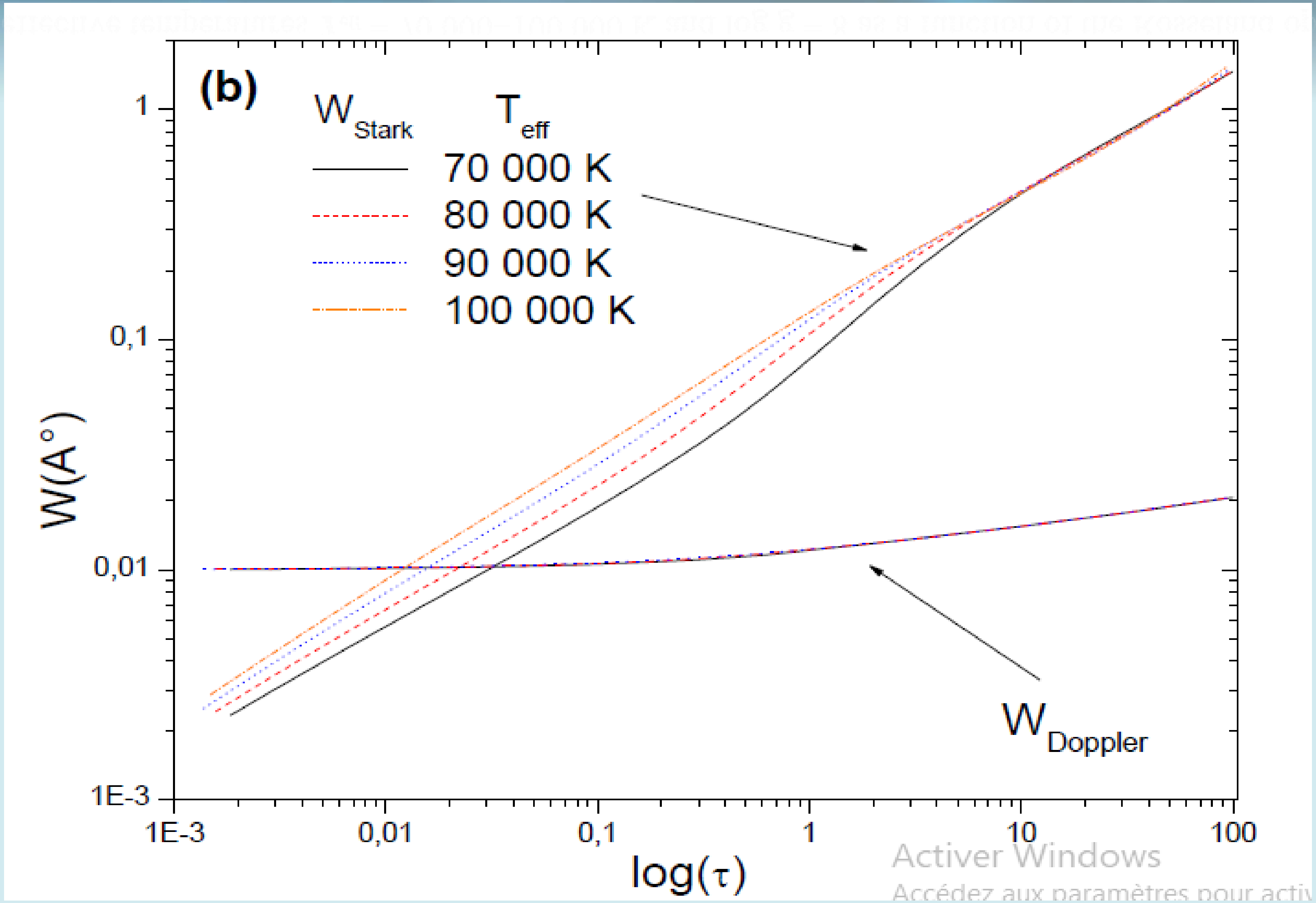


Fig. c : Stark W_{Stark} and Doppler $W_{Doppler}$ widths for the Sr V line **4p^3(^{2}D°)4d ^{3}D°$_3$ – 4p^3(^{4}S°)5p ^{3}P$_2$** (λ=97.452 nm) for the atmospheric models Wesemael (1981) with log g = 6 – 9 and effective temperature T_{eff} = 80 000 K as a function of atmospheric layer temperatures

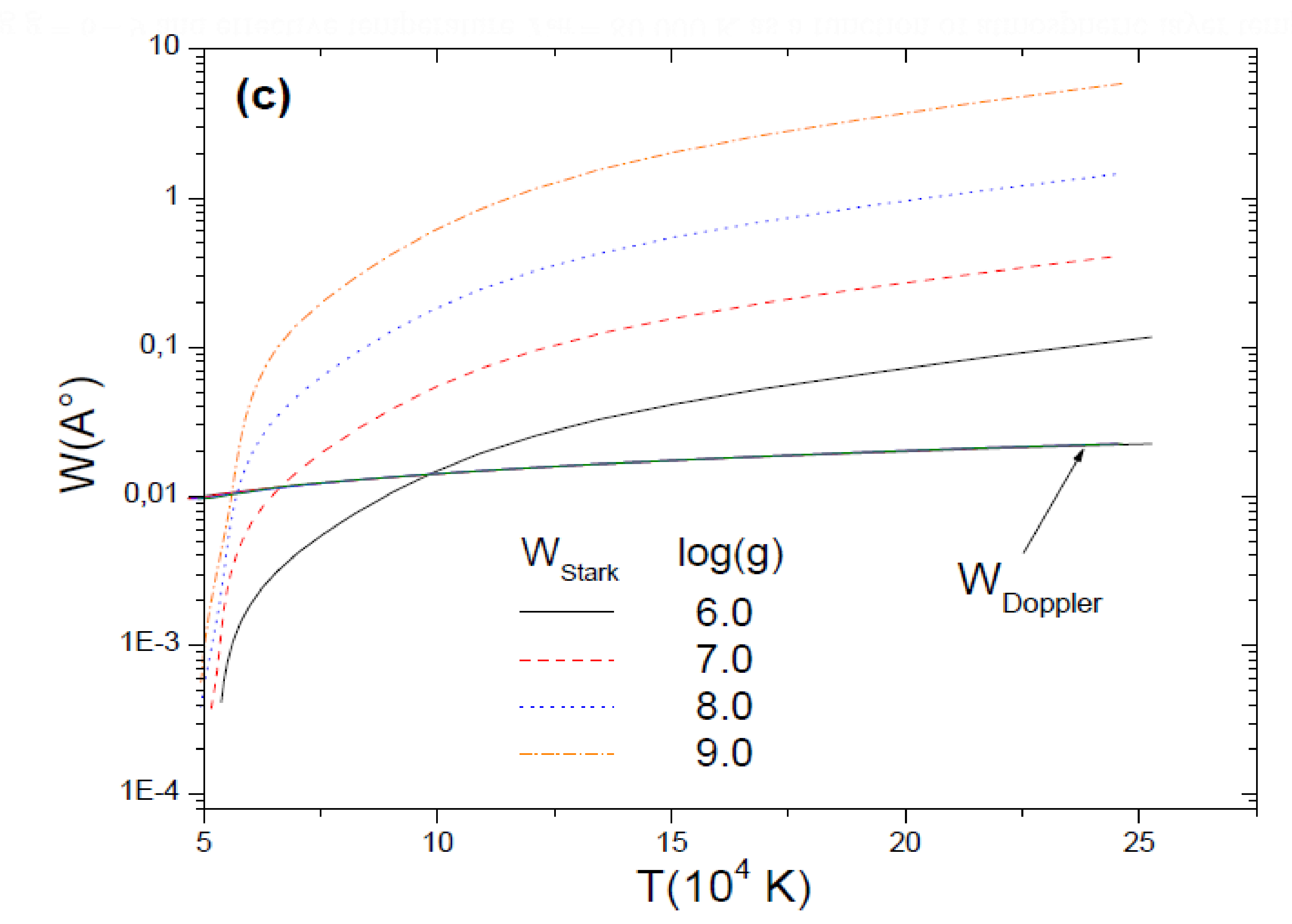
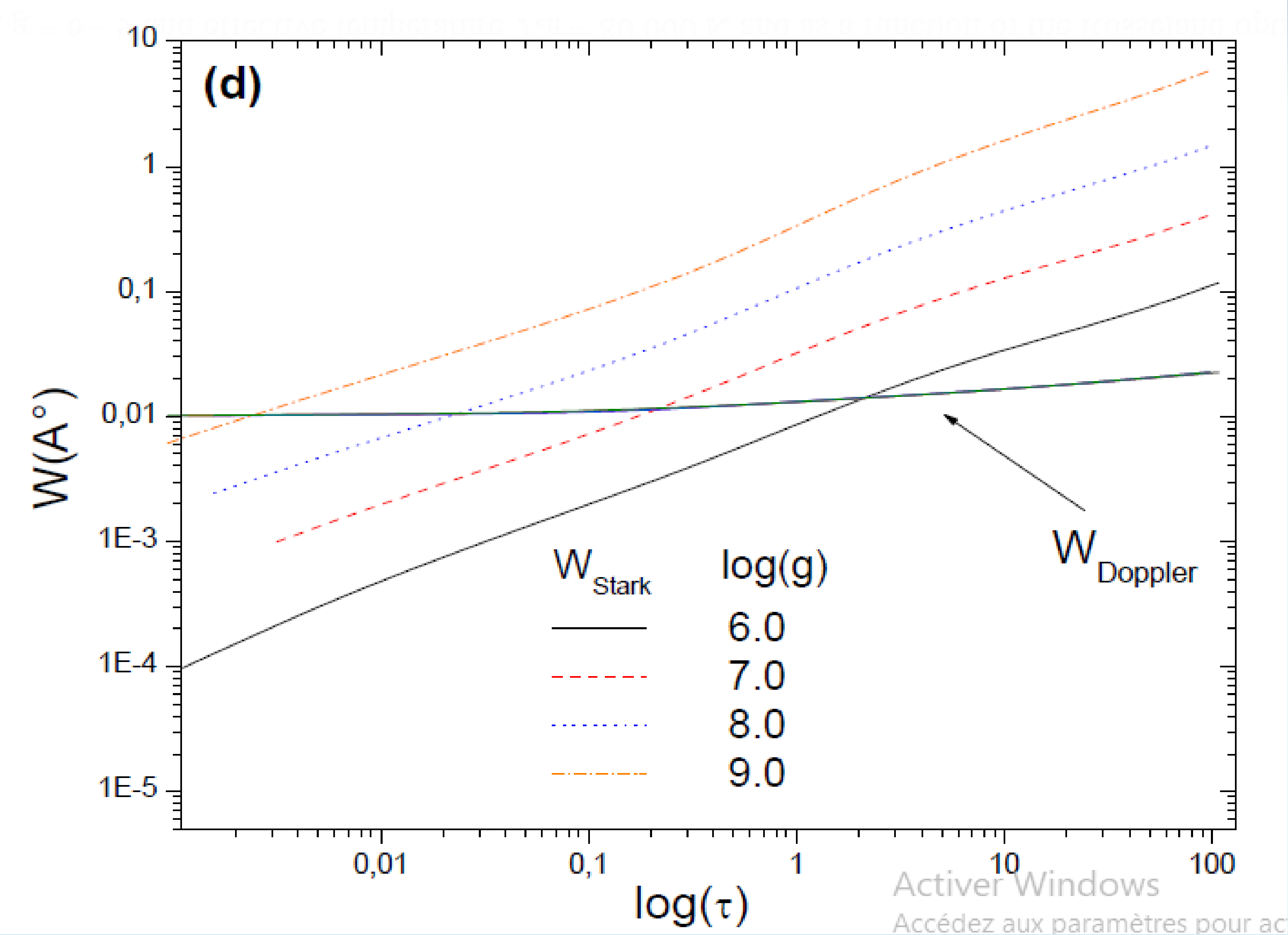


Fig. d : Stark W_{Stark} and Doppler $W_{Doppler}$ widths for the Sr V line **$4p^3(^2D°)4d\ ^3D°_3 – 4p^3(^4S°)5p\ ^3P_2$** (λ=97.452 nm) for the atmospheric models Wesemael (1981) with log g = 6 – 9 and effective temperature T_{eff} = 80 000 K and as a function of the Rosseland optical depth



Conclusions

- Our energy levels for Sr V are in agreement with the NIST results. Their relative errors are less than 2 %.
- We did not find any other results in the literature of Sr V radiative data (A_{ij}, *S* and ***gf***). We hope that our calculations fill the lack in the database

- Stark broadening parameters for 10 Sr V lines have been calculated using our quantum method. These lines have been recently discovered by Rauch et al. (2017) for the first time in the UV spectrum of the hot white dwarf RE 0503–289, which have never been detected before in hot white dwarfs. So, there are no other results for the Stark broadening in the literature to compare with them. Measurements or new calculations of Sr V line widths maybe interesting for checking our calculations.

- Stark widths are compared with thermal Doppler widths as a function of atmospheric layer temperatures for different stellar atmospheres. Doppler widths are calculated using the model atmospheres of Wesemael (1981) which are LTE models assuming plane-parallel geometry and pure helium composition.

- We investigated the importance of the role of Stark and the Doppler broadening in the atmospheres of the considered white dwarfs. The principal conclusion drawn here is that Stark broadening is more significant than Doppler for almost all the atmospheric models (Wesemael 1981) studied here. This conclusion shows the importance of Stark broadening data in the investigation and modelling of stellar-atmospheres.

Thank you for your ATTENTION !