White Dwarf - M Dwarf Binaries

from the

Sloan Digital Sky Survey

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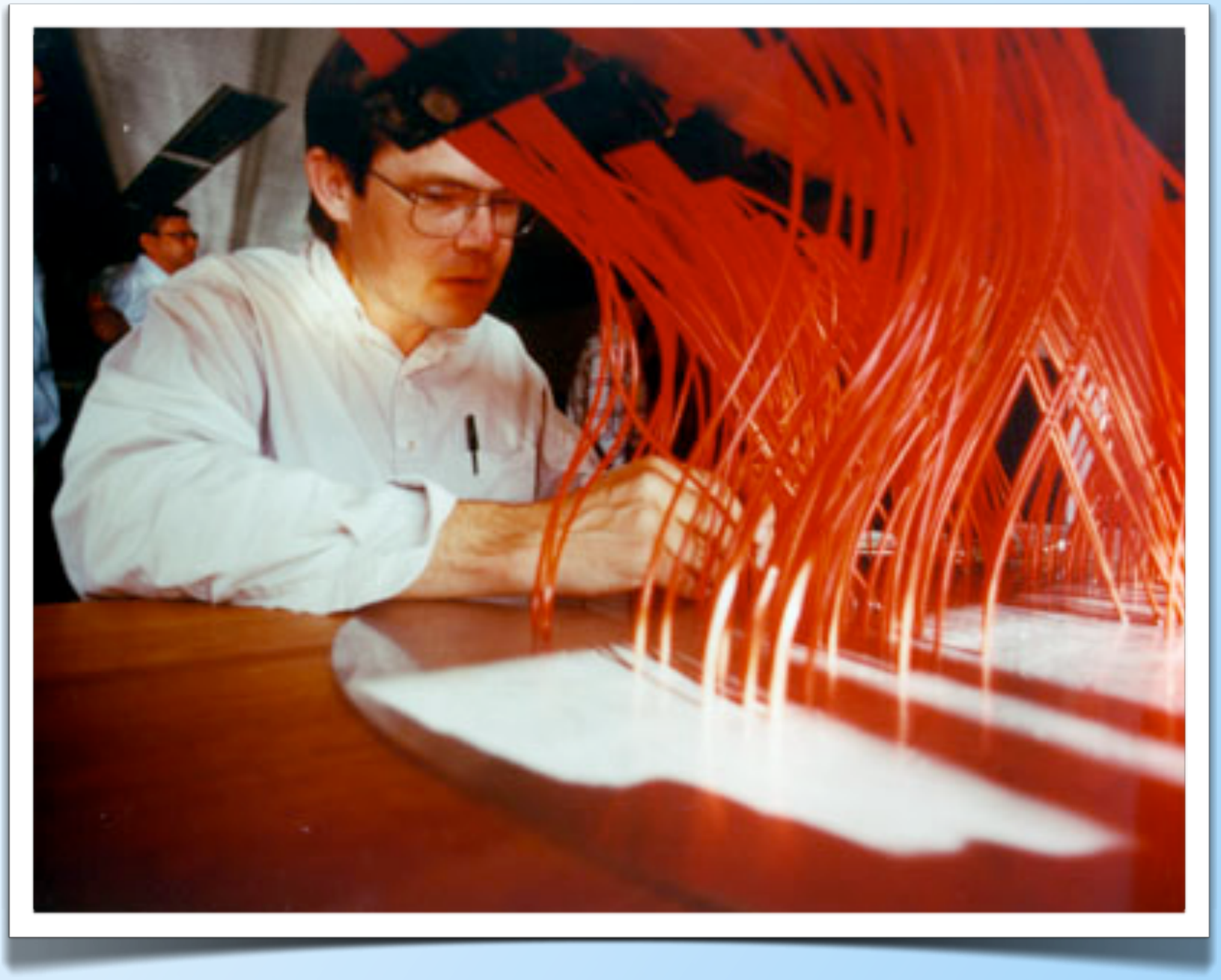
Viña del Mar
March 08, 2011

The Sloan Digital Sky Survey

www.sdss.org/gallery/gal_photos.html

- 3200 - 9200 Å
- 2.5m telescope, 3° FoV
- inverse resolution
  $R = \lambda/\Delta\lambda \approx 2000$
- ≈ 3800 data points per spectrum
- each fiber covers a circle with 3″ diameter on the celestial plane

The Sloan Digital Sky Survey

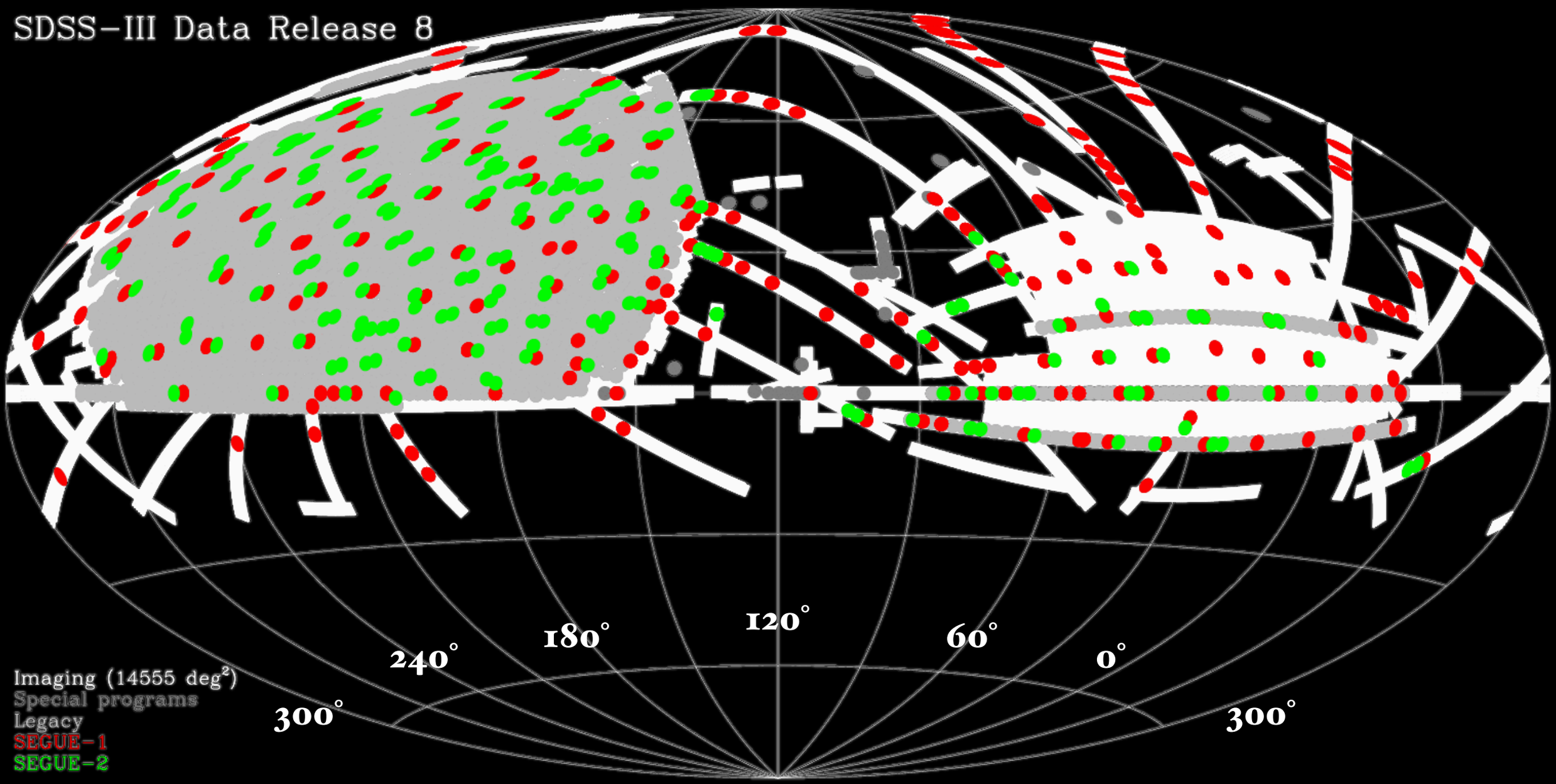


www.sdss.org/photos/spectro23

- 3200 - 9200 Å
- 2.5m telescope, 3° FoV
- inverse resolution
  $R = \lambda/\Delta\lambda \approx 2000$
- ≈ 3800 data points per spectrum
- each fiber covers a circle with 3″ diameter on the celestial plane

The Sloan Digital Sky Survey

equatorial cordinates



> 1/3 sky-coverage

Sample Setup

(1) this study, (2) Nebot Gómez-Morán et al. (2011, in prep.), (3) Rebassa-Mansergas et al. (2010), (4) Heller et al. (2009), (5) Augusteijn et al. (2008), (6) Silvestri et al. (2007), (7) Huegelmeyer et al. (2006), (8) Pourbaix et al. (2004), (9) Raymond et al. (2003), (10) Nilsson et al. (2006), (11) Wachter et al. (2003), (12) Eisenstein et al. (2006, white dwarf sample), (13) Eisenstein et al. (2006, sub dwarf sample), (14) Mukadam et al. (2004), (15) Kleiman et al. (2004), (16,17) Luyten (1997,1999), (18) Greenstein (1986)

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			SDSS WD-dM									WD-dM		SDSS WD					WD		
SDSSJ	α [°]	δ [°]	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
000007.49−010910.90	0.03120	−1.15302	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
000152.08+000644.56	0.467	0.11236	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
000250.64−045041.60	0.711	−4.84488	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000356.93−050332.70	0.98720	−5.05908	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000442.00−002011.60	1.175	−0.33655	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000453.93+265420.40	1.22470	26.90566	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000504.91+243409.60	1.27045	24.56933	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000531.09−054343.24	1.37954	−5.72866	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000559.87−054416.00	1.49945	−5.73777	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000605.38−103302.30	1.52241	−10.55063	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
000611.93+003446.50	1.54970	0.57958	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000624.86−100024.70	1.60358	−10.00686	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
000651.91+284647.10	1.71629	28.77975	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000829.26+004645.20	2.12191	0.77922	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
000829.92+273340.50	2.12466	27.56125	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000935.50+243251.20	2.39791	24.54755	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
001029.87+003126.20	2.62445	0.52394	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
001105.93−110859.00	2.77470	−11.14972	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
001247.18+001048.70	3.19658	0.18019	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
001324.33−085021.40	3.35137	−8.83927	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
001339.10+001924.80	3.41291	0.32355	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
001359.39−110838.60	3.49745	−11.14405	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
001549.02+010937.30	3.95425	1.16036	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
001726.63−002451.10	4.36095	−0.41419	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
001733.59+004030.43	4.38995	0.67511	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
001742.43+004137.28	4.42679	0.69366	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
001749.24−000955.58	4.45516	−0.16541	1	0	1	1	1	1	0	0	1	0	0	0	0	0	1	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

> 3000 WD-dM candidates (not necessarily from the SDSS)

Sample Setup

(1) this study, (2) Nebot Gómez-Morán et al. (2011, in prep.), (3) Rebassa-Mansergas et al. (2010), (4) Heller et al. (2009), (5) Augusteijn et al. (2008), (6) Silvestri et al. (2007), (7) Huegelmeyer et al. (2006), (8) Pourbaix et al. (2004), (9) Raymond et al. (2003), (10) Nilsson et al. (2006), (11) Wachter et al. (2003), (12) Eisenstein et al. (2006, white dwarf sample), (13) Eisenstein et al. (2006, sub dwarf sample), (14) Mukadam et al. (2004), (15) Kleiman et al. (2004), (16,17) Luyten (1997,1999), (18) Greenstein (1986)

≈2230 of them have SDSS spectra, may be 2000 will turn out to be genuine WD-dM binaries.

			SDSS WD-dM									WD-dM		SDSS WD				WD		
SDSSJ	α [°]	δ [°]	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
000007.49−010910.90	0.03120	−1.15302	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
000152.08+000644.56	0.467		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000250.64−045041.60	0.711	−4.84488	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000356.93−050332.70	0.98720	−5.05908	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000442.00−002011.60	1.175	−0.33655	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000453.93+265420.40	1.2240	26.90566	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000504.91+243409.6	1.270	24.5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000531.09−054343.24	1.37954	−5.7	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000559.87−054416.00	1.49945	−5.73777	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000605.38−103302.30	1.52241	−10.55063	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
000611.93+003446.50	1.54970	0.57958	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000624.86−100024.70	1.60358	−10.00686	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
000651.91+284647.10	1.71629	28.77975	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000829.26+004645.20	2.12191	0.77922	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
000829.92+273340.50	2.12466	27.56125	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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001105.93−110859.00	2.77470	−11.14972	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
001247.18+001048.70	3.19658	0.18019	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
001324.33−085021.40	3.35137	−8.83927	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
001339.10+001924.80	3.41291	0.32355	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
001359.39−110838.60	3.49745	−11.14405	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
001549.02+010937.30	3.95425	1.16036	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
001726.63−002451.10	4.36095	−0.41419	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
001733.59+004030.43	4.38995	0.67511	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
001742.43+004137.28	4.42679	0.69366	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
001749.24−000955.58	4.45516	−0.16541	1	0	1	1	1	1	0	0	1	0	0	0	0	0	1	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

> 3000 WD-dM candidates (not necessarily from the SDSS)

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Suggestions of SDSS WD-dM candidates are welcome and will be acknowledged.

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	SDSS WD-dM											GSS WD					WD		
SDSSJ	α [°]	δ [°]	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
000007.49–010910.90	0.03120	−1.15302	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
000152.08+000644.56	0.467	0.11236	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
000250.64–045041.60	0.711	−0.84487	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000356.93–050332.70	0.98720	−5.05908	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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000504.91+243409.60	1.27045	24.56933	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000531.09–054343.24	1.37954	−5.72866	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
000559.87–054416.00	1.49945	−5.73777	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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000611.93+003446.50	1.54970	0.57958	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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000829.26+004645.20	2.12191	0.77922	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
000829.92+273340.50	2.12466	27.56125	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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001247.18+001048.70	3.19658	0.18019	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
001324.33–085021.40	3.35137	−8.83927	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
001339.10+001924.80	3.41291	0.32355	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
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001549.02+010937.30	3.95425	1.16036	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
001726.63–002451.10	4.36095	−0.41419	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
001733.59+004030.43	4.38995	0.67511	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
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001749.24–000955.58	4.45516	−0.16541	1	0	1	1	1	1	0	0	1	0	0	0	0	0	1	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

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Sample Setup:
Disentangling Duplicates

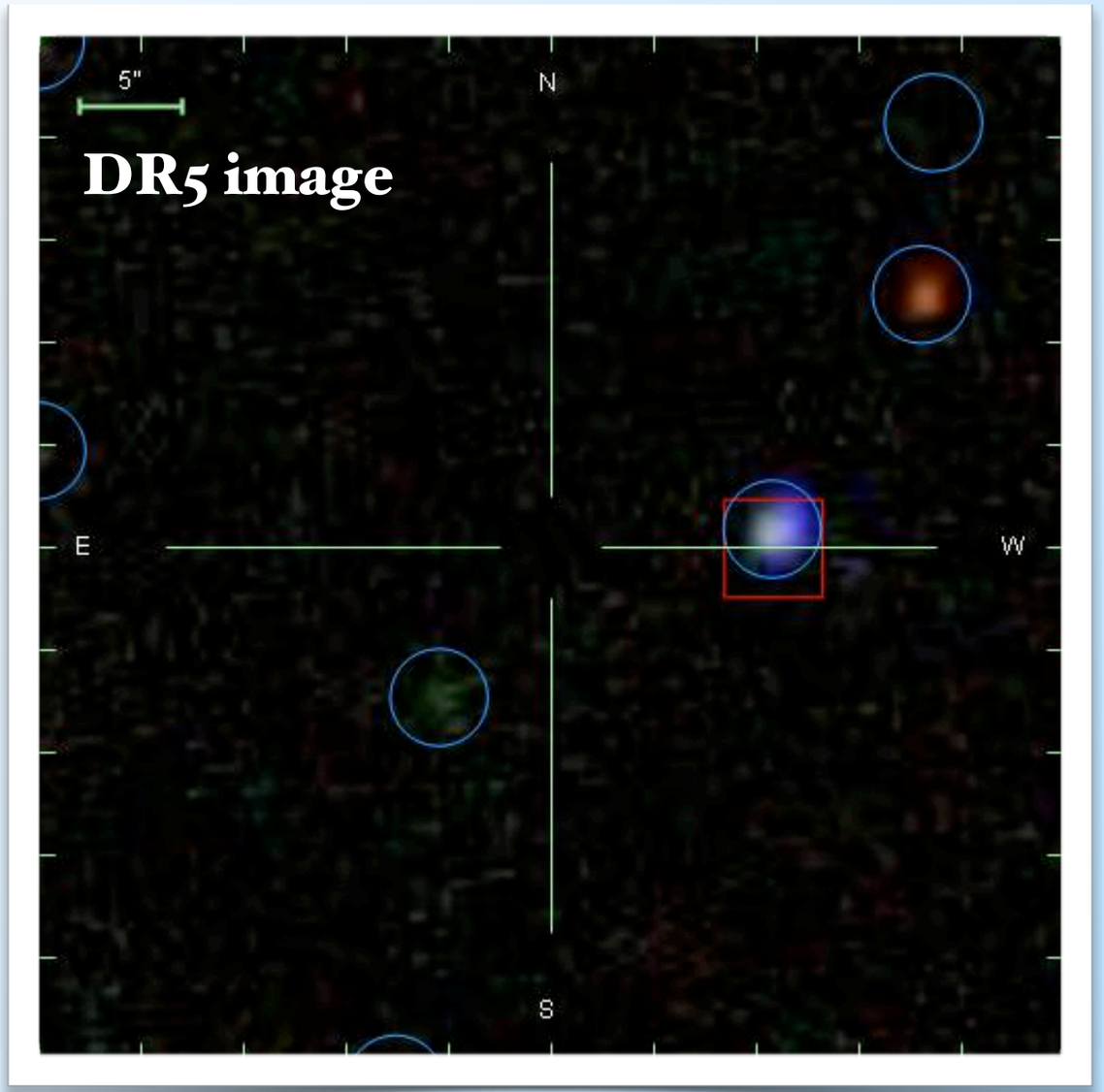
Sample Setup:
Disentangling Duplicates

(1) Wachter et al. (2003), (2) this study, (3) Silvestri et al. (2007), (4) Rebassa-Mansergas et al. (2010), (5) Kleiman et al. (2004), (6) Augusteijn et al. (2008), (7) Nebot Gómez-Morán et al. (2011, in prep.)

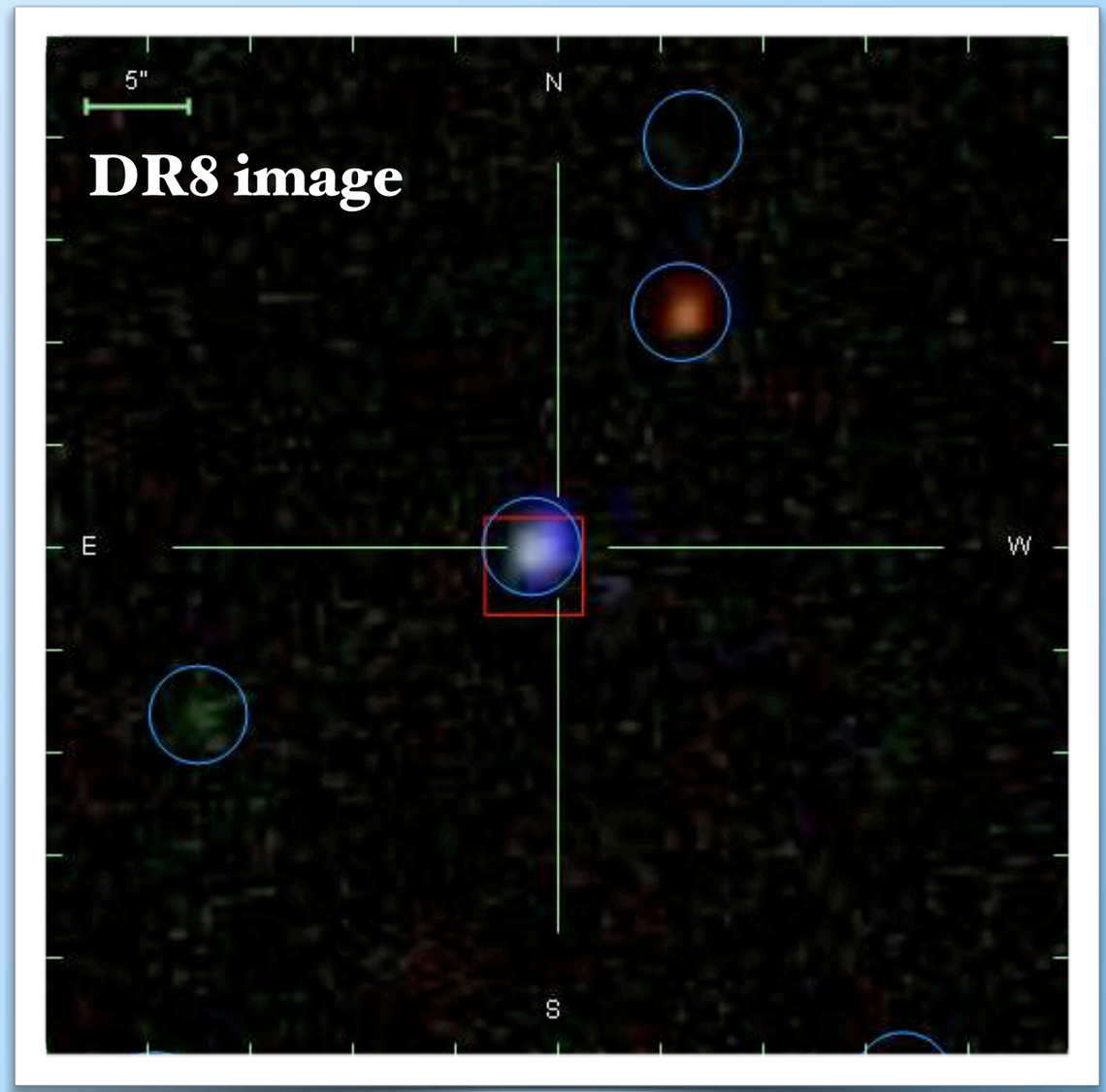
Plate	MJD	Fiber	official SDSS identifier SDSSJ...	published before as...
2232	53827	584	122630.86+303852.5	122630.80+303852.00[1], 122630.86+303852.5[4], 122630.87+303852.6[3], 122630.86+303852.58[2]
329	52056	615	114947.95-012044.5	114948.00-012044.0[3], 114947.99-012043.9[4], 114948.00-012044.51[2]
329	52056	542	114913.52-014728.4	114913.44-014728.50[2], 114913.53-014728.6[3,5], SDSSJ114913.52-014728.64
329	52056	542	114914.72-014726.6	114914.74-014726.70[1,*]
971	52644	303	122105.34+492720.5	122105.27+492720.52[2], 122105.35+492720.6[3], 122105.34+492720.5[4], 122106.00+492710.0[1]
1646	53498	177	144600.72+332849.9	144600.72+332849.94[2], 144600.00+332848.00[1], 144600.72+332849.9[4]
540	51996	551	151212.08+015231.3	151212.00+015231.40[2], 151212.80+015230.5[3,*], 151212.07+015230.4[4], 151212.08+015230.5[5]
2449	54271	420	152425.22+504010.0	152425.00+504006.00[1], 152425.20+504009.84[2], 152425.21+504009.8[3,4], 152425.21+504009.7[7]
627	52144	589	163708.04+474600.1	163708.04+474600.1[3], 163708.16+474559.75[3], 163708.04+474559.9[4]
1852	53534	510		160900.10+225934.07, 160860.00+225934.10
1684	53239	81		162448.00+321654.00, 162449.00+321702.00
3297	54941	53		151906.00+500700.00, 151905.96+500702.89

Sample Setup:
Disentangling Duplicates

SDSSJ151212.08+015231.4 (DR7) as an example

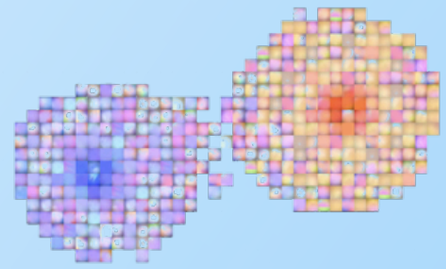


SDSS DR5
SDSSJ151212.80+015230.5
RA=228.05333, DEC=1.87514
(Silvestri et al. 2007)



SDSS DR8
SDSSJ151211.99+015231.40
RA=228.05033, DEC=1.8751296
(this study)

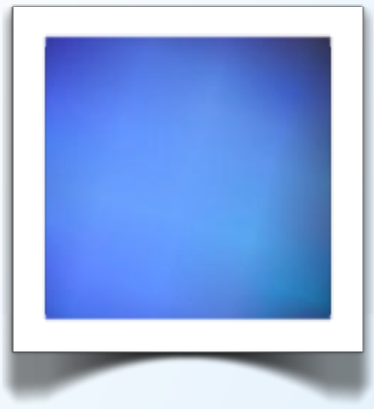
SDSS

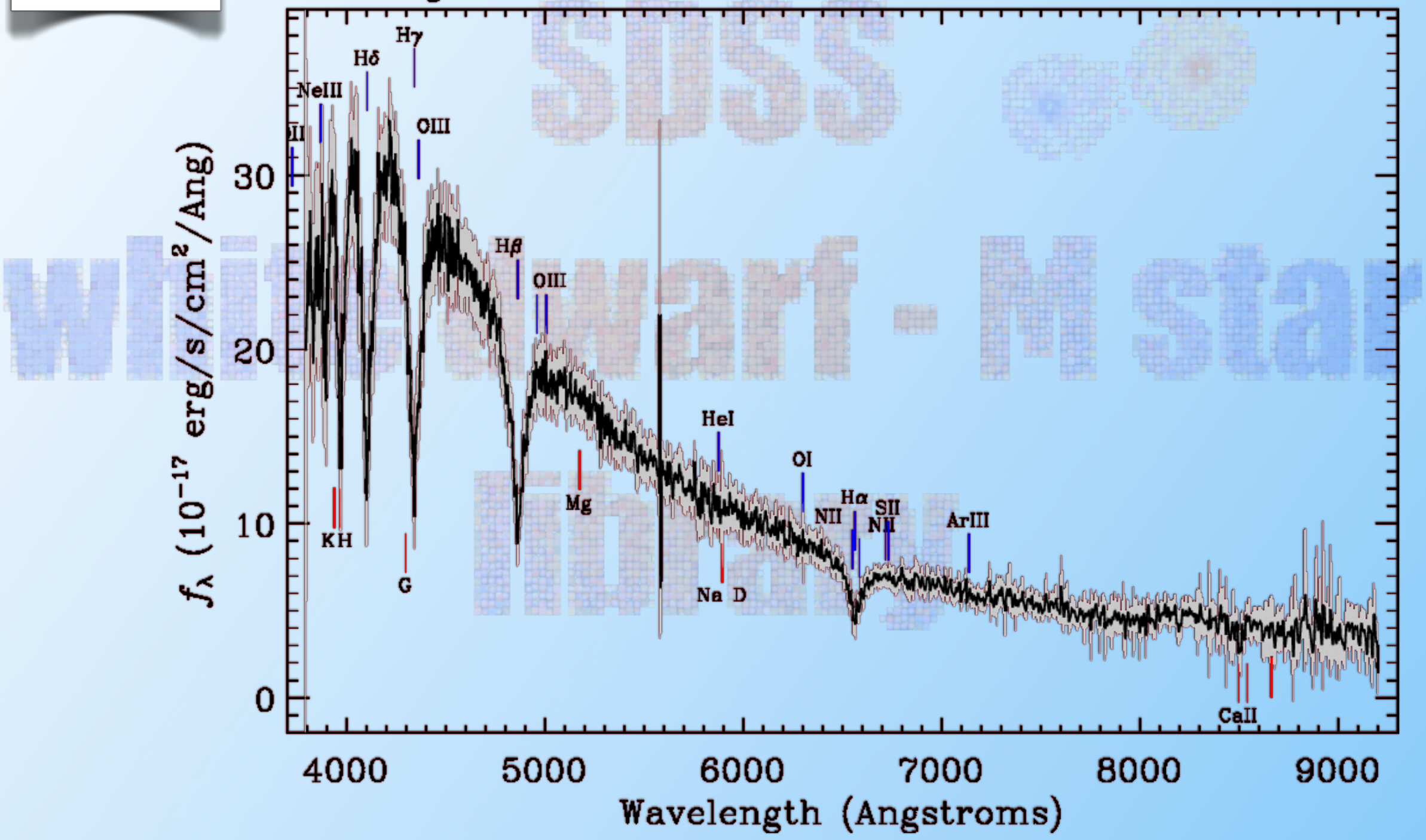


white dwarf - M star

library

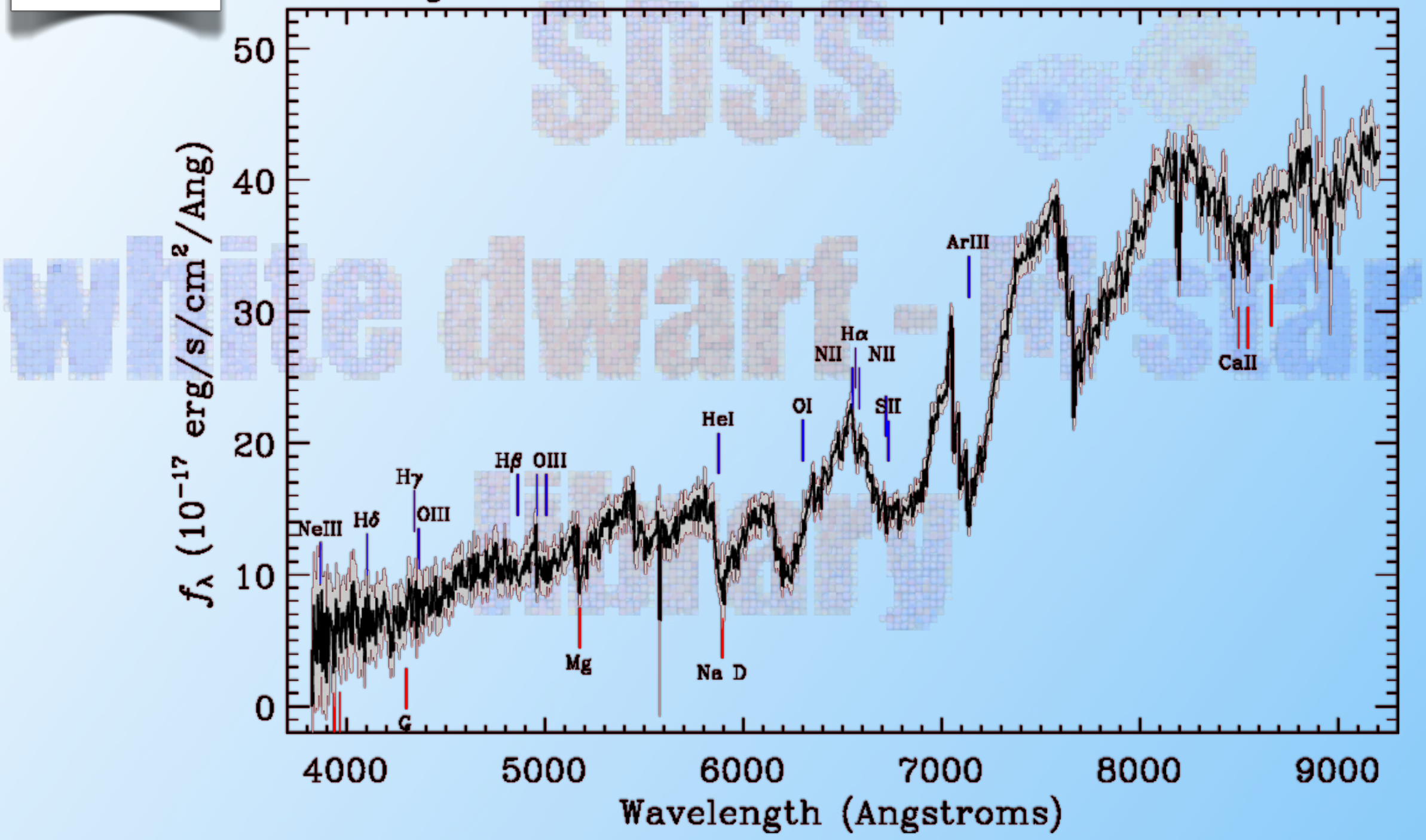
SDSS images




Survey: sdss Program: legacy Target: QSO_SKIRT SERENDIP_DISTANT
RA=261.02239, Dec=62.08377, Plate=352, Fiber=85, MJD=51694
cz=-54+/-21 km/s Class=STAR WD
No warnings.
Hγ
Hδ
NeIII
OIII
Hβ
OIII
HeI
OI
Hα
NII
SII
NII
ArIII
Mg
KH
G
Na D
CaII
30
20
10
0
4000
5000
6000
7000
8000
9000
Wavelength (Angstroms)
f_λ (10^{-17} erg/s/cm^2/Ang)

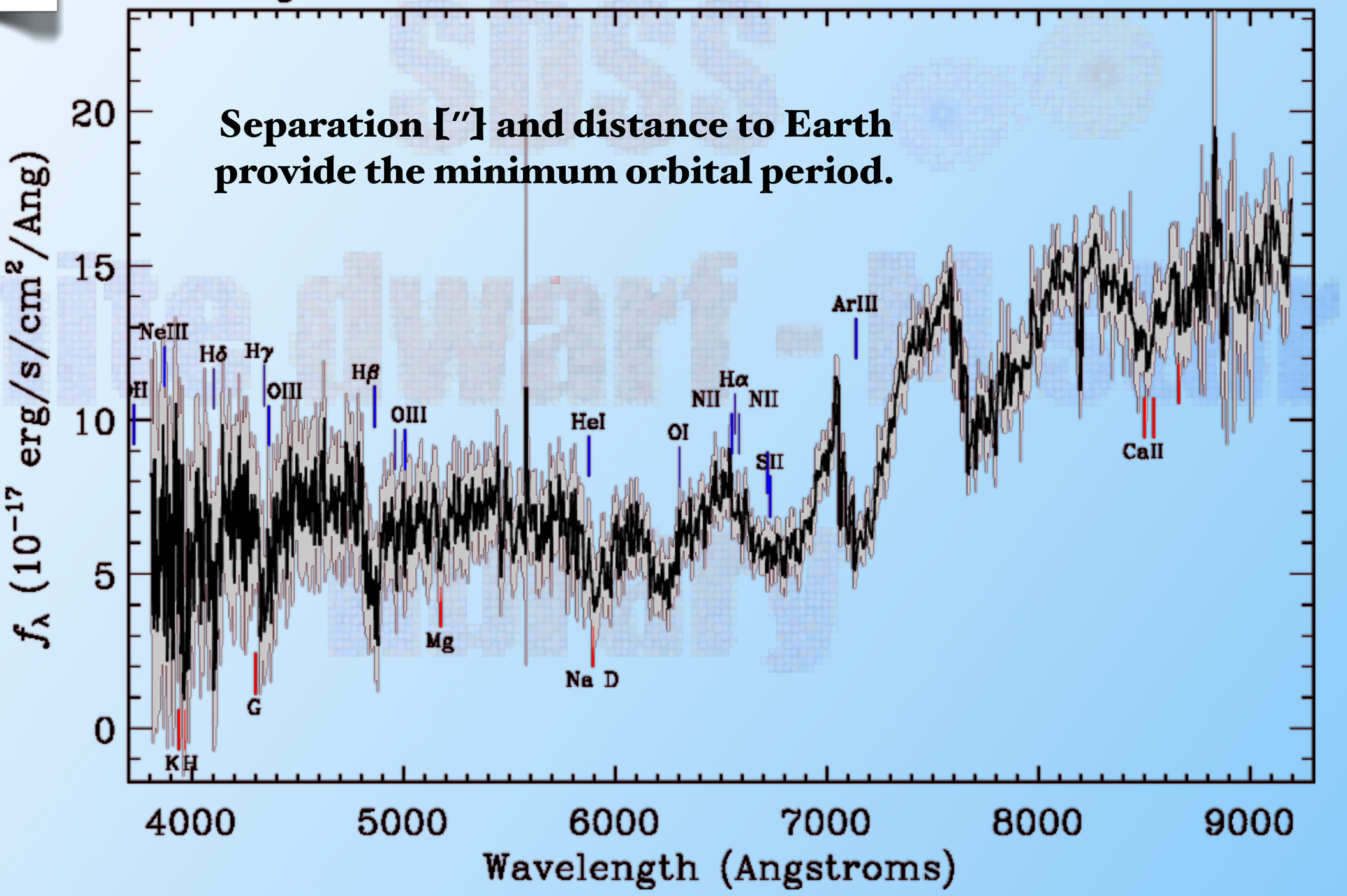
SDSS images

SDSS images


Survey: sdss Program: legacy Target: QSO_HIZ
RA=179.59515, Dec=-2.44217, Plate=330, Fiber=637, MJD=52370
cz=-30+/-5 km/s Class=STAR M4
No warnings.
SDSS
white dwarf - star
f_λ (10^{-17} erg/s/cm^2/Ang)
0
10
20
30
40
50
4000
5000
6000
7000
8000
9000
Wavelength (Angstroms)
NeIII
Hδ
Hγ
OIII
Hβ
OIII
HeI
Mg
Na D
OI
NII
Hα
NII
SII
ArIII
CaII

SDSS images

SDSS images


Survey: sdss Program: legacy Target: QSO_SKIRT
RA=4.38997, Dec=0.67512, Plate=389, Fiber=614, MJD=51794
cz=-6+/-7 km/s Class=STAR M4
No warnings.
Separation ["] and distance to Earth
provide the minimum orbital period.
f_λ (10^{-17} erg/s/cm^2/Ang)
Wavelength (Angstroms)
NeIII
Hδ
Hγ
HI
OIII
Hβ
OIII
HeI
OI
Hα
NII
NII
SII
ArIII
CaII
Mg
G
Na D
KH
0
5
10
15
20
4000
5000
6000
7000
8000
9000

SDSS images

from 636 objects
(Heller et al. 2009)

41 optically resolved binaries

from ≈2000 objects
in the SDSS WD-dM library
(Heller et al. 2011, in prep.)

≈130 optically resolved binaries

Designation	$d_{\rm proj}$ [″]	$\overline{d}$ [pc]	$d_{\rm proj}$ [AU]	$d_{\rm proj}^{\rm corr}$ [AU]	$M_{\rm M}$ [$M_\odot$]	P [yr] ≳	$P^{\rm corr}$ [yr]
J0017−0009	1.4	500	700	1000	0.46	16 000	33 000
J0122+1542	1.0	300	300	500	0.17	6500	13 000
J0151−0800	1.0	350	350	600	0.17	8000	16 000
J0215+1418	0.9	700	600	900	0.27	16 000	30 000
J0249+3342	1.4	500	700	1200	0.17	23 000	45 000
J0348−0614	1.1	500	600	900	0.17	16 000	31 000
J0725+4145	1.3	400	500	900	0.17	15 000	29 000
J0729+4304	1.5	150	250	400	0.12	5000	10 000
J0739+2743	0.6	700	350	600	0.17	8000	16 000
J0740+3859	1.1	300	350	600	0.12	8000	15 000
J0741+3808	0.9	300	250	400	0.17	5000	9000
J0752+4332	1.3	600	800	1200	0.18	23 000	46 000
J0800+5002	1.1	700	800	1200	0.27	22 000	44 000
J0801+2216	1.3	500	700	1100	0.17	20 000	40 000
J0806+4035	1.2	350	450	700	0.17	11 000	21 000
J0809+1251	1.3	400	500	800	0.17	14 000	27 000
J0813+2152	0.9	900	800	1300	0.18	28 000	55 000
J0829+2701	1.4	1000	1400	2200	0.27	55 000	110 000
J0845+2348	1.1	1400	1400	2200	0.46	50 000	100 000
J0904+5621†	1.5	200	300	450	0.10	6000	12 000
J0931+3941	1.4	350	500	800	0.17	13 000	26 000
J0939+5729	1.3	250	300	500	0.17	6000	12 000
J0942+1846	1.3	600	700	1200	0.17	23 000	45 000
J1001+3203	1.3	250	350	500	0.17	7000	13 000
J1006+5633	1.4	1200	1700	2700	0.46	70 000	135 000
J1032+3722	1.3	350	450	700	0.17	10 000	20 000
J1127−0028†	1.5	200	250	400	0.10	4500	9000
J1127+4249	1.2	350	400	600	0.12	9000	18 000
J1205+0312	1.4	250	400	600	0.17	8500	17 000
J1209+6510†	1.4	250	350	500	0.10	7500	14 000
J1210+0549	1.4	350	500	800	0.17	12 000	24 000
J1216+4328	1.5	900	1300	2000	0.46	46 000	90 000
J1242+4506	1.5	450	700	1100	0.17	20 000	40 000
J1253+5813	1.4	400	600	900	0.27	14 000	28 000
J1304+1449	1.3	500	600	1000	0.17	18 000	35 000
J1347+4129	1.3	1200	1600	2500	0.46	65 000	125 000
J1456+4824	1.4	450	600	1000	0.17	18 000	35 000
J1606+4217	1.1	500	600	900	0.17	17 000	35 000
J1630+1302	1.4	600	900	1420	0.17	31 000	60 000
J1744+2442	1.4	1100	1500	2400	0.46	55 000	115 000
J2200−0715†	1.5	200	250	400	0.10	5000	10 000

SDSS images

Designation	$d_{\rm proj}$ [″]	$\overline{d}$ [pc]	$d_{\rm proj}$ [AU]	$d_{\rm proj}^{\rm corr}$ [AU]	$M_{\rm M}$ [$M_\odot$]	P [yr] ≳	$P^{\rm corr}$ [yr]
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J0725+4145	1.3	400	500	900	0.17	15 000	29 000
J0729+4304	1.5	150	250	400	0.12	5000	10 000
J0739+2743	0.6	700	350	600	0.17	8000	16 000
J0740+3859	1.1	300	350	600	0.12	8000	15 000
J0741+3808	0.9	300	250	400	0.17	5000	9000
J0752+4332	1.3	600	800	1200	0.18	23 000	46 000
J0800+5002	1.1	700	800	1200	0.27	22 000	44 000
J0801+2216	1.3	500	700	1100	0.17	20 000	40 000
J0806+4035	1.2	350	450	700	0.17	11 000	21 000
J0809+1251	1.3	400	500	800	0.17	14 000	27 000
J0813+2152	0.9	900	800	1300	0.18	28 000	55 000
J0829+2701	1.4	1000	1400	2200	0.27	55 000	110 000
J0845+2348	1.1	1400	1400	2200	0.46	50 000	100 000
J0904+5621[†]	1.5	200	300	450	0.10	6000	12 000

SDSS images

Designation	$d_{\rm proj}$ [″]	$\bar{d}$ [pc]	$d_{\rm proj}$ [AU]	$d_{\rm proj}^{\rm corr}$ [AU]	$M_{\rm M}$ [$M_\odot$]	P [yr] $\gtrsim$	$P^{\rm corr}$ [yr]
J0017−0009	1.4	500	700	1000	0.46	16 000	33 000
J0122+1542	1.0	300	300	500	0.17	6500	13 000
J0151−0800	1.0	350	350	600	0.17	8000	16 000
J0215+1418	0.9	700	600	900	0.27	16 000	30 000
J0249+3342	1.4	500	700	1200	0.17	23 000	45 000
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J0725+4145	1.3	400	500	900	0.17	15 000	29 000
J0729+4304	1.5	150	250	400	0.12	5000	10 000
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J0806+4035	1.2	350	450	700	0.17	11 000	21 000
J0809+1251	1.3	400	500	800	0.17	14 000	27 000
J0813+2152	0.9	900	800	1300	0.18	28 000	55 000
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J0845+2348	1.1	1400	1400	2200	0.46	50 000	100 000
J0904+5621[†]	1.5	200	300	450	0.10	6000	12 000

SDSS images

$M_{WD} = 0.6\ M_{Sun}$ assumed

Designation	d_{proj} [″]	$\bar{d}$ [pc]	d_{proj} [AU]	d_{proj}^{corr} [AU]	M_M [$M_\odot$]	P [yr] ≳	P^{corr} [yr]
J0017−0009	1.4	500	700	1000	0.46	16 000	33 000
J0122+1542	1.0	300	300	500	0.17	6500	13 000
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J0725+4145	1.3	400	500	900	0.17	15 000	29 000
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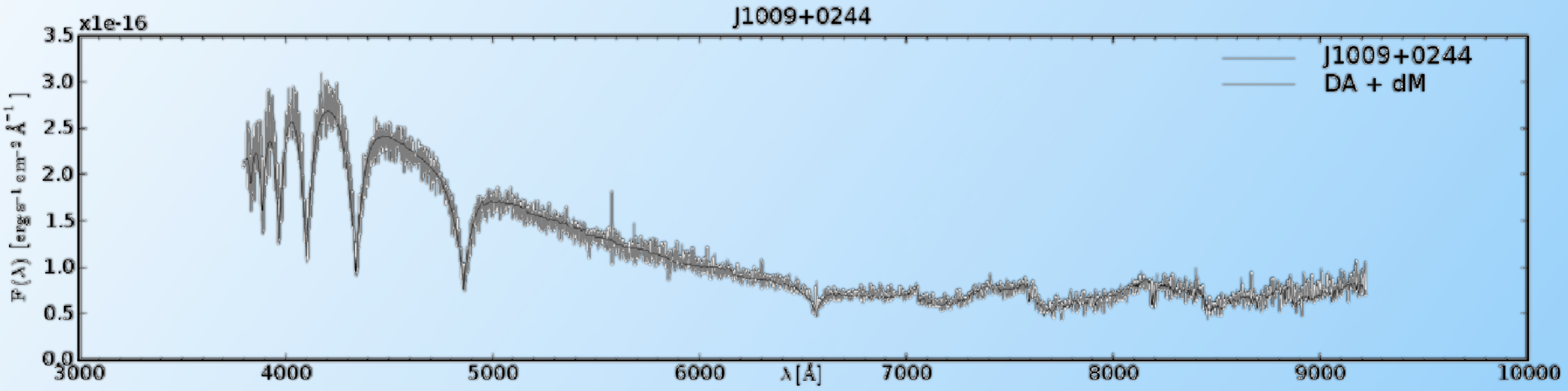
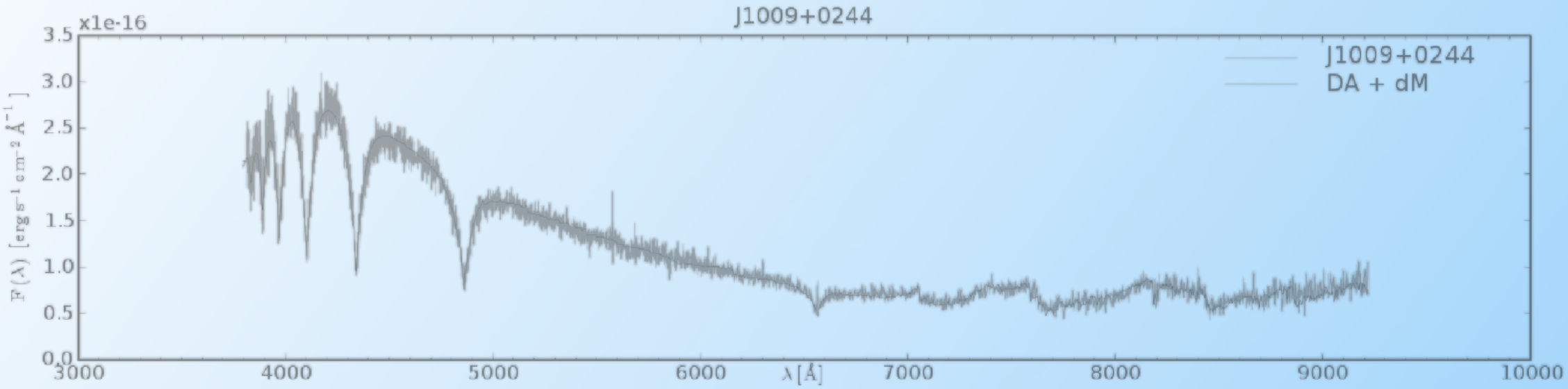
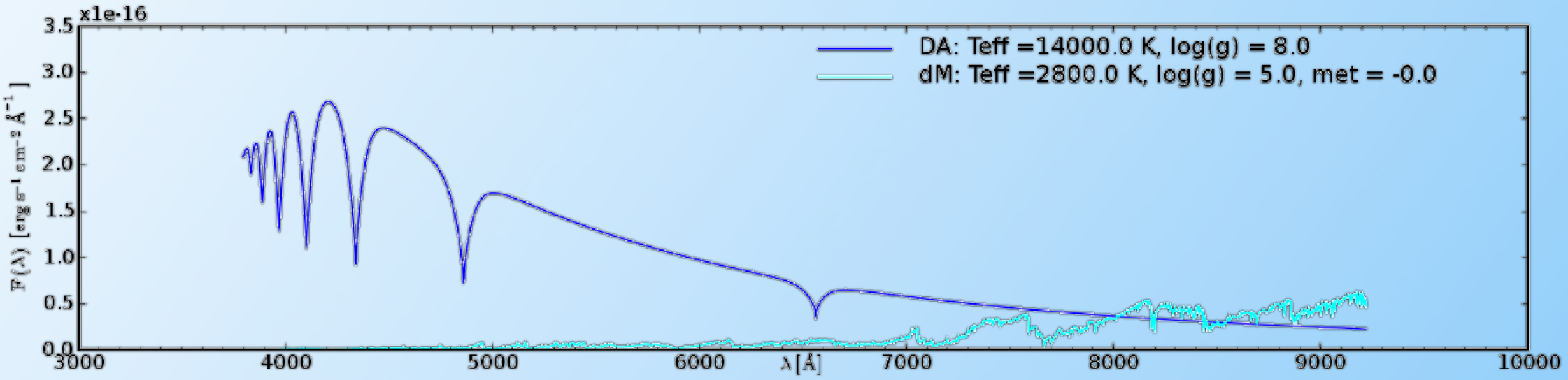
J0904+5621†	1.5	200	300	450	0.10	6000	12 000

Spectral Decomposition

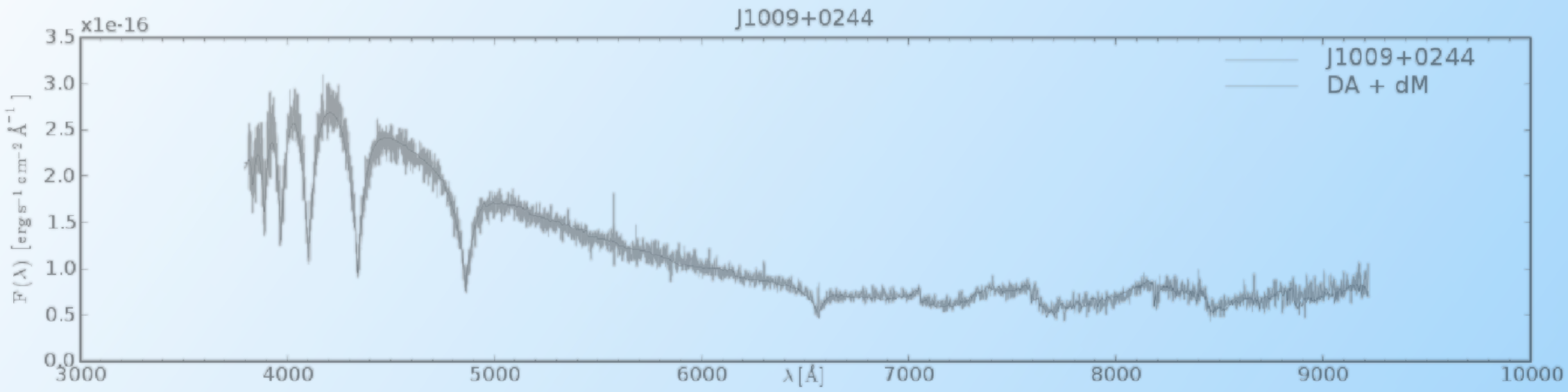


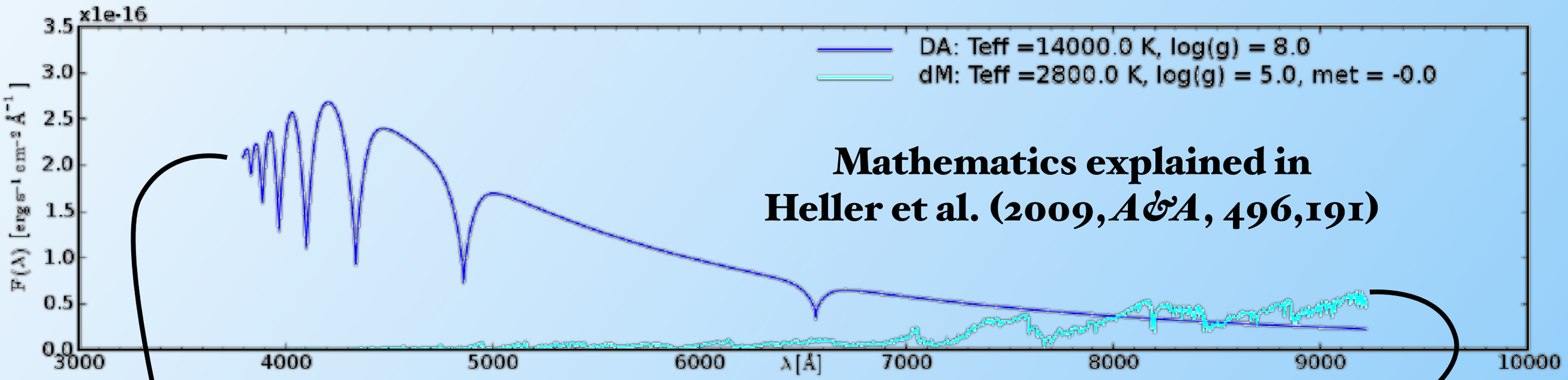
Spectral Decomposition





Spectral Decomposition



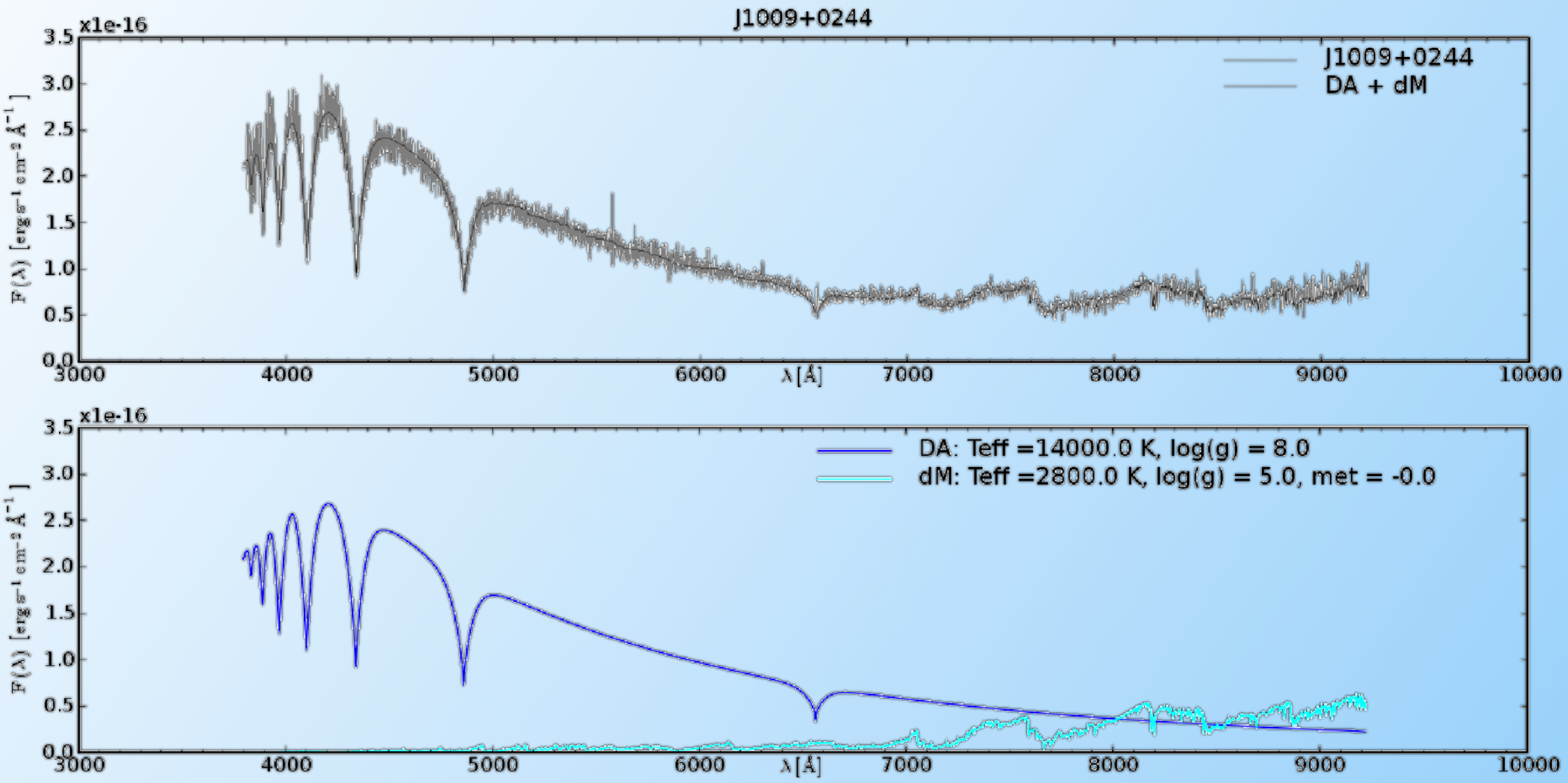


Mathematics explained in Heller et al. (2009, *A&A*, 496,191)

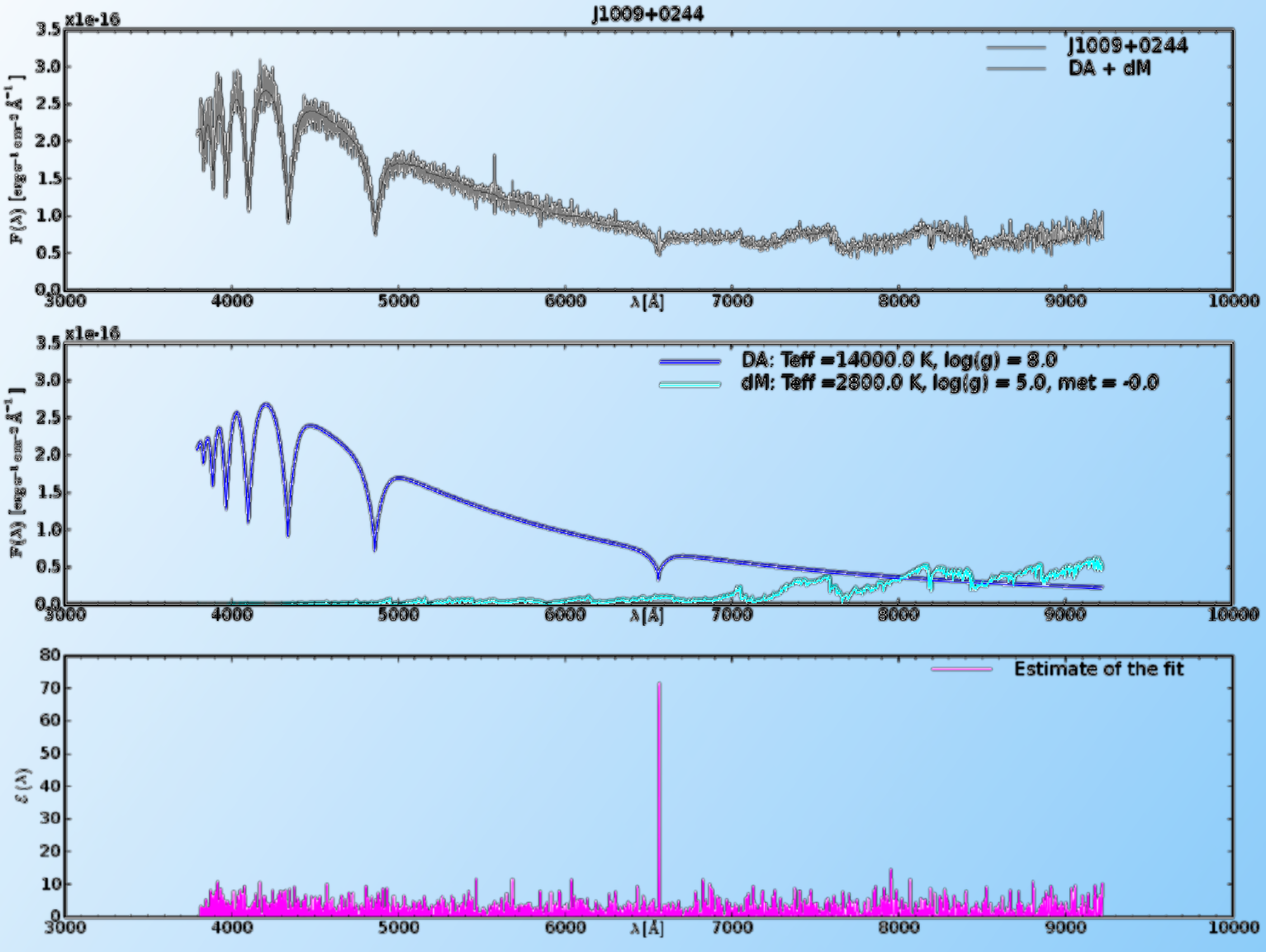
WD synthetic spectrum
Koester (2001, *A&A*, 378,556)

dM synthetic spectrum (PHOENIX, v14.2)
Hauschildt & Baron (1999, *JCoAM*, 109, 41)

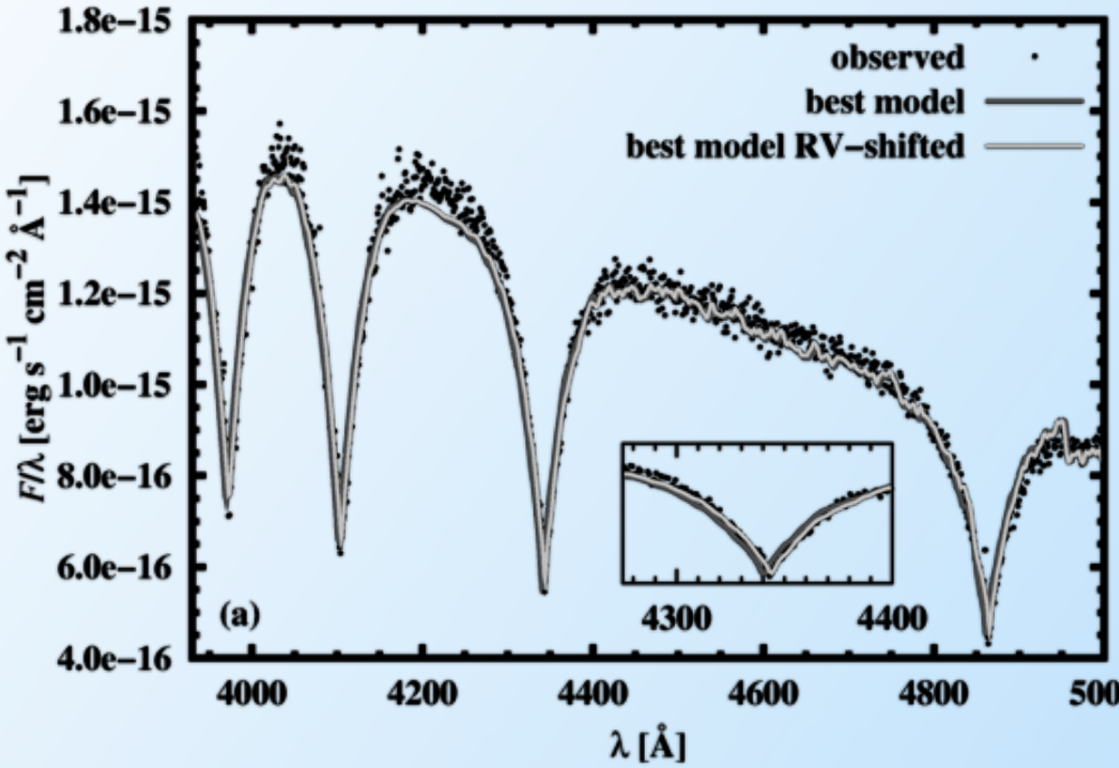
Spectral Decomposition

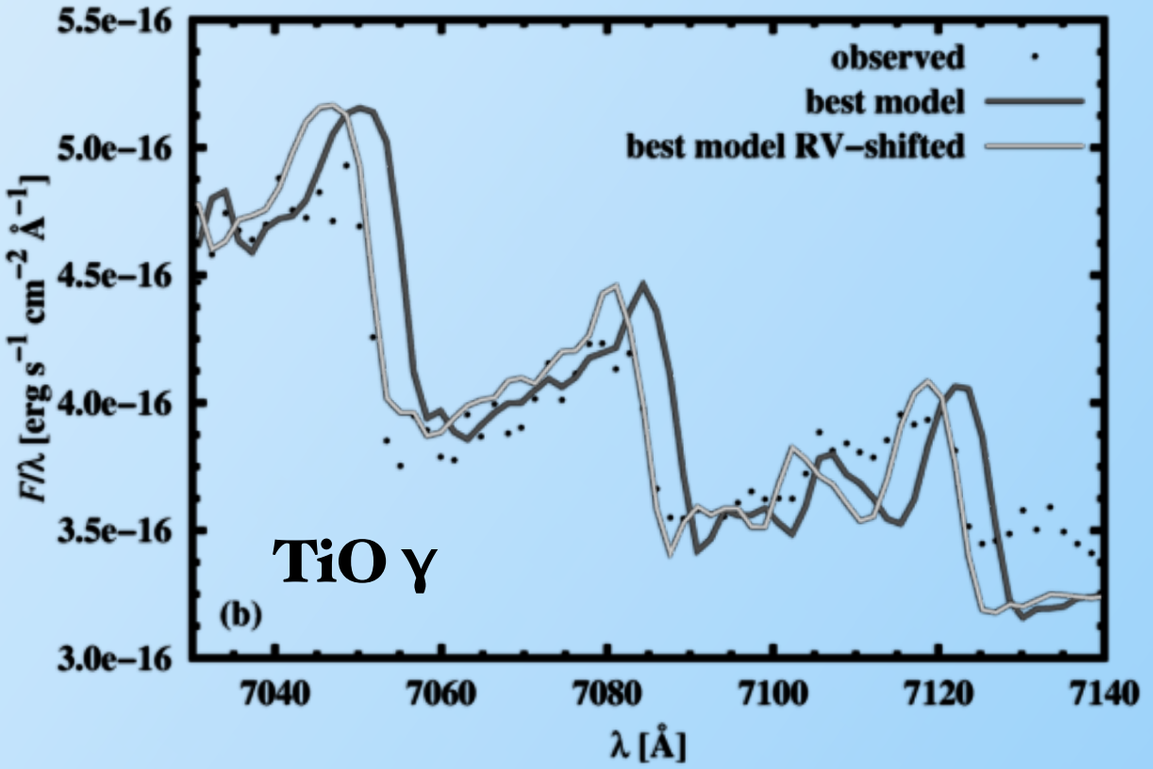


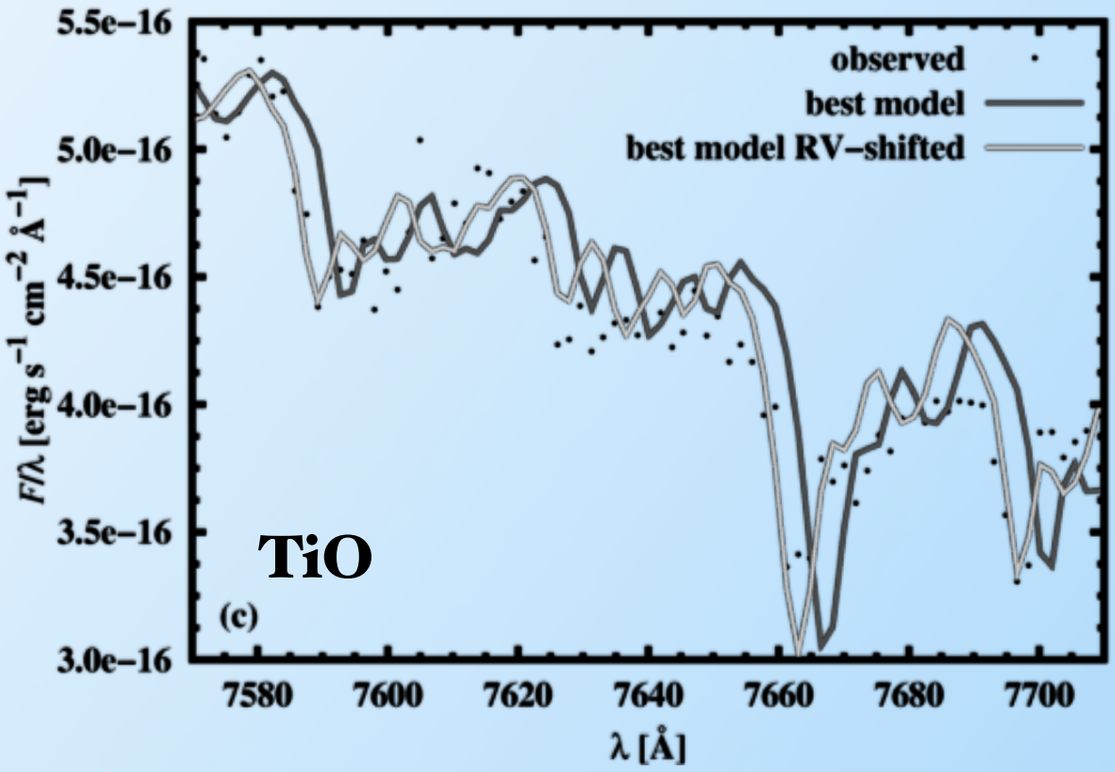
Spectral Decomposition

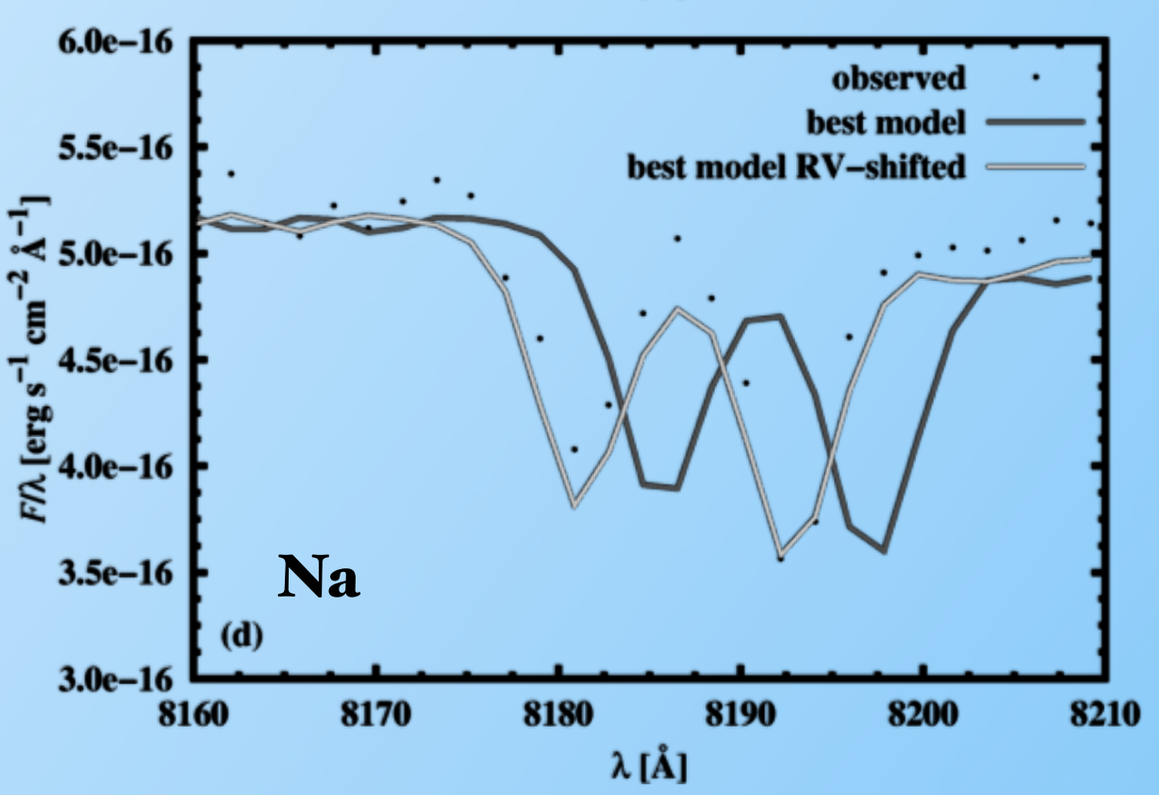


Spectral Decomposition
Radial Velocities



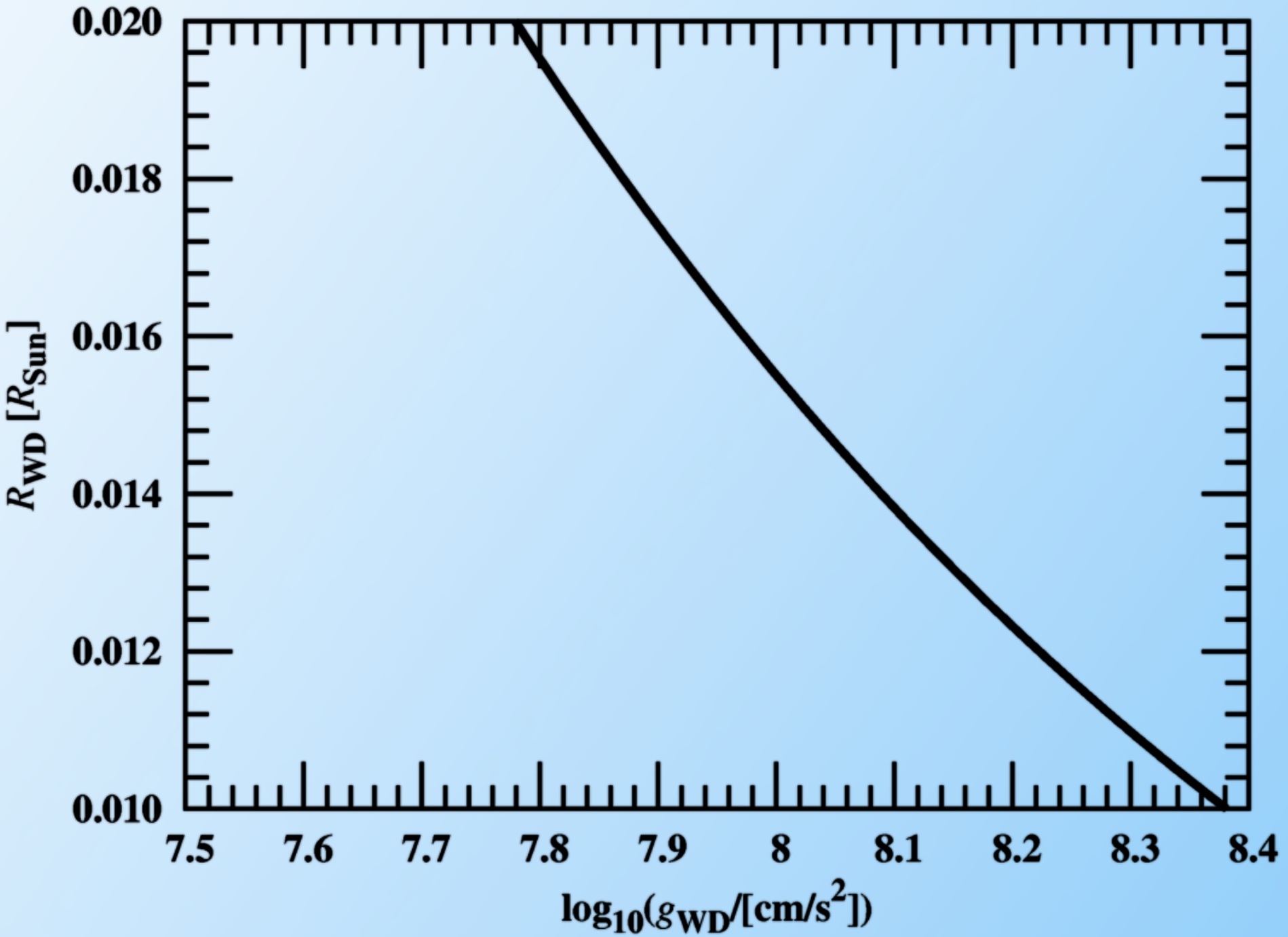




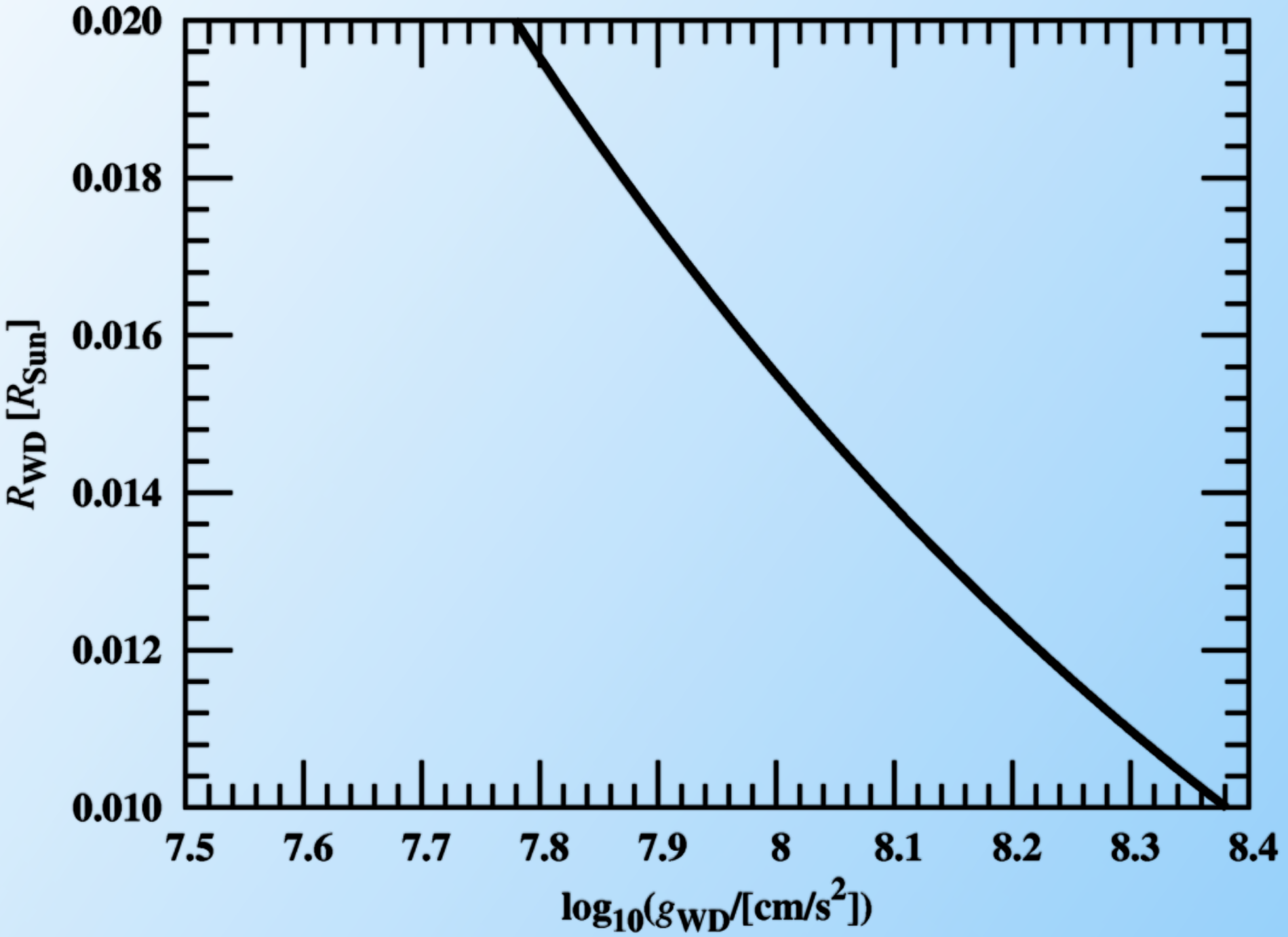


White Dwarf Evolution Tracks from Renedo et al. (2010)

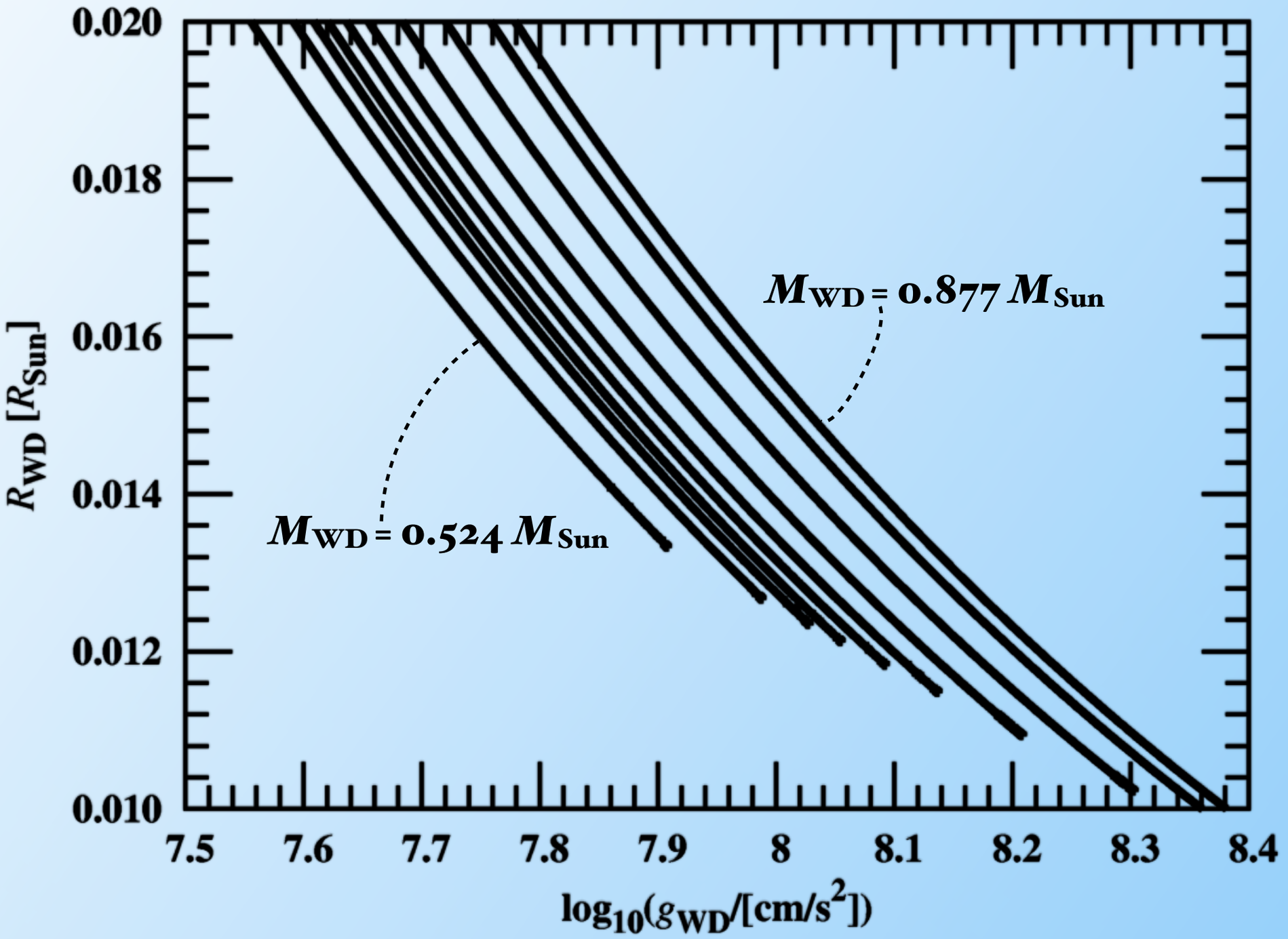
- Self-consistent stellar evolution from ZAMS
- Includes residual hydrogen-burning in WDs
- Includes carbon-oxygen phase separation



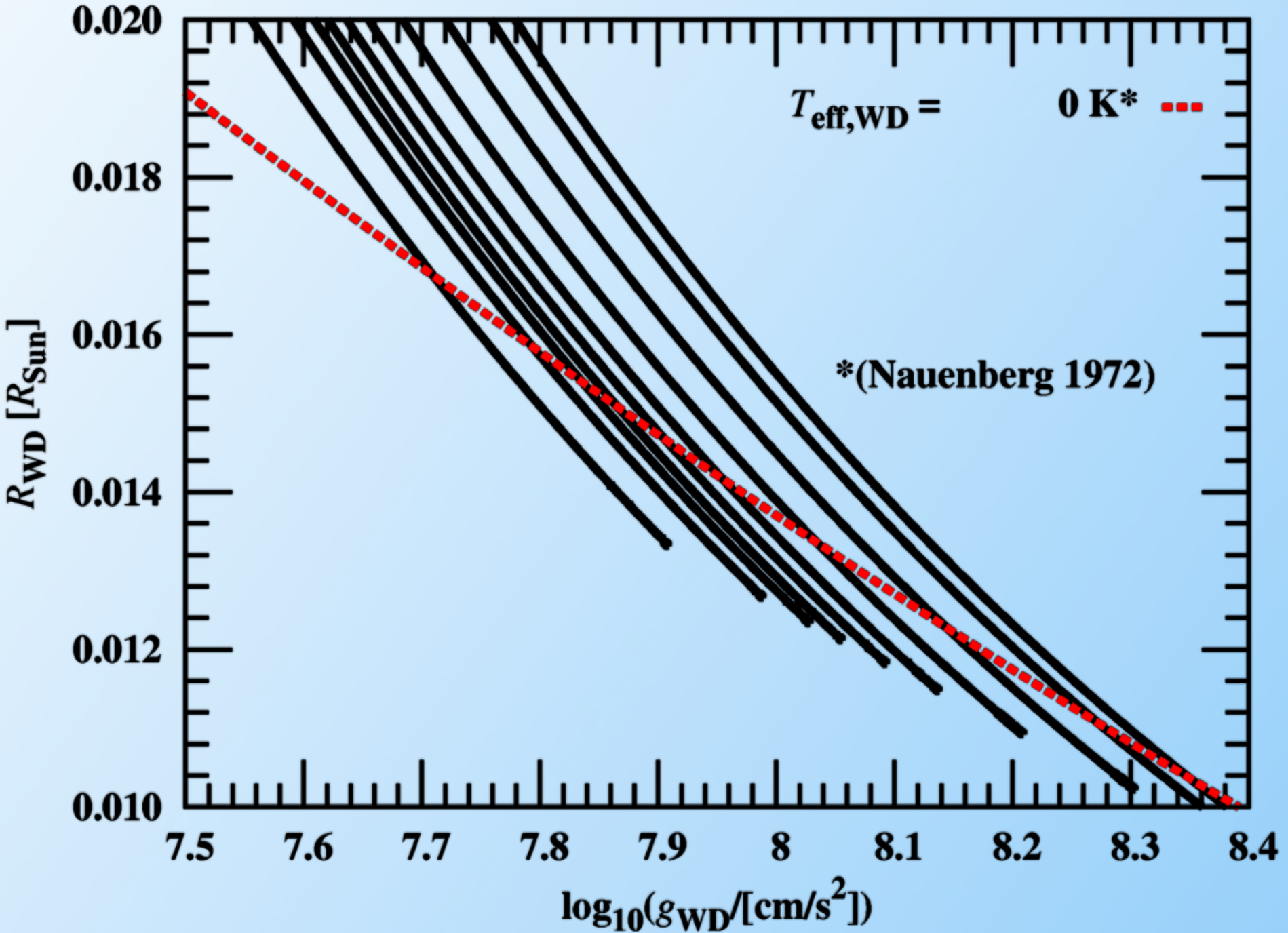
White Dwarf Evolution Tracks from Renedo et al. (2010)



White Dwarf Evolution Tracks from Renedo et al. (2010)

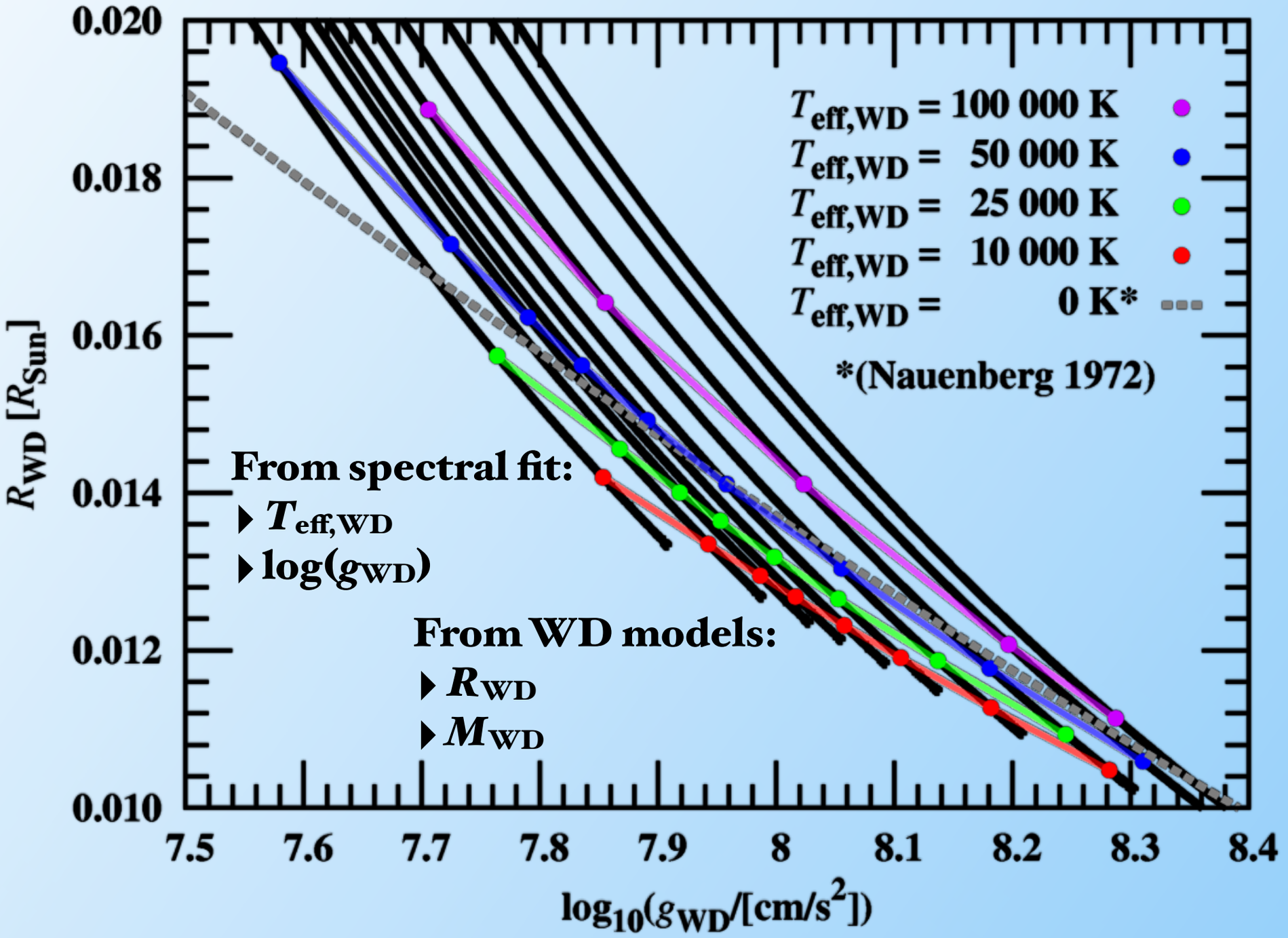


White Dwarf Evolution Tracks from Renedo et al. (2010)



White Dwarf Evolution Tracks from Renedo et al. (2010)

no additional M_{WD}-R_{WD} relation necessary



System parametrization

White Dwarf parametrization

From spectral fit:

- $T_{\mathrm{eff,WD}}$
- $\log(g_{\mathrm{WD}})$
- $v_{\mathrm{rad,WD}}$

} 7-dimensional parameter fit {

M Dwarf parametrization

From spectral fit:

- $T_{\mathrm{eff,dM}}$
- $\log(g_{\mathrm{dM}})$
- $[\mathrm{Fe/H}]_{\mathrm{dM}}$
- $v_{\mathrm{rad,dM}}$

System parametrization

White Dwarf parametrization

From spectral fit:

- $T_{\mathrm{eff,WD}}$
- $\log(g_{\mathrm{WD}})$
- $v_{\mathrm{rad,WD}}$

From WD models:

- R_{WD}
- M_{WD}
- d_{WD}

M Dwarf parametrization

From spectral fit:

- $T_{\mathrm{eff,dM}}$
- $\log(g_{\mathrm{dM}})$
- $[\mathrm{Fe/H}]_{\mathrm{dM}}$
- $v_{\mathrm{rad,dM}}$

From dM models:

- R_{dM}
- M_{dM}
- d_{dM}

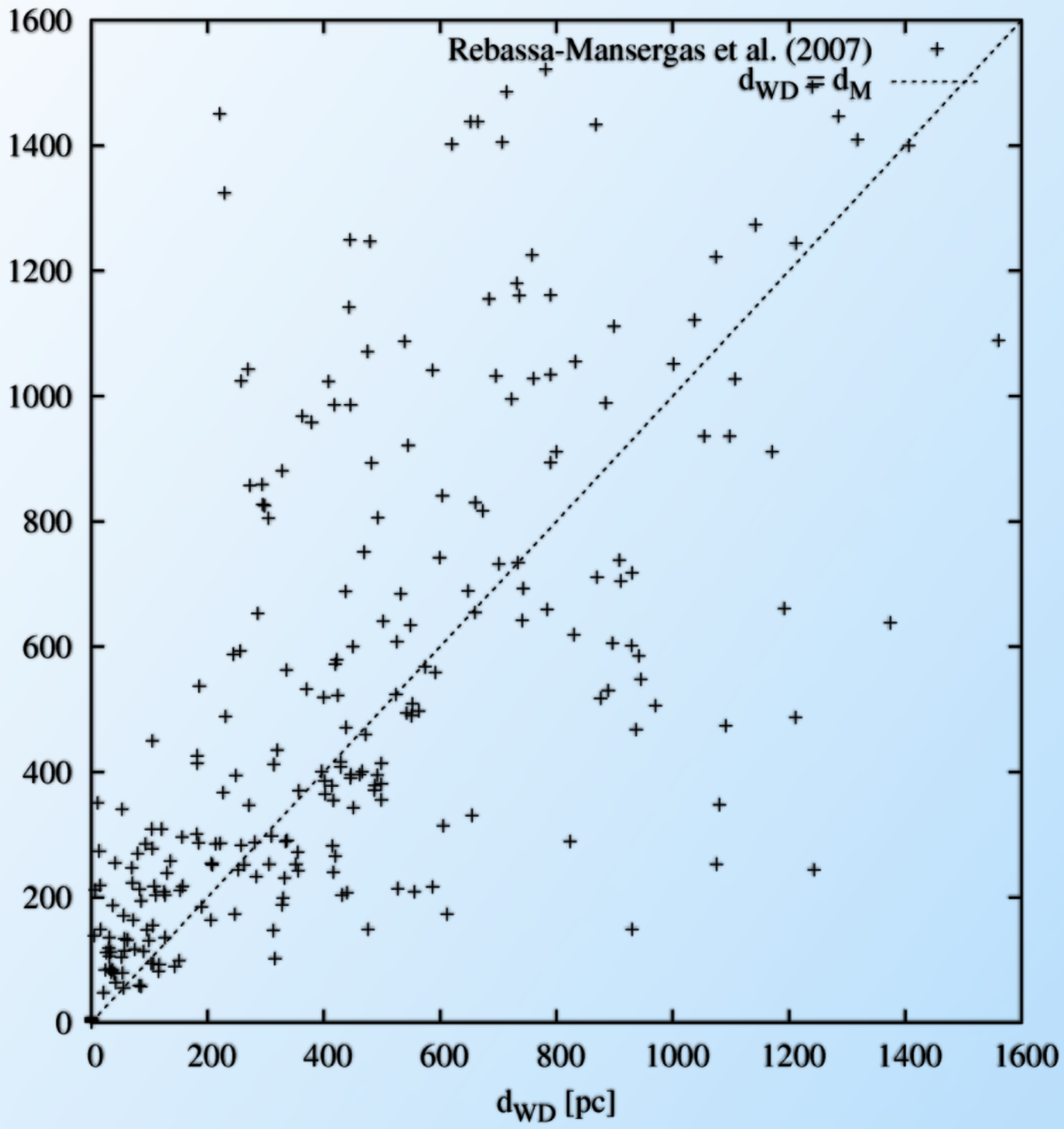
7-dimensional parameter fit

For optically resolved binaries:

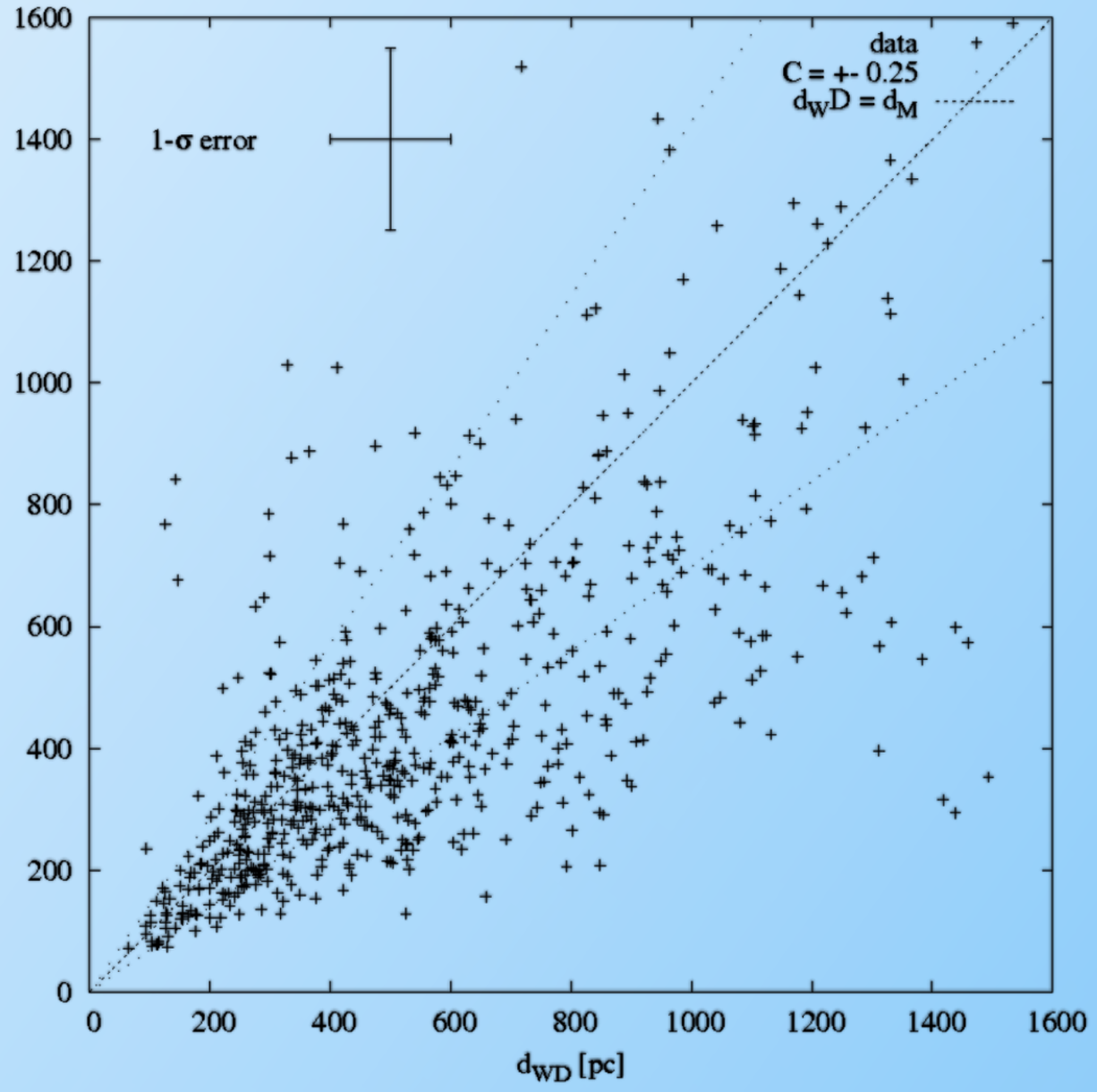
- minimum P_{orb}

WD-dM binaries as standard candles

Rebassa-Mansergas et al. (2007)



Heller et al. (2009)

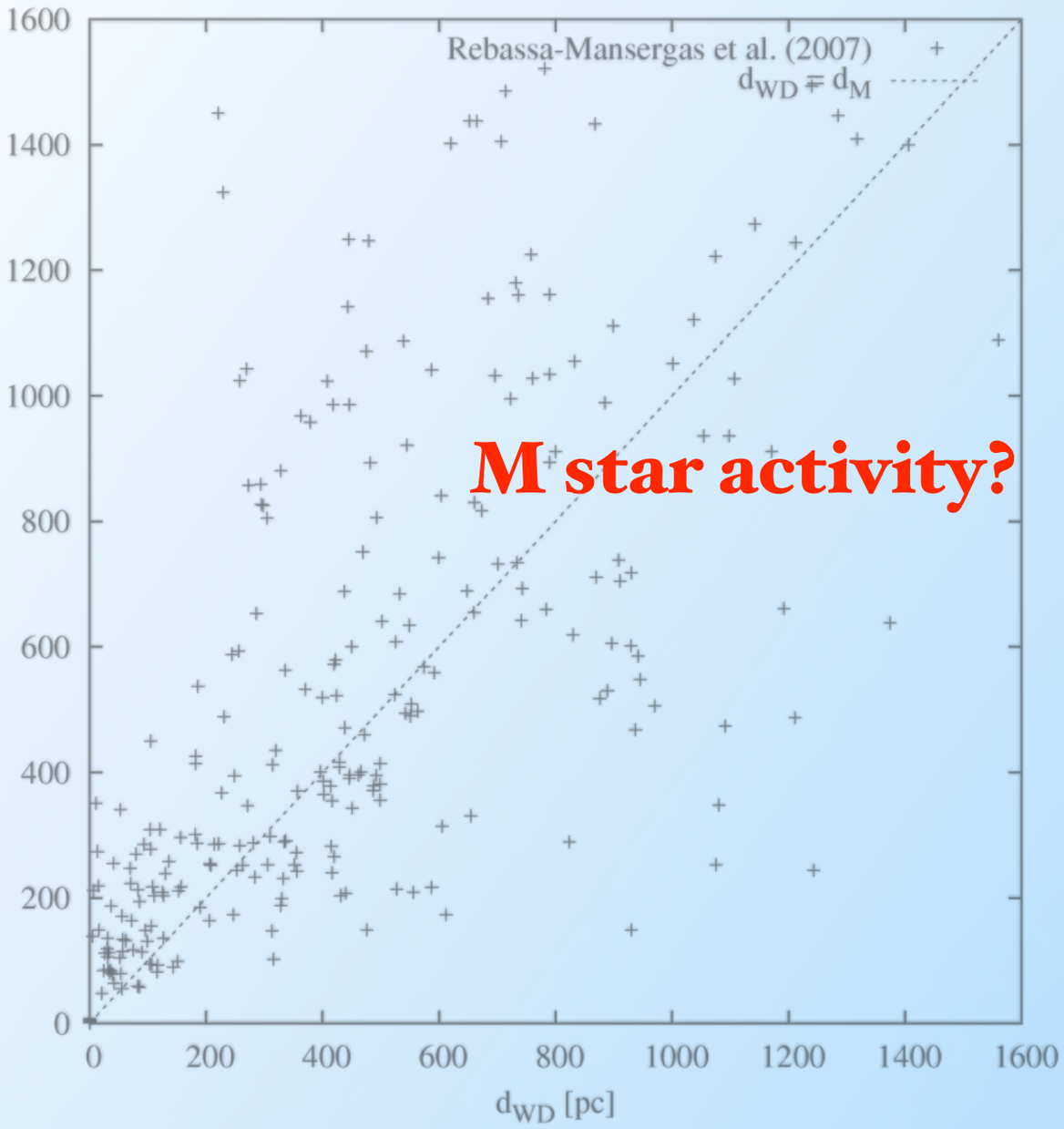


observed M star templates (SDSS)

synthesized M star templates (PHOENIX)

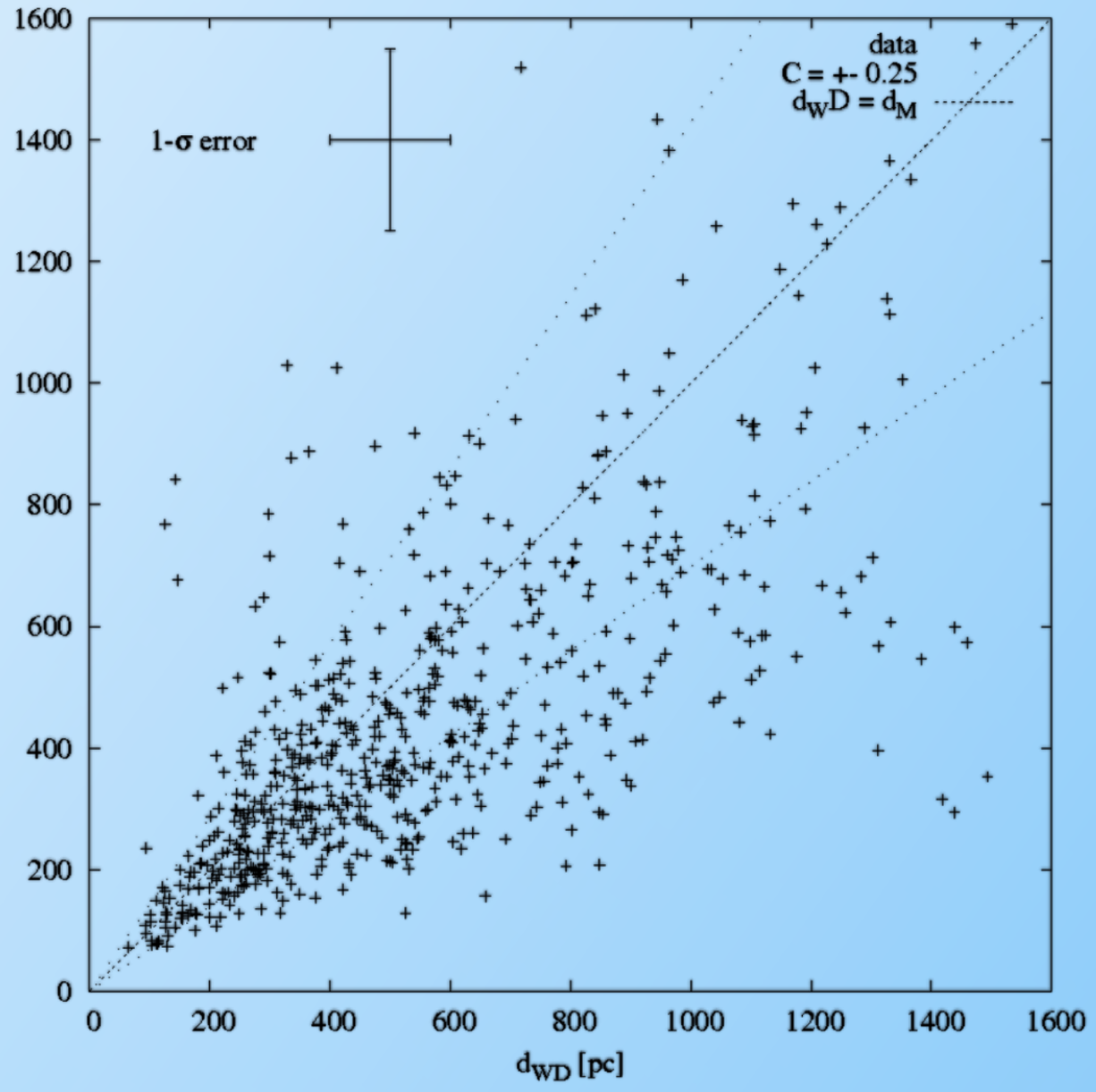
WD-dM binaries as standard candles

Rebassa-Mansergas et al. (2007)



observed M star templates
(SDSS)

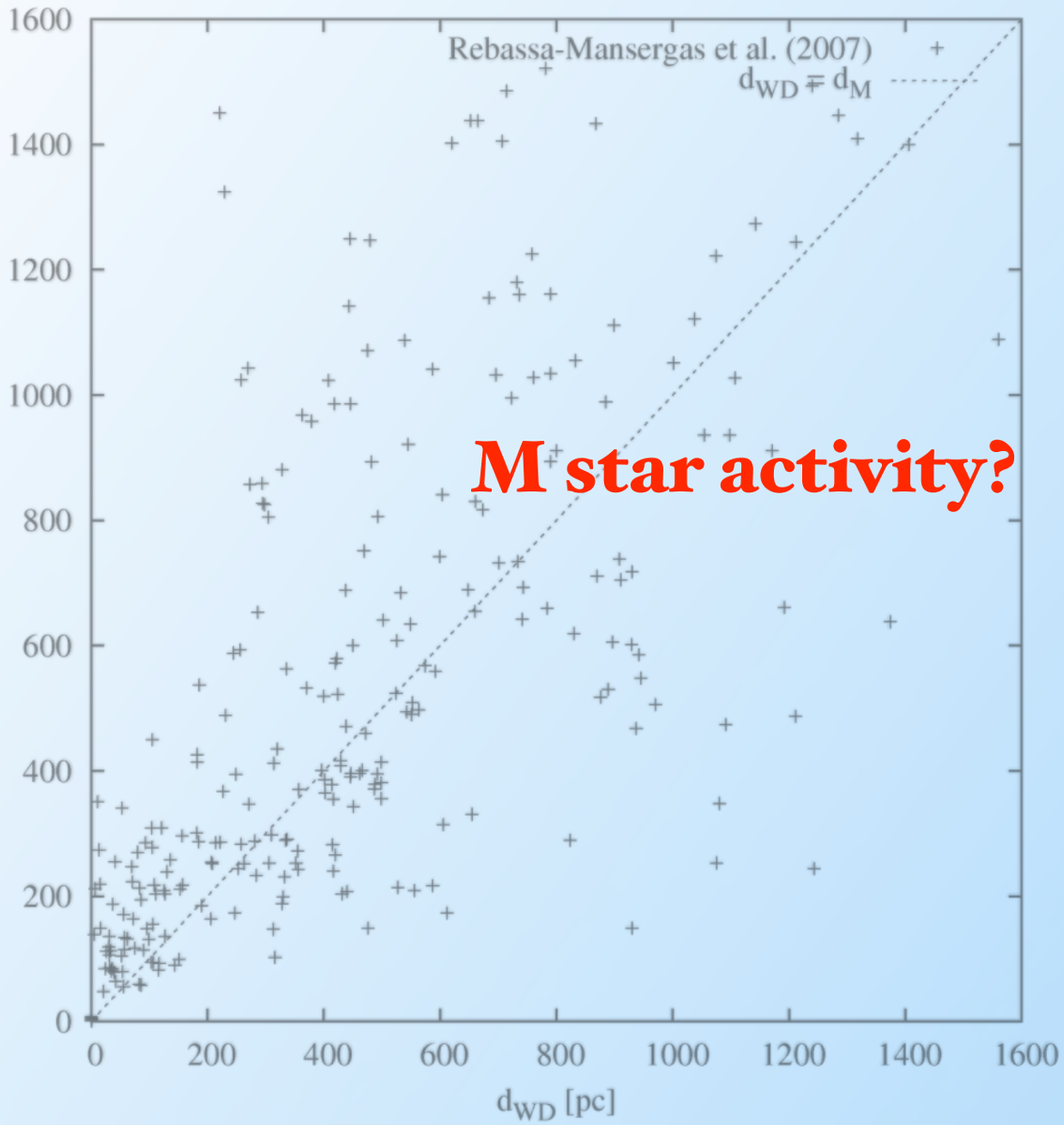
Heller et al. (2009)



synthesized M star templates
(PHOENIX)

WD-dM binaries as standard candles

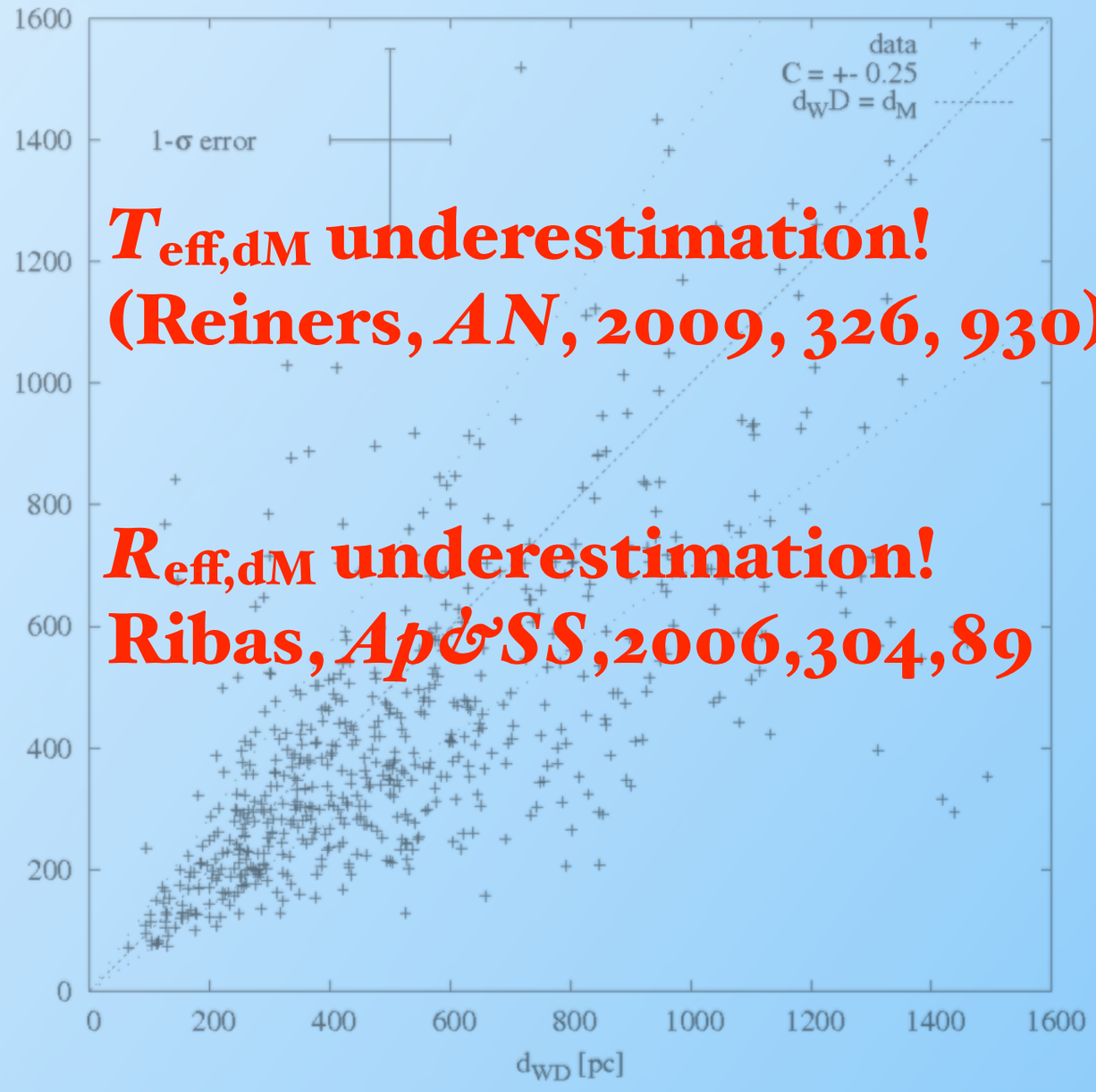
Rebassa-Mansergas et al. (2007)



M star activity?

observed M star templates (SDSS)

Heller et al. (2009)



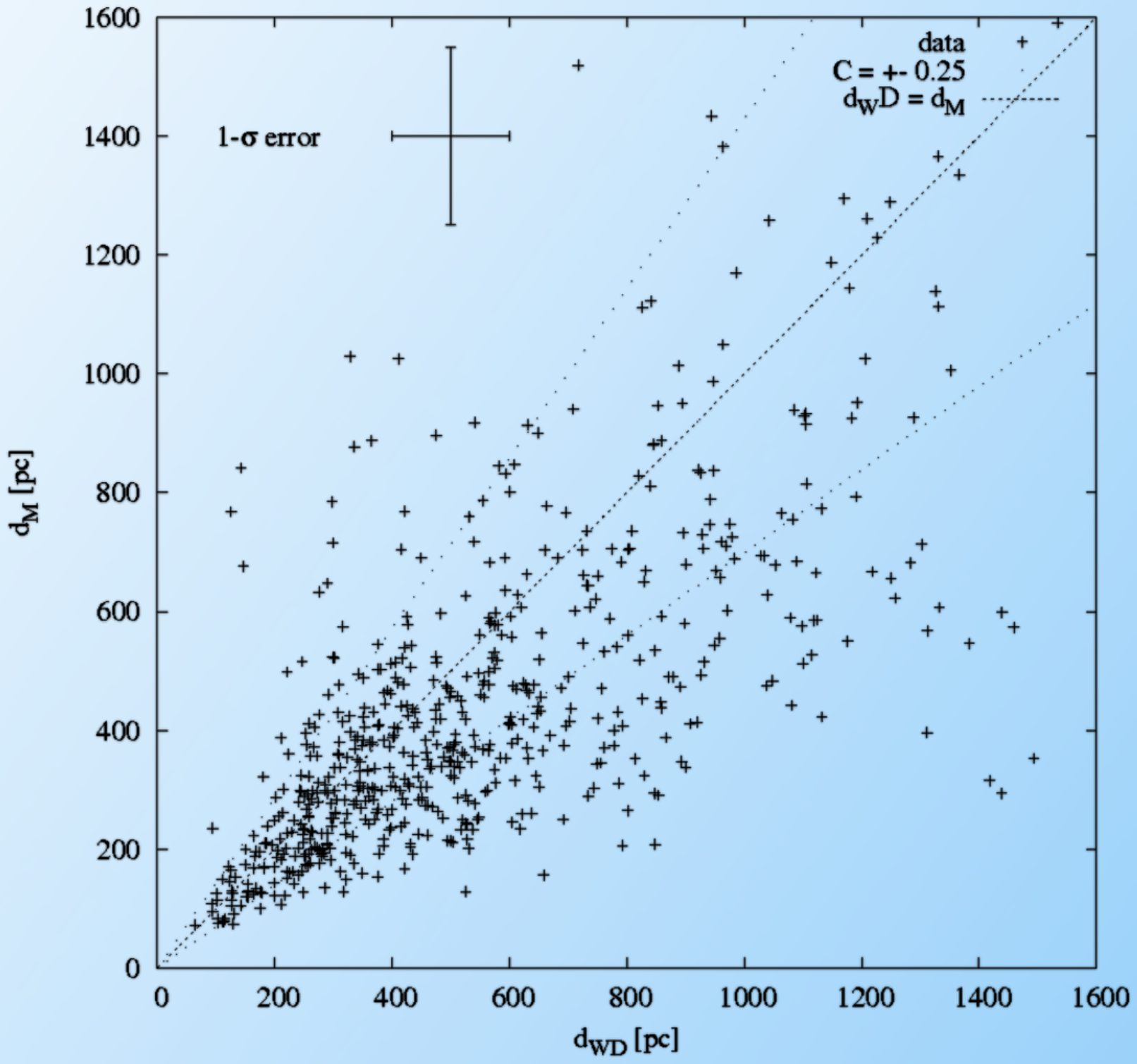
$T_{eff,dM}$ underestimation!
(Reiners, *AN*, 2009, 326, 930)

$R_{eff,dM}$ underestimation!
Ribas, *Ap&SS*, 2006, 304, 89

synthesized M star templates (PHOENIX)

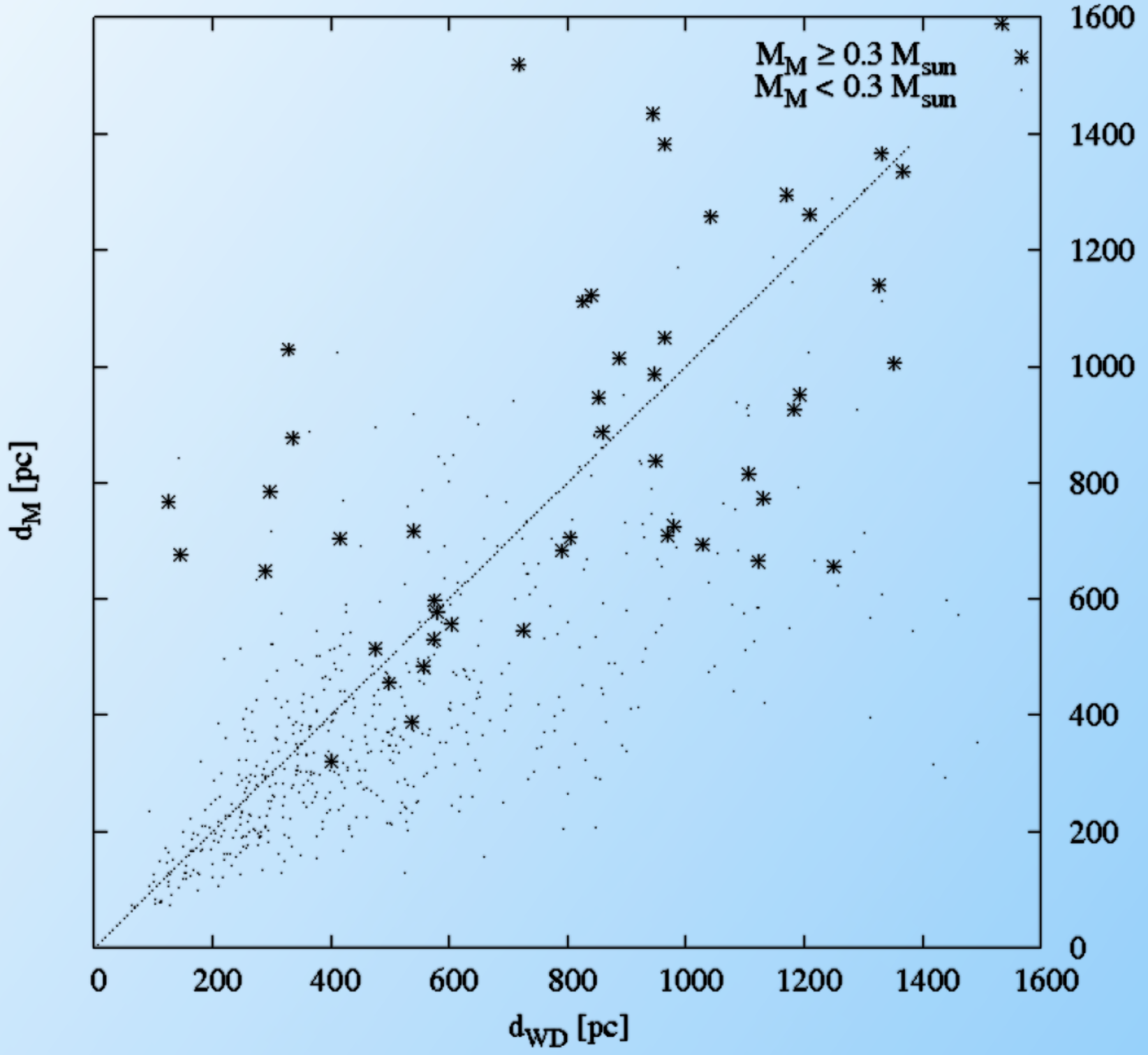
WD-dM binaries as standard candles

Heller et al. (2009)



WD-dM binaries as standard candles

Heller et al. (2009)

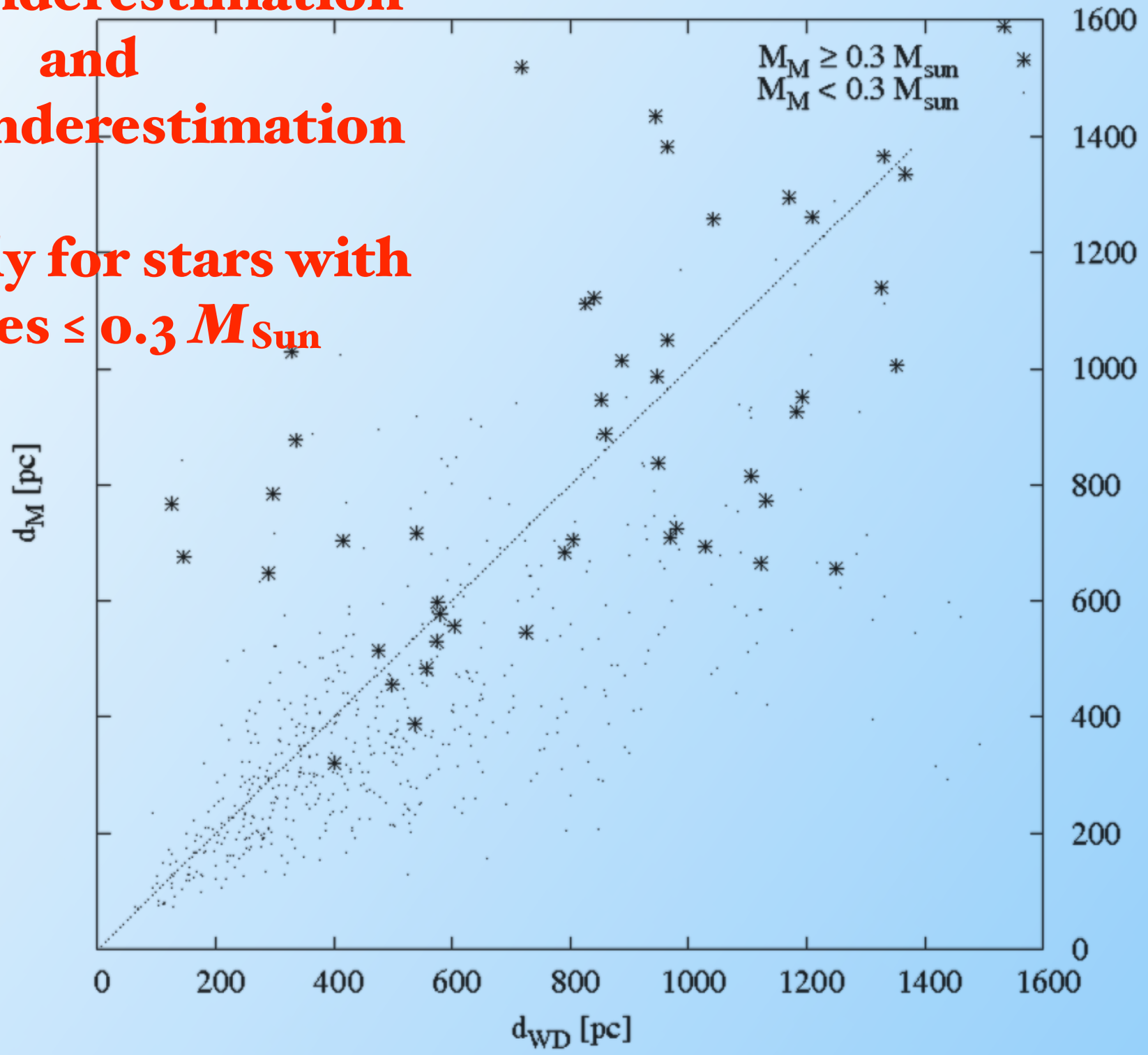


WD-dM binaries as standard candles

Heller et al. (2009)

$T_{eff,dM}$ underestimation and $R_{eff,dM}$ underestimation

especially for stars with masses ≤ 0.3 M_{Sun}



White Dwarf - M Dwarf Binaries

from the

Sloan Digital Sky Survey

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March 08, 2011

Appendix

Appendix

The Poisson probability to find ν objects with an area density ρ inside an area $A = \pi \times (1.5'')^2$ is given by

$$P_{\rm M}(\nu) = \frac{\mu^\nu}{\nu!} e^{-\mu}, \tag{1}$$

where $\mu = A \times \rho$. For $\nu \geq 1$ and n trials, i.e. WD-dM candidates, we get an expectation value

$$N = n \times P(\nu \geq 1) = n \times (1 - e^{-\mu}). \tag{2}$$

The approximate magnitude range of our sample is $15 < u, g, r, i, z < 20.5$. From Boachanski et al. (2009, and priv. comm.) we count 3632 objects per square degree with $15 \leq z \leq 20.5$, and less objects in the other four filters. This provides us with $\rho \lesssim 3632/(3600'')^2$. Our spectroscopic sample consists of 2230, thus $n = 2230$ and Eq. (2) yields $N \lesssim 4$.