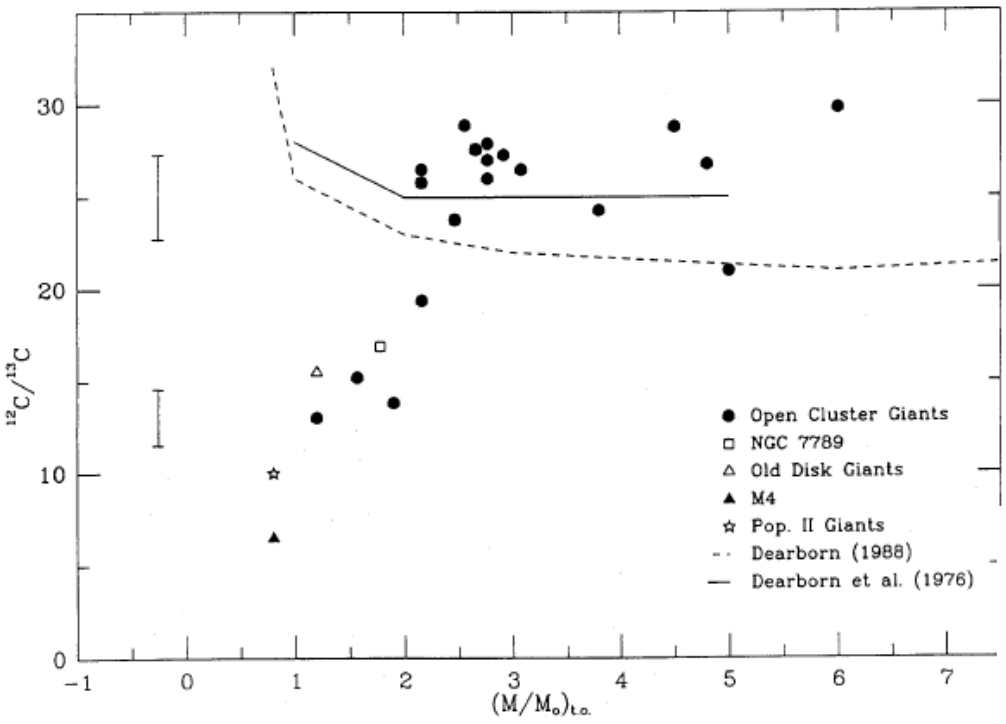
Açık Küme Üyesi Kırmızı Dev Yıldızların Kimyasal Analizi

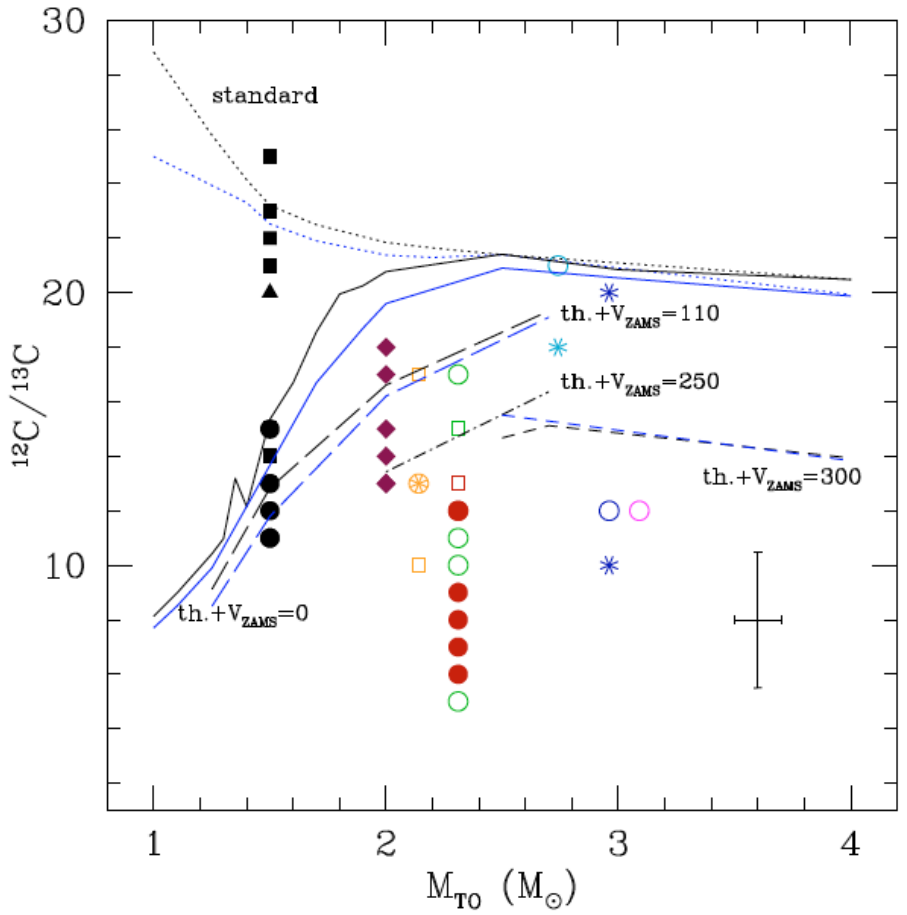
Gamze BÖCEK TOPCU

Melike Afşar
Chris Sneden (UT)

Motivasyonumuz

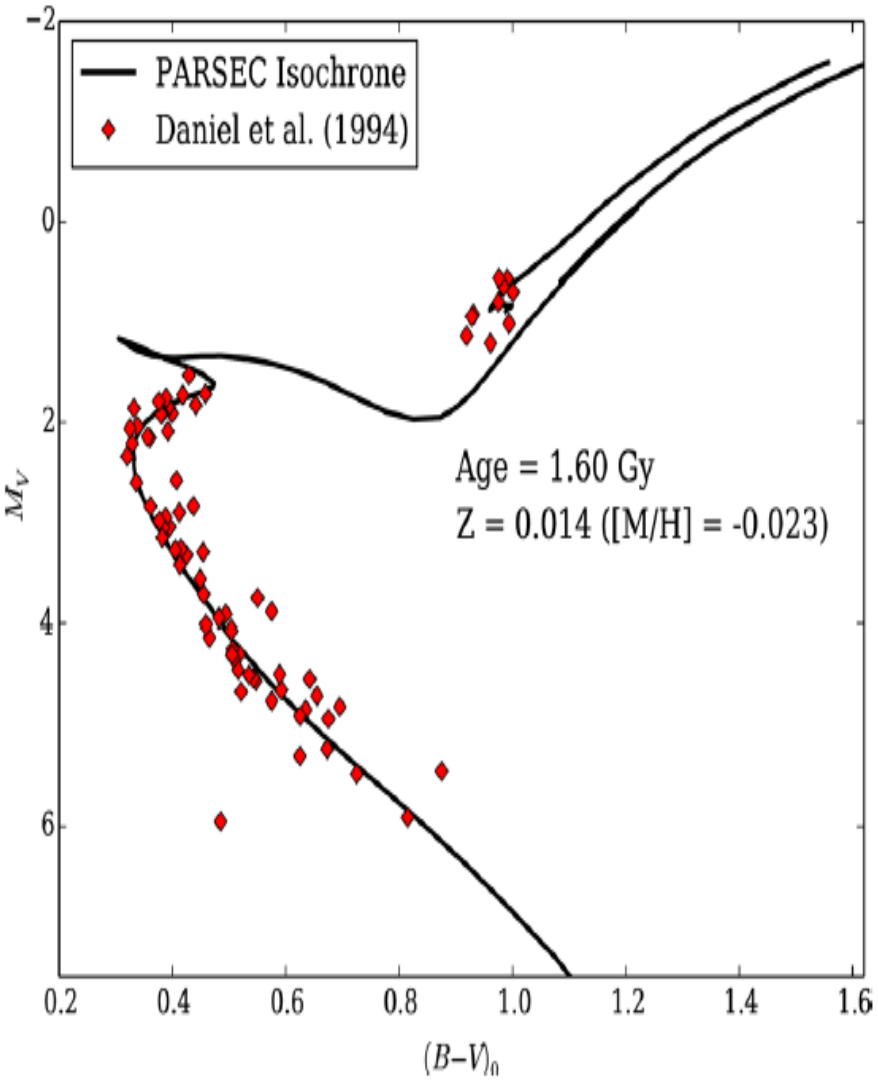


Gilroy, 1989



C. Charbonnel & N. Lagarde, 2010

NGC 752



Sağ Açıklık (2000)	01 57 41
Dik Açıklık (2000)	+37 47 06
Galaktik Enlem	137.125
Galaktik Boylam	−23.254
Uzaklık	447 pc
E(B-V)	0.035
$(m-M)_0$	8.25
Yaş	1.7–1.9 Gyr
Dönme noktası kütlesi	1.5 $M_\odot$

- [Fe/H] = +0.08±0.04 (Carrera et al. 2011)
- [Fe/H] = -0.02±0.05 (Reddy et al. 2012)

- [Fe/H] = -0.02±0.05 (Bu çalışma)

Böcek Topcu et al., 2014

Amacımız...

- ★ Model atmosfer parametreleri (T_{eff} – log g – [M/H] – ξ)
- ★ Hafif elementler (Li, C, N, O)
- ★ Alfa elementleri (Mg, Si, Ca)
- ★ Fe-civarı (Fe-peak) elementleri (Sc, V, Ti, Cr, Mn, Co, Ni, Cu, Zn)
- ★ n-yakalama elementleri (Y, La, Nd, Eu)
- ★ $^{12}C/^{13}C$
- ★ IGRINS (Immersion Grating INfrared Spectrometer)
  - ➢ $R=\lambda/\Delta\lambda$ = 40,000
  - ➢ Tüm H ve K bandını (1.5 – 2.4 μm) tek pozda kapsıyor.
  - ➢ Kızılöte moleküler bandlar (C_2, CN, NH, OH, CO ve HF)

Gözlemler

Table 3. Observing logs and radial velocities of the observed stars.

Star	Obs. date	Exp. (s)	S/N	RV[a] (km s^{-1})	RV[b] (km s^{-1})	RV[c] (km s^{-1})	RV[d] (km s^{-1})
			Cluster members				
MMU 1	2012 November	3600	160	4.73 ± 0.20	5.19 ± 0.15	5.49 ± 0.44	
MMU 3	2012 November	3600	150	4.11 ± 0.20	4.56 ± 0.10		
MMU 11	2012 November	3600	175	4.45 ± 0.19	4.75 ± 0.12		
MMU 24	2012 October	3600	185	4.86 ± 0.19	5.36 ± 0.10		
MMU 27	2012 November	3600	190	4.39 ± 0.19	4.58 ± 0.11		
MMU 77	2012 November	3600	155	4.58 ± 0.20	5.02 ± 0.09		6.3 ± 0.2
MMU 137	2012 October	1350	170	5.59 ± 0.20	5.25 ± 0.09		5.9 ± 0.2
MMU 295	2014 February	2700	140	6.32 ± 0.23	5.20 ± 0.09		6.3 ± 0.2
MMU 311	2012 October	2700	180	5.19 ± 0.19	5.79 ± 0.09	6.00 ± 0.30	6.7 ± 0.2
MMU 1367	2012 October	2700	210	3.98 ± 0.19	4.55 ± 0.11		
			Non-members				
MMU 39	2012 October	3600	180	-21.05 ± 0.20	-21.67 ± 0.14		
MMU 215	2012 October	1800	290	9.51 ± 0.24	9.29 ± 0.13		

[a]This study.
[b]Mermilliod et al. (2008).
[c]Carrera & Pancino (2011).
[d]Reddy et al. (2012).

<RV> = 4.82±0.20 kms^{-1}

<RV>=5.04±0.08 kms^{-1}

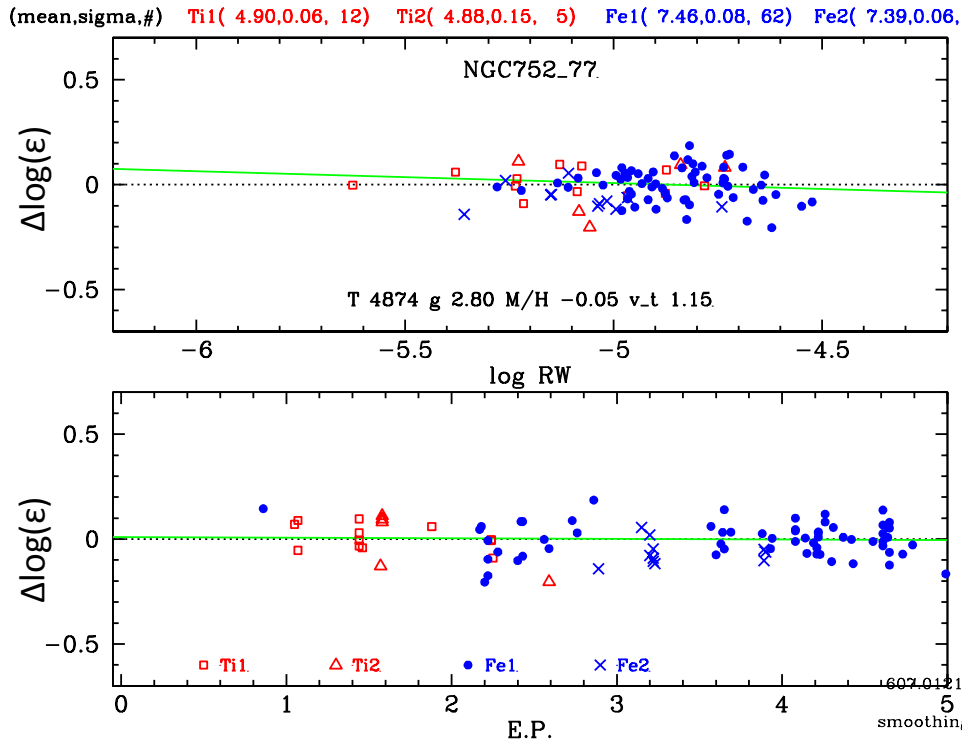
✧ Çizgi Listeleri

Model Atmosfer

- Kurucz atmosfer modelleri (Castelli & Kurucz 2003)
- R ≈ 150.000 Güneş tayfı, Kurucz et al. (1984).
- EW ölçümleri, IDL – 'ew.pro' (Ian Roederer tarafından yazılan ve Erik Brugamyer tarafından geliştirilen)

Table 9. Solar abundances.

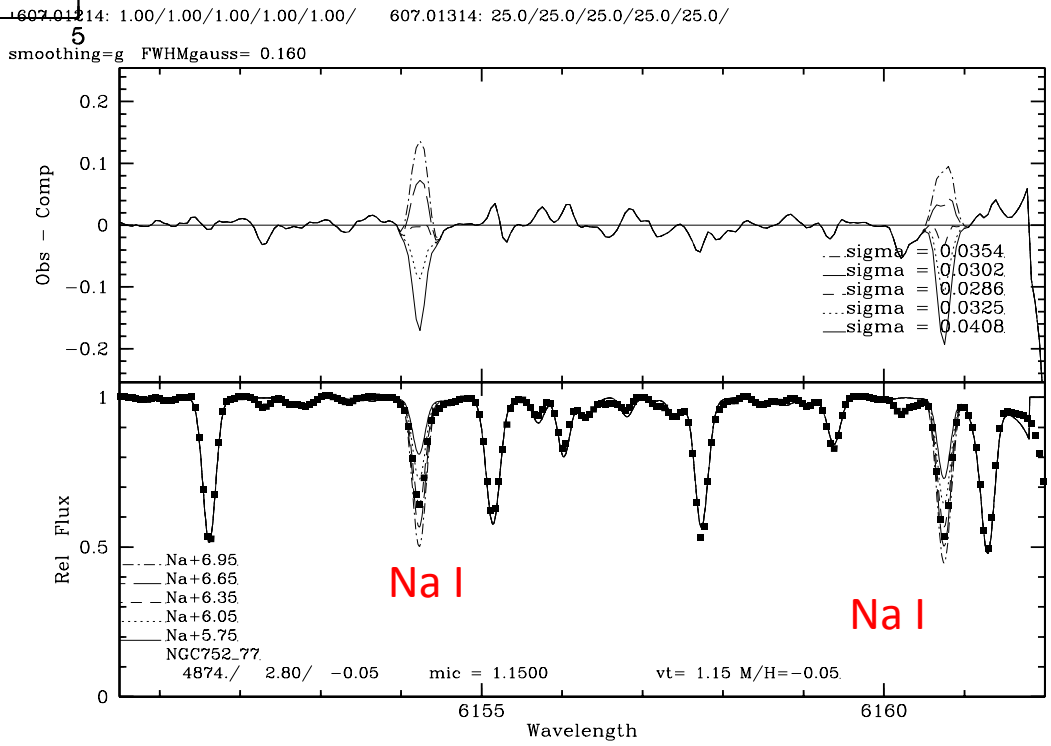
Species	$\log \epsilon_\odot$ (this study)	$\log \epsilon_\odot$ (Asplund et al. 2009)
Li I	1.05 ± (0.05)	1.05 ± 0.10
C	8.43 ± (0.05)	8.43 ± 0.05
N	8.13 ± (0.05)	7.83 ± 0.05
O	8.69 ± (0.05)	8.69 ± 0.05
Na I	6.34 ± (0.10)	6.24 ± 0.04
Mg I	7.63 ± 0.16	7.6 ± 0.04
Al I	6.33 ± 0.18	6.45 ± 0.03
Si I	7.57 ± 0.05	7.51 ± 0.03
Ca I	6.31 ± 0.03	6.34 ± 0.04
Sc II		3.15 ± 0.04
Ti I	4.88 ± 0.06	4.95 ± 0.05
Ti II	4.98 ± 0.05	
V I		3.93 ± 0.08
Cr I	5.61 ± 0.04	5.64 ± 0.04
Cr I	5.72 ± 0.08	
Mn I	5.41 ± 0.06	5.43 ± 0.04
Fe I	7.42 ± 0.04	7.50 ± 0.04
Fe II	7.45 ± 0.04	
Co I		4.99 ± 0.07
Ni I	6.24 ± 0.07	6.22 ± 0.04
Cu I	4.07 ± 0.10	4.19 ± 0.04
Zn I	4.51 ± (0.05)	4.56 ± 0.05
Y II	2.19 ± 0.04	2.21 ± 0.05
La II	1.15 ± 0.06	1.10 ± 0.04
Nd II	1.37 ± (0.05)	1.42 ± 0.04
Eu II	0.54 ± 0.08	0.52 ± 0.04

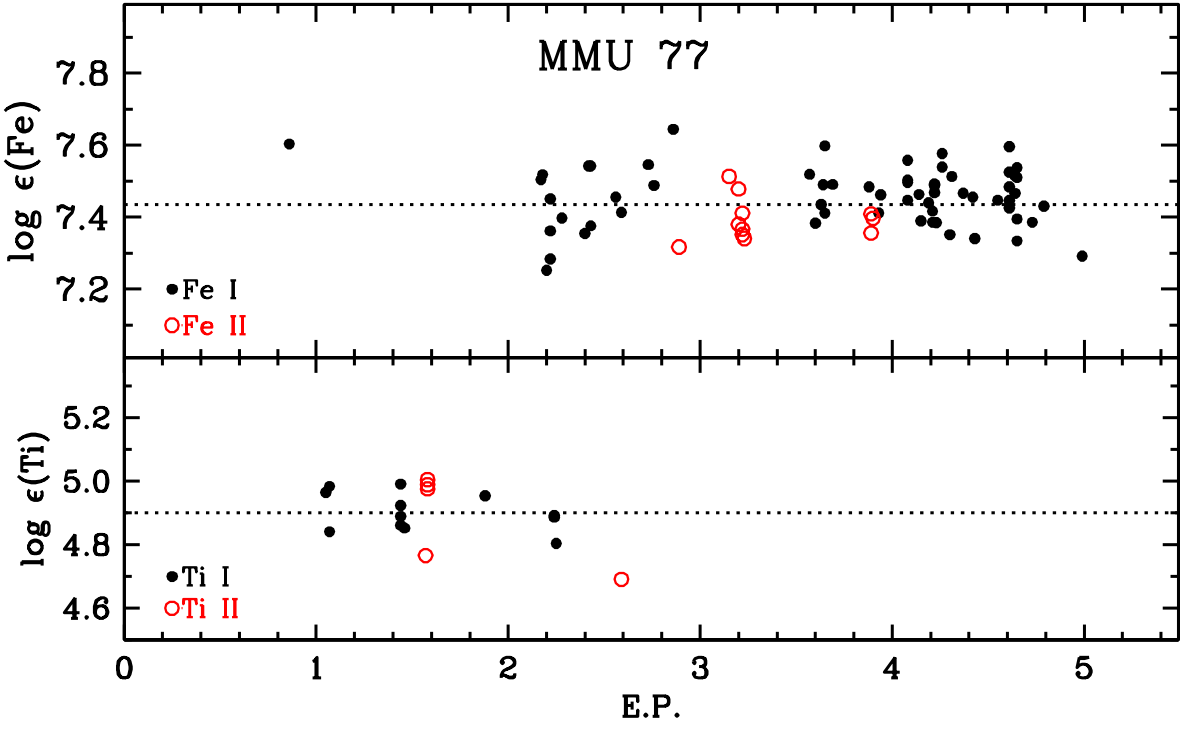


EW ve sentetik tayf analiz kodu: **MOOG** (Sneden, 1973)

Model Atmosfer

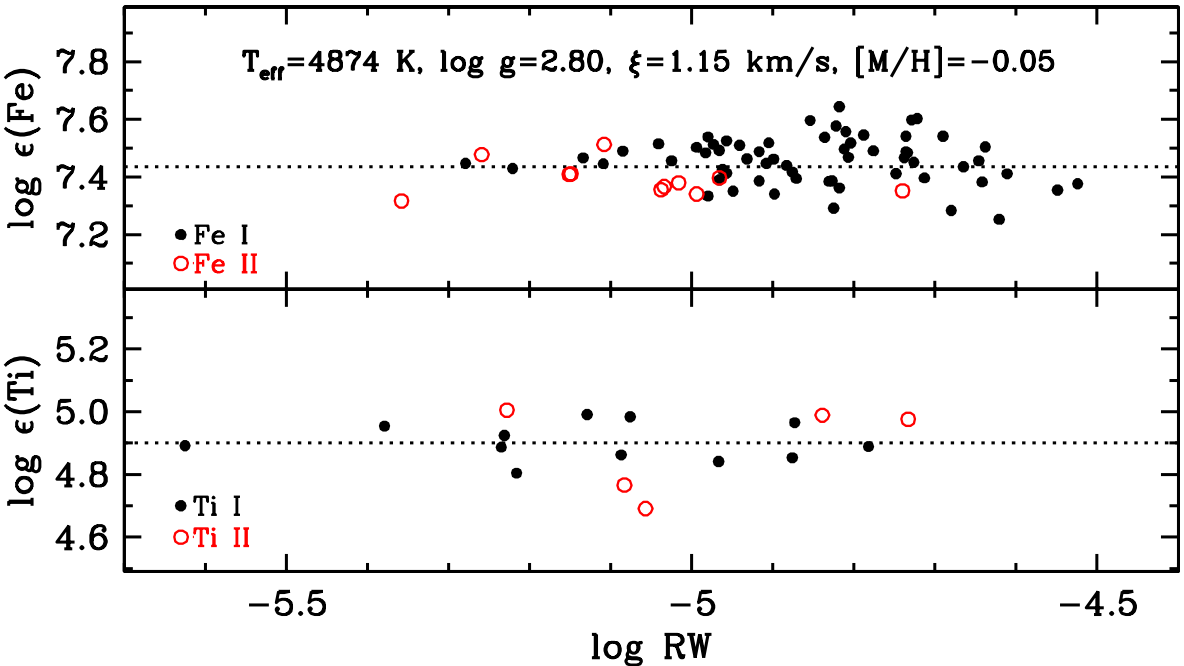
Sentetik Analiz





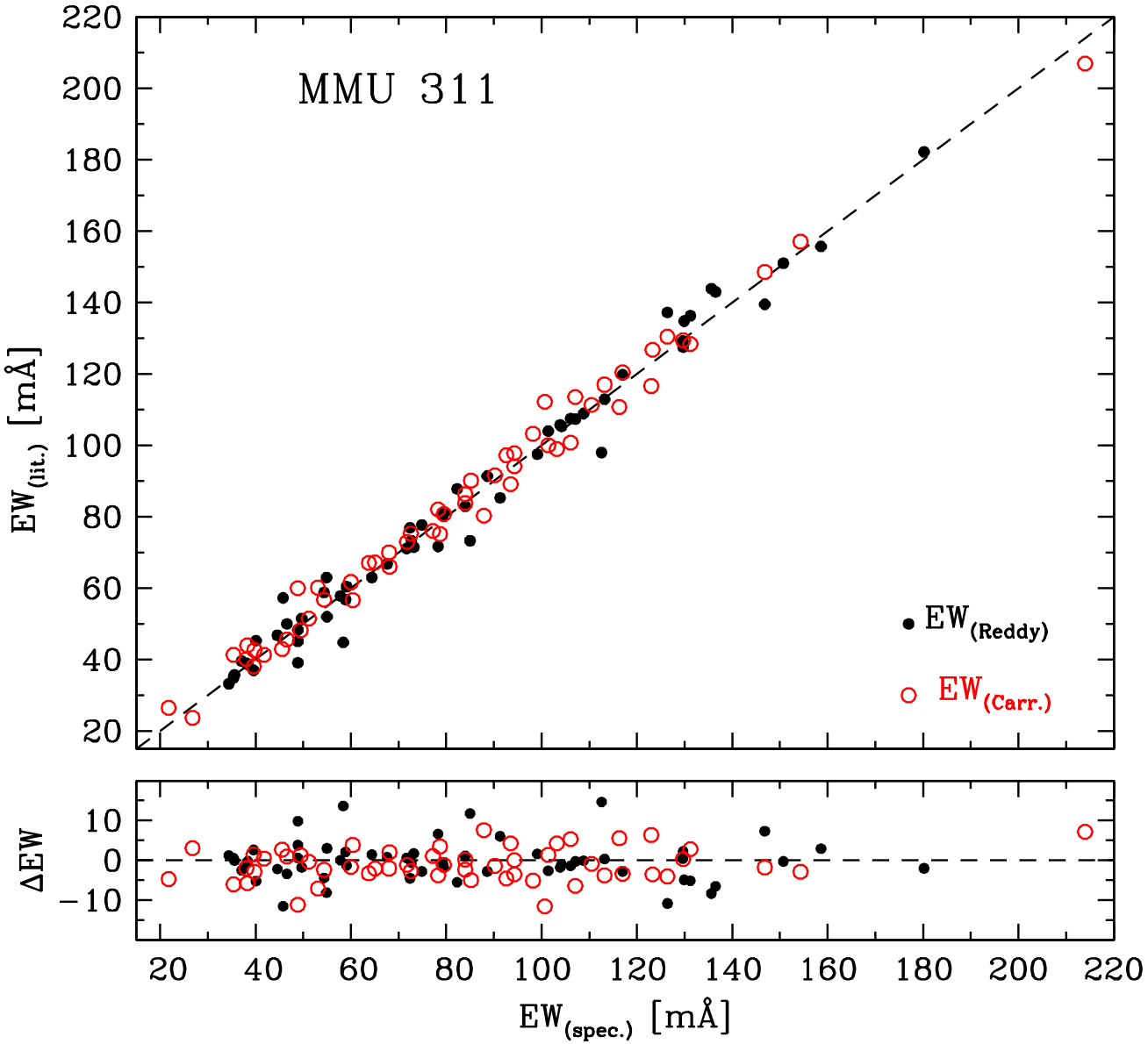
- 62 Fe I - 12 Fe II
- 12 Ti I (Lawler et al., 2013)
  5 Ti II (Wood et al.,2013)

Ep, eğim olmaması: Sıcaklık belirlemesi



Nötr ve iyonize elementler arasındaki denge; log g değerini gösteriyor.

RW=log(EW/λ), eğim olmaması: Mikrotürbülans hızı belirlemesi



4850 K
log *g*=2.6
ξ=1.45 km/s
[Fe/H]=-0.04±0.05

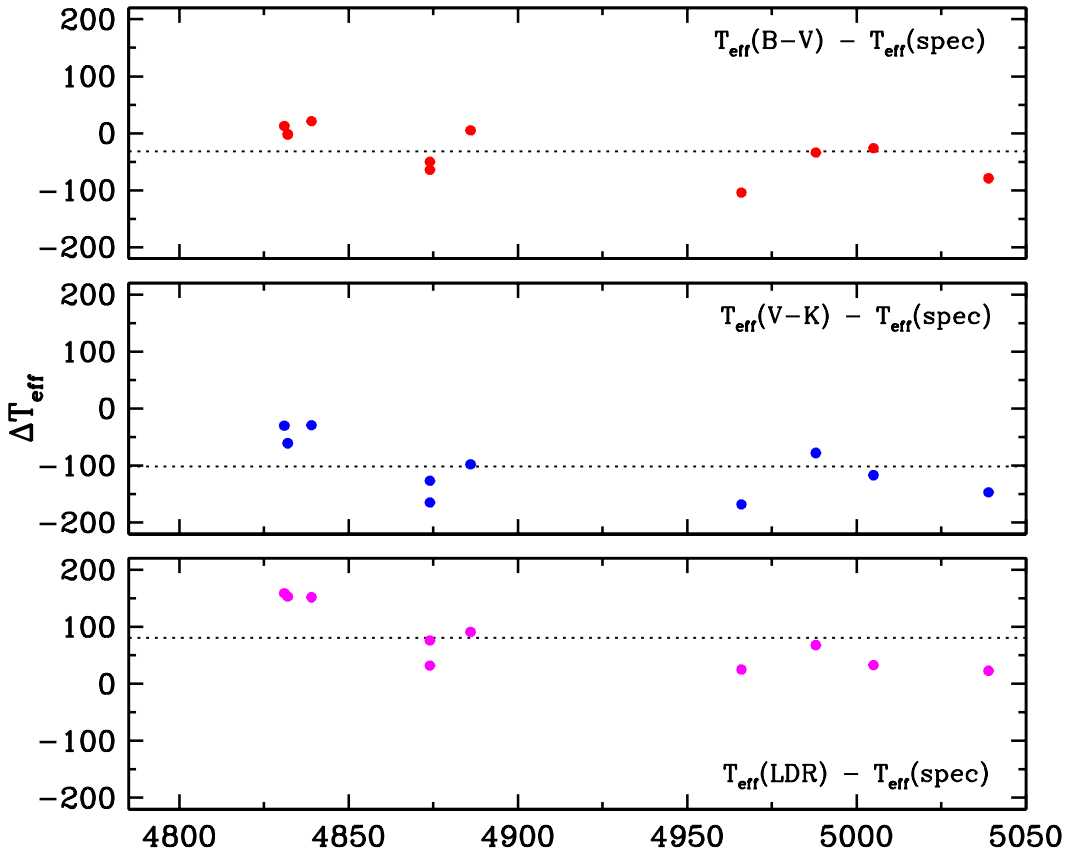
- Kendi Güneş tayfları

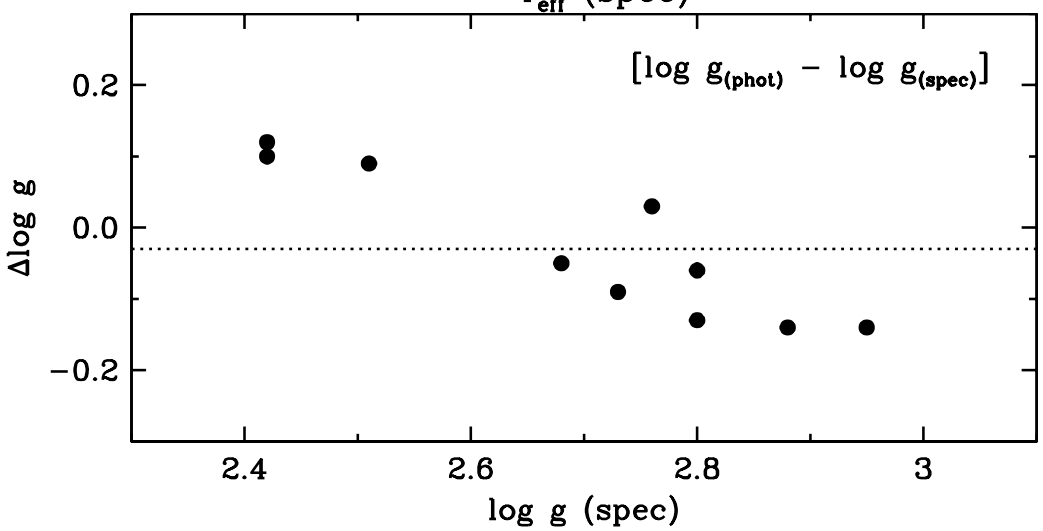
4874 K
log *g*=2.68
ξ=1.24
[Fe/H]=-0.02

- Bu çalışma

4800 K
log *g*=3.2
ξ=1.2 km/s
[Fe/H]=0.16±0.07

- Güneş bollukları ; Grevesse et al. (1996)





σ=±0.1

Diğer çalışmalar ile karşılaştırma:

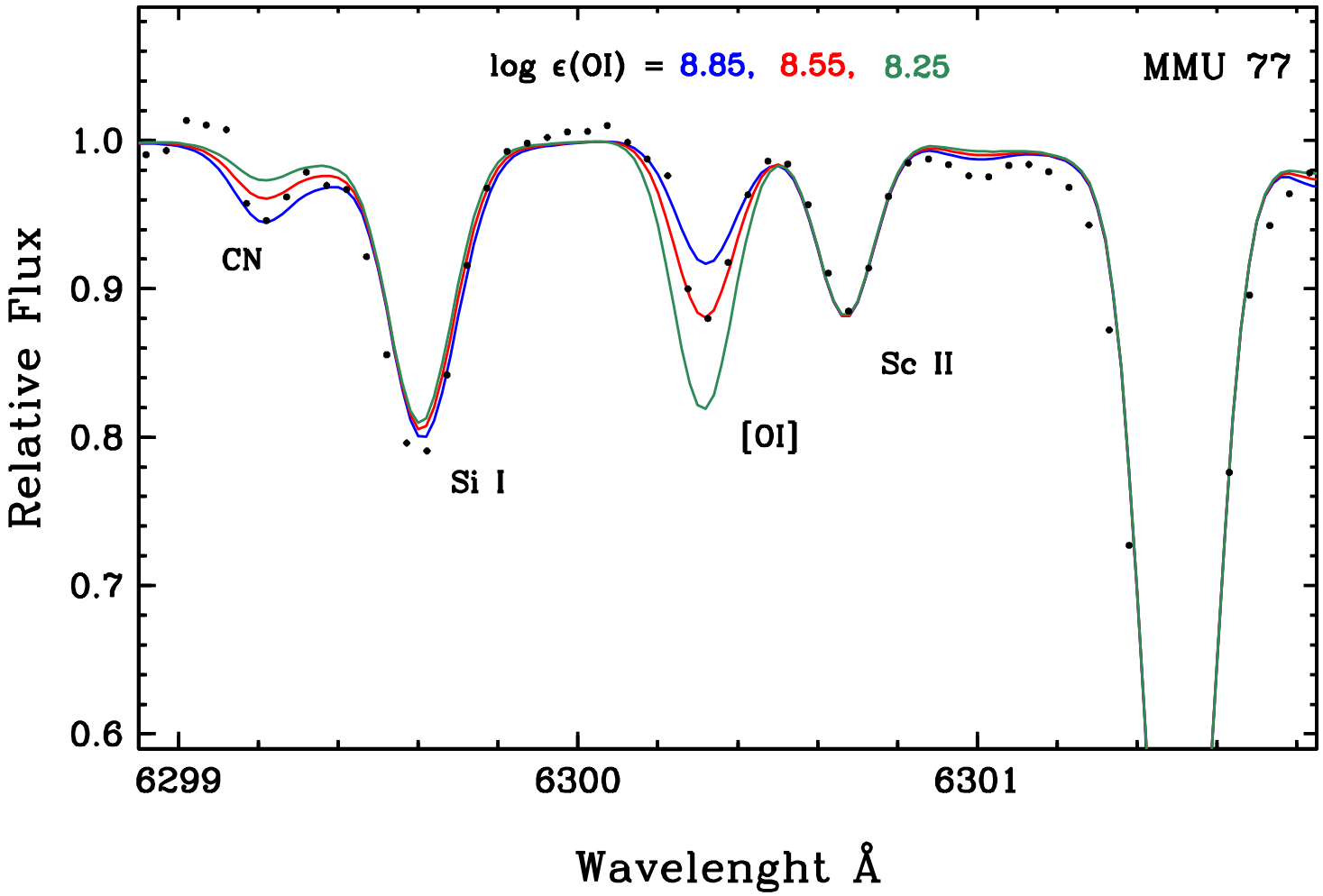
- Ortak 4 RG
  Reddy et al., 2012

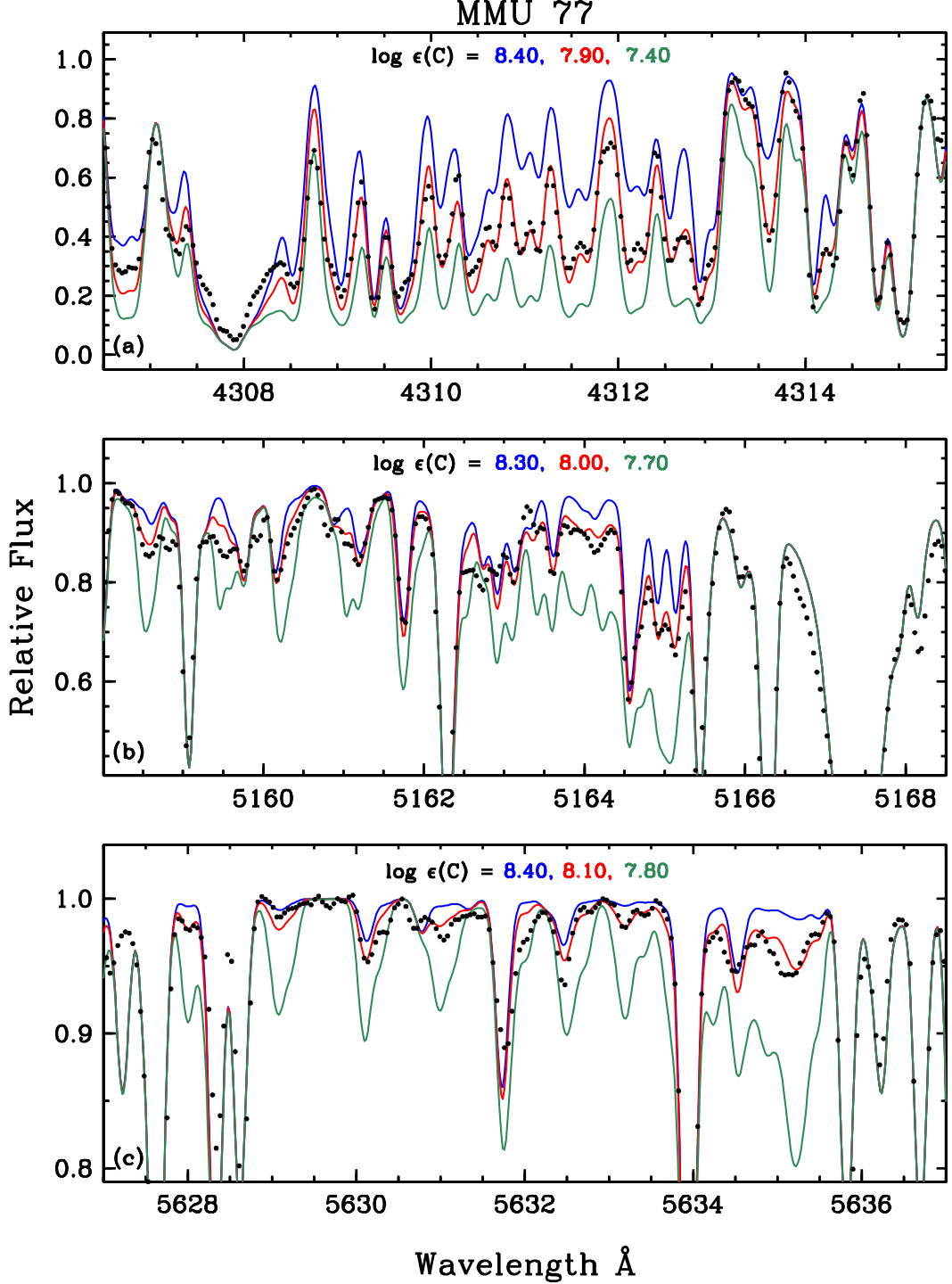
  $\langle \Delta T_{eff} \rangle = \pm 20$ K
  $\langle \Delta \log g \rangle = \pm 0.06$
  $\langle \Delta \xi \rangle = \pm 0.13$

- Ortak 2 RG
  Carrera et al., 2011

  $\langle \Delta T_{eff} \rangle = \pm 84$
  $\langle \Delta \log g \rangle = \pm 0.26$
  $\langle \Delta \xi \rangle = \pm 0.19$

Sentetik Analiz



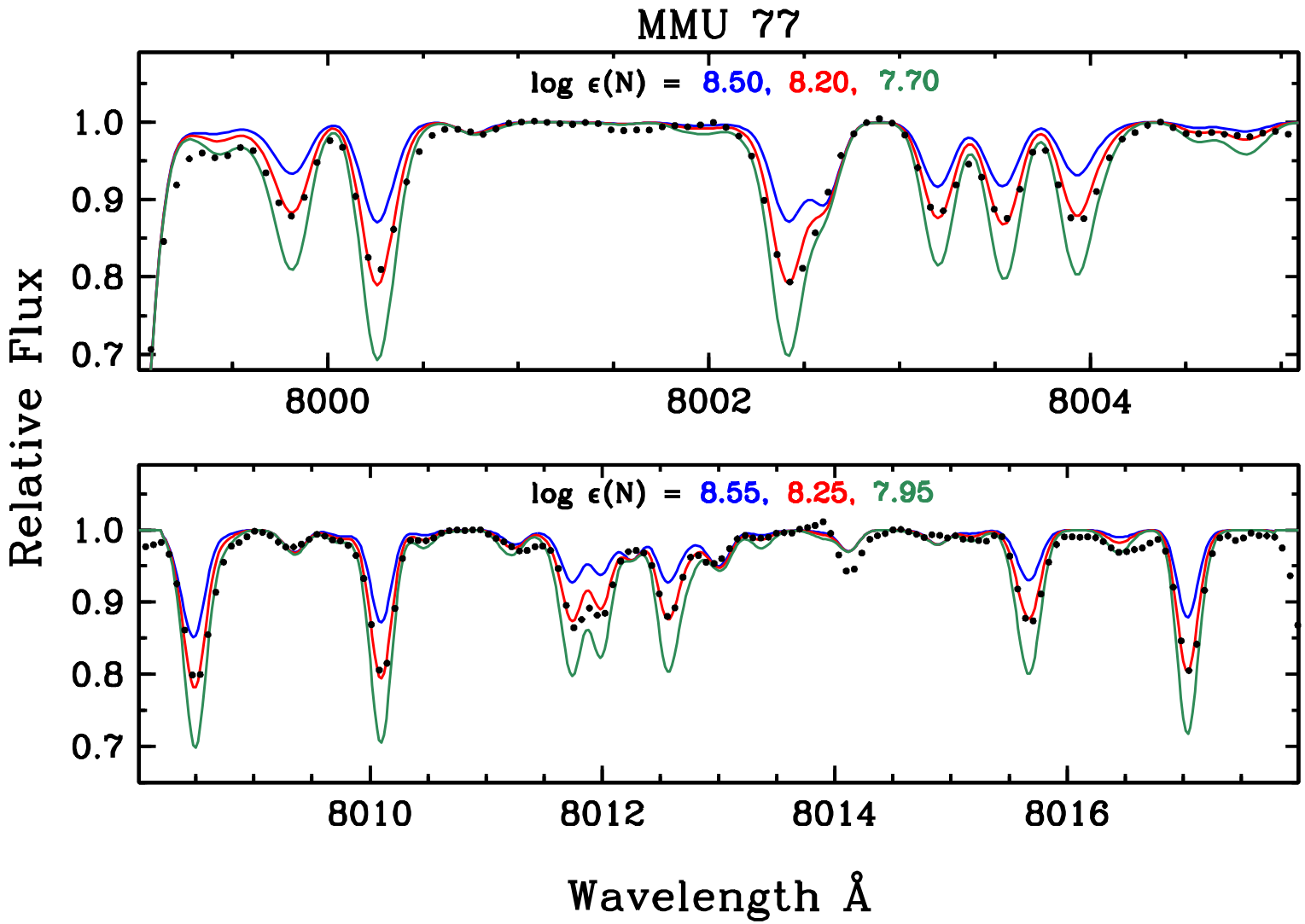


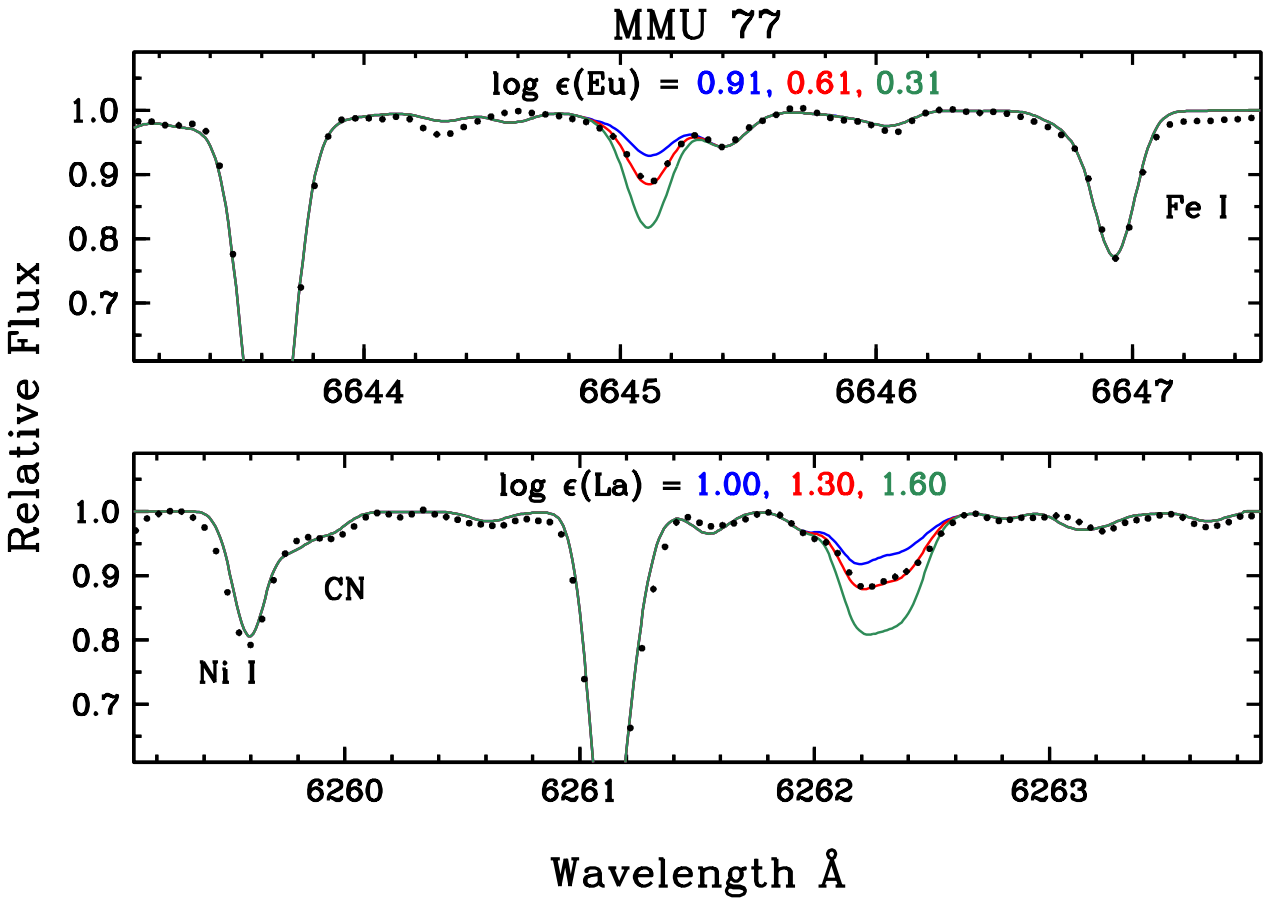
CH (G-band)

C_2

C_2

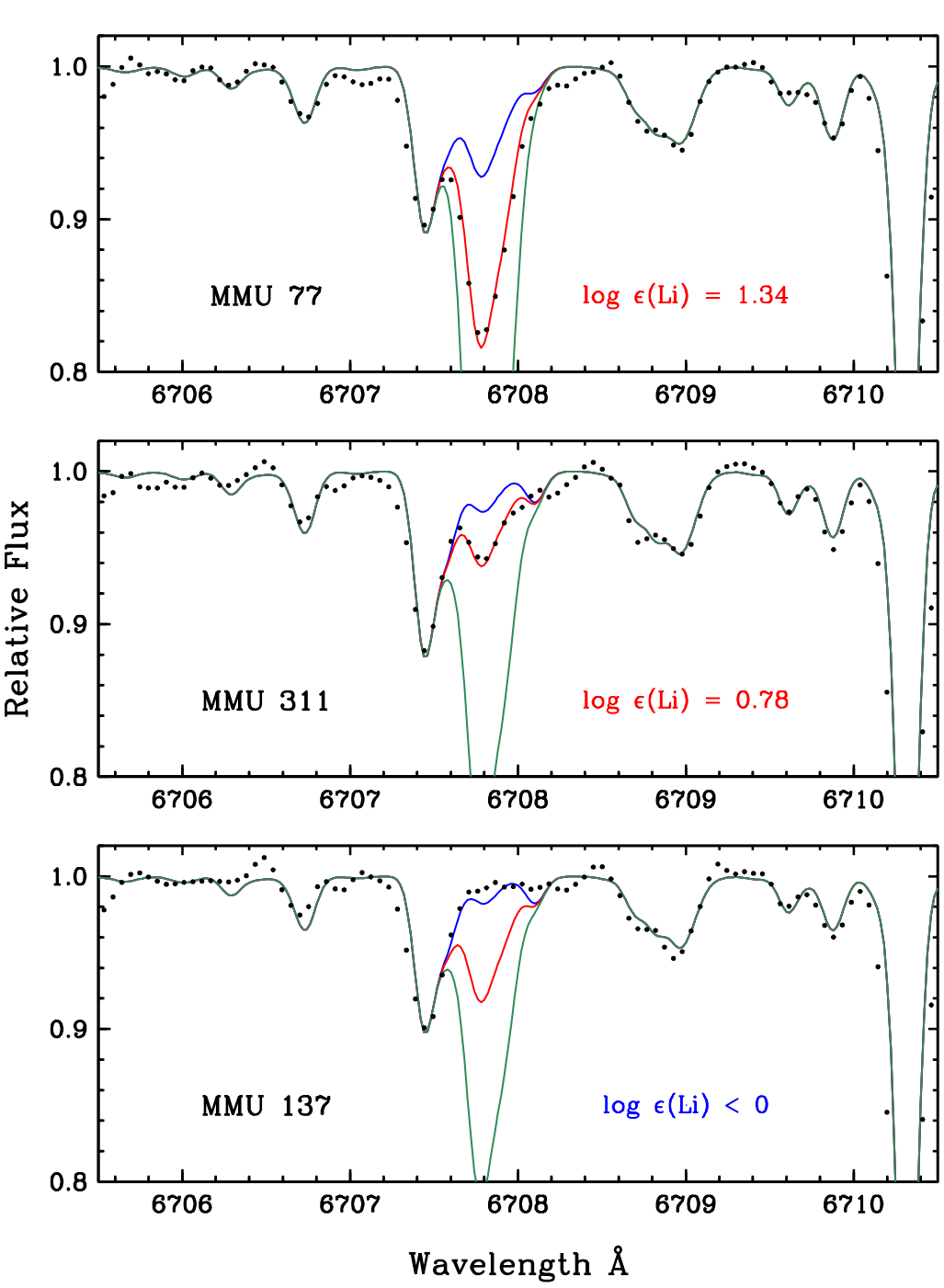
CN


MMU 77
log ϵ(N) = 8.50, 8.20, 7.70
log ϵ(N) = 8.55, 8.25, 7.95
Relative Flux
1.0
0.9
0.8
0.7
8000
8002
8004
8010
8012
8014
8016
Wavelength Å

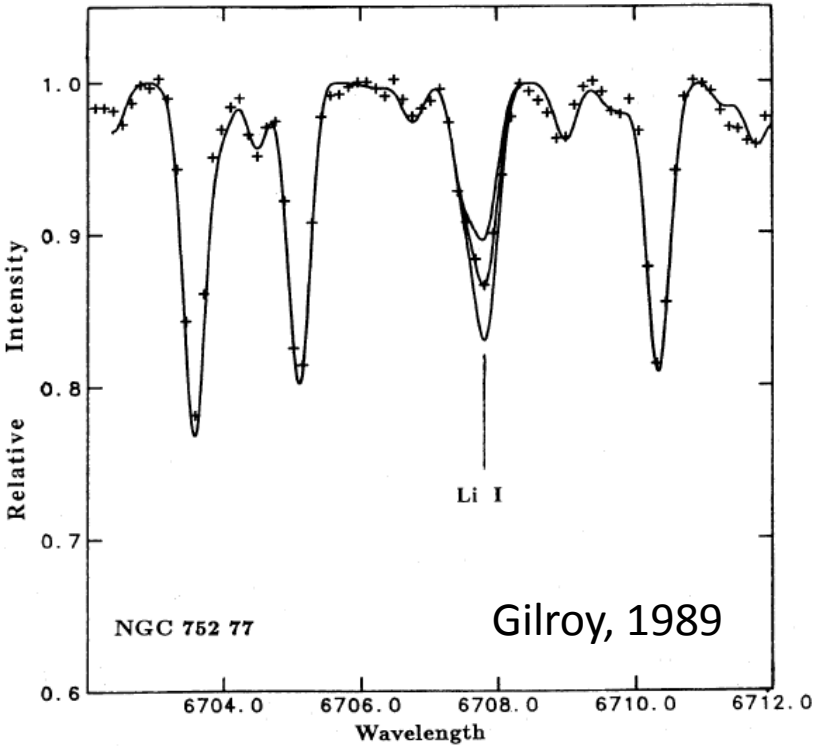


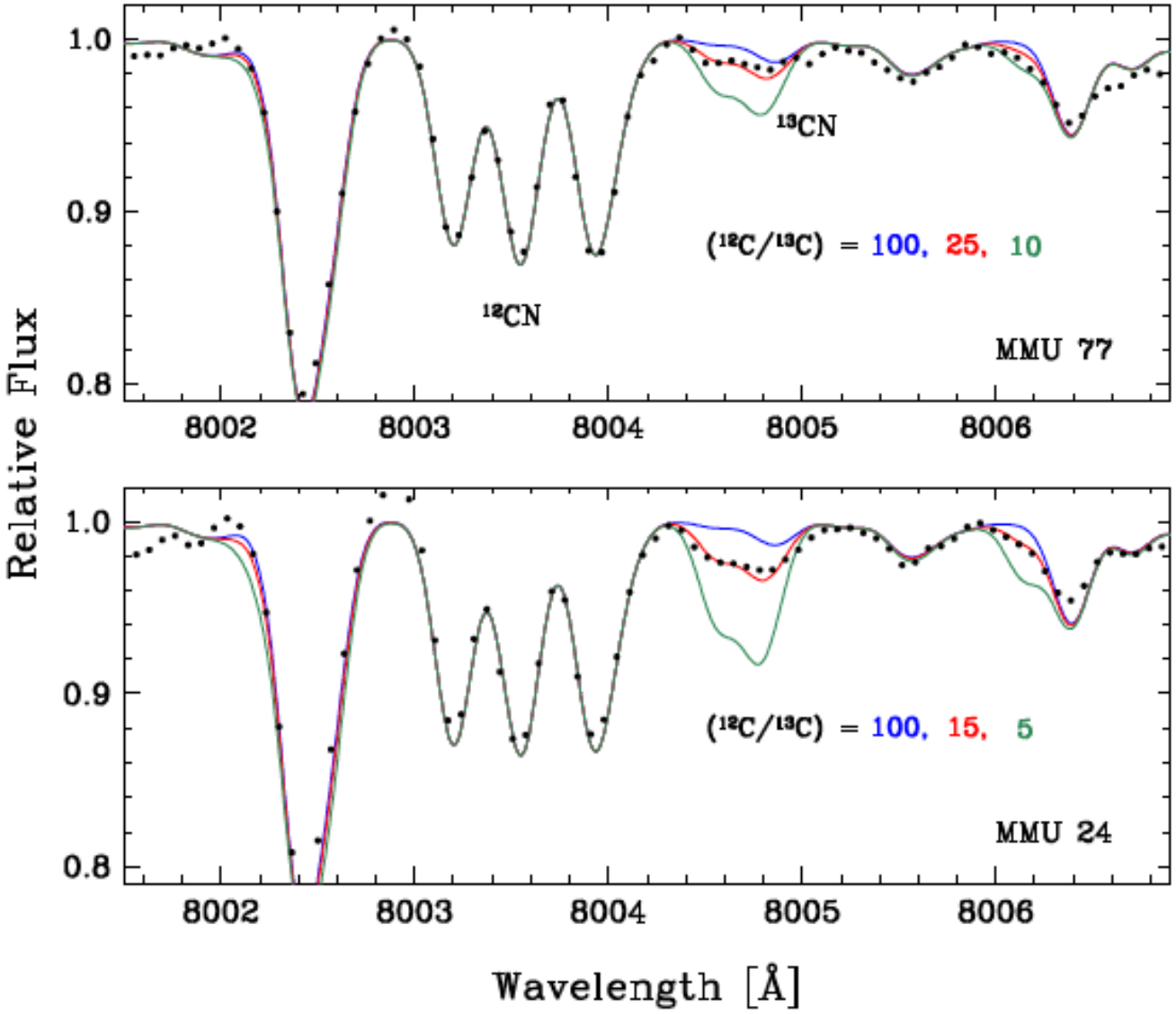
MMU 77	6645	7217	7301	Ortalama
log ε(Eu)	0.61	0.61	0.75	0.66

MMU 77	6262	6390	5003	5797	Ortalama
log ε(La)	1.3	1.45	1.32	1.32	1.35



	Pilachowski, 1988	Gilroy, 1989	Bu Çalışma
MMU 1	<+0.5	0.40	0.15
MMU 3			1.25
MMU 11			1.00
MMU 24	<+0.5		<0
MMU 27			0.95
MMU 77	1.10	1.40	1.34
MMU 137	<+0.3		<0
MMU 295	<+0.5	0.20	<0
MMU 311	<+0.3	0.75	0.78
MMU 1367			<0

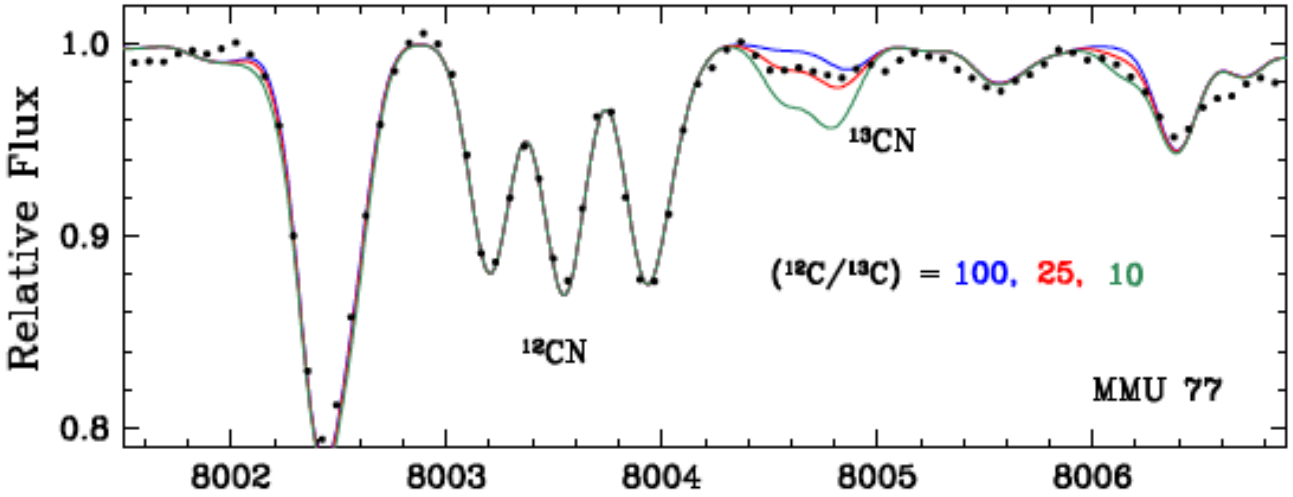


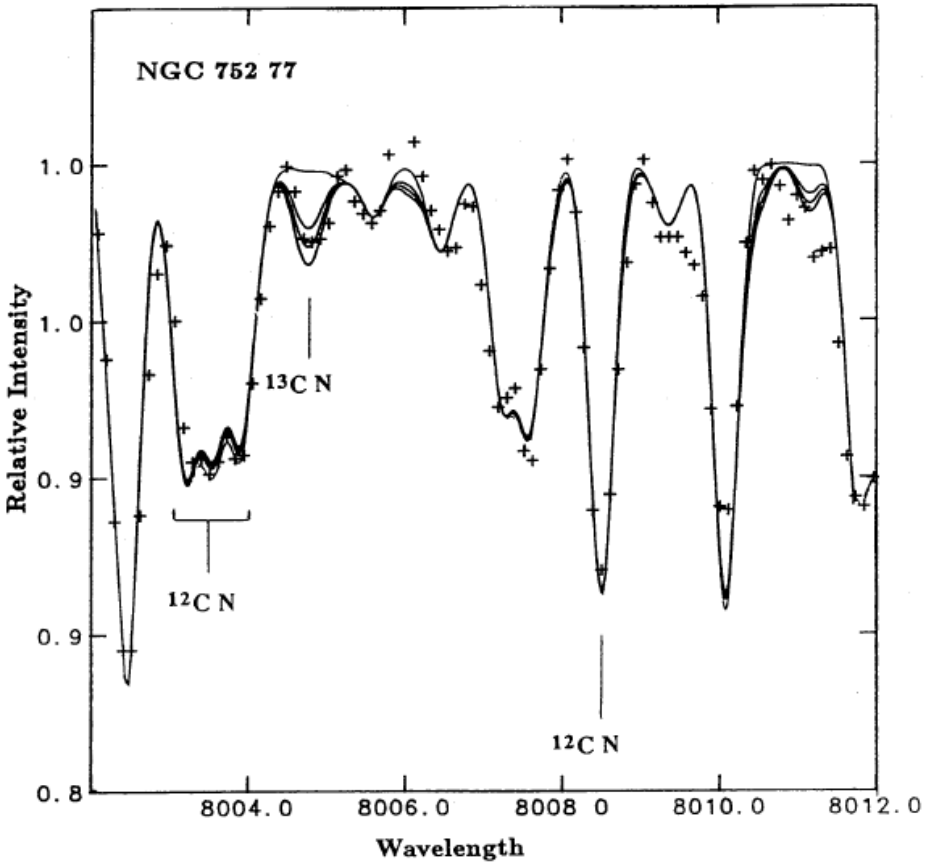


$^{12}C/^{13}C$

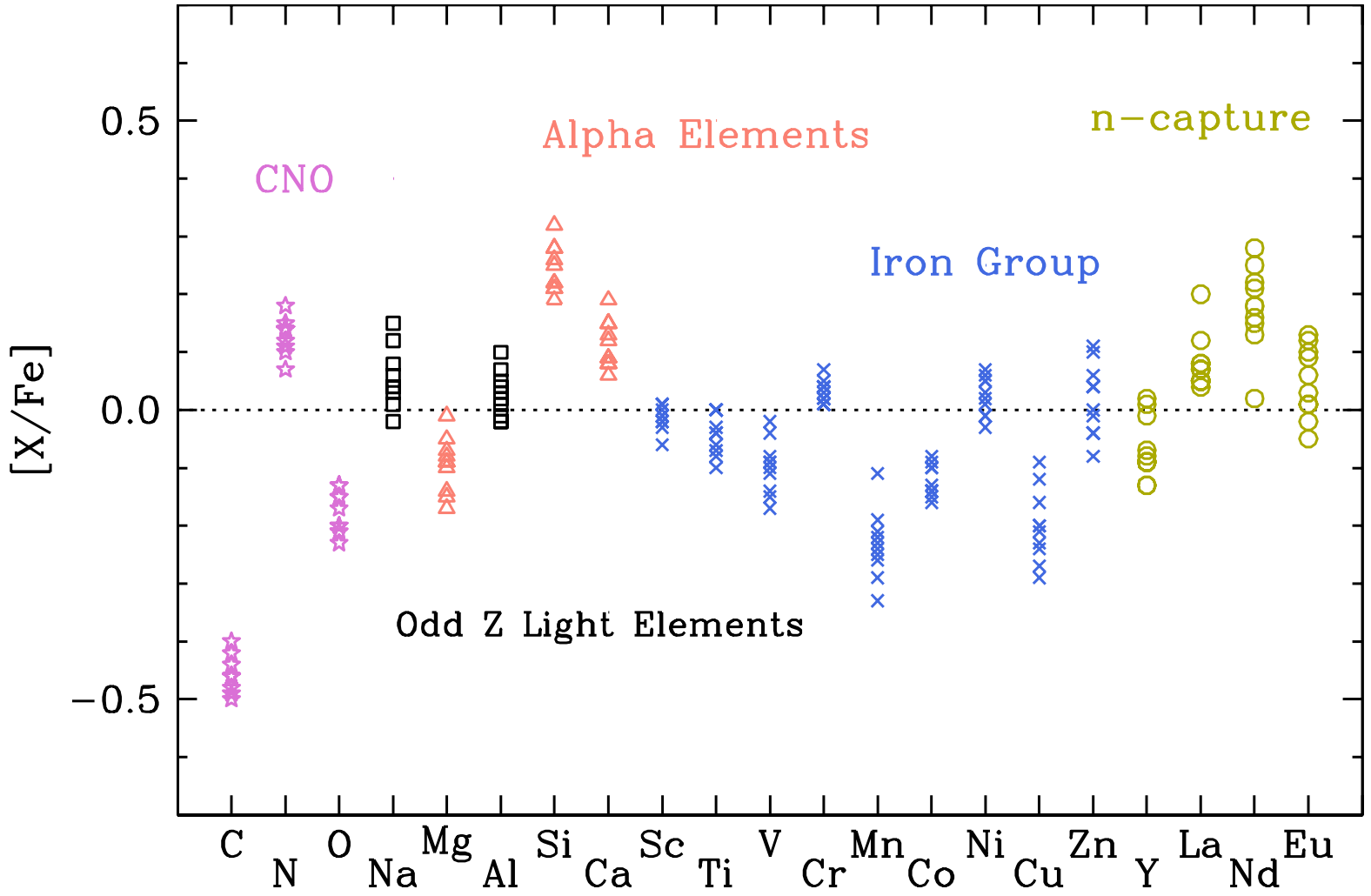
$^{12}C/^{13}C$ belirlenmesi için önerilen tüm bölgeleri analiz ettik;

8004.6	8006	8010.4	8015.2	8016.4	8036	8048.2	8050.5	8051.7	8056.5	8065

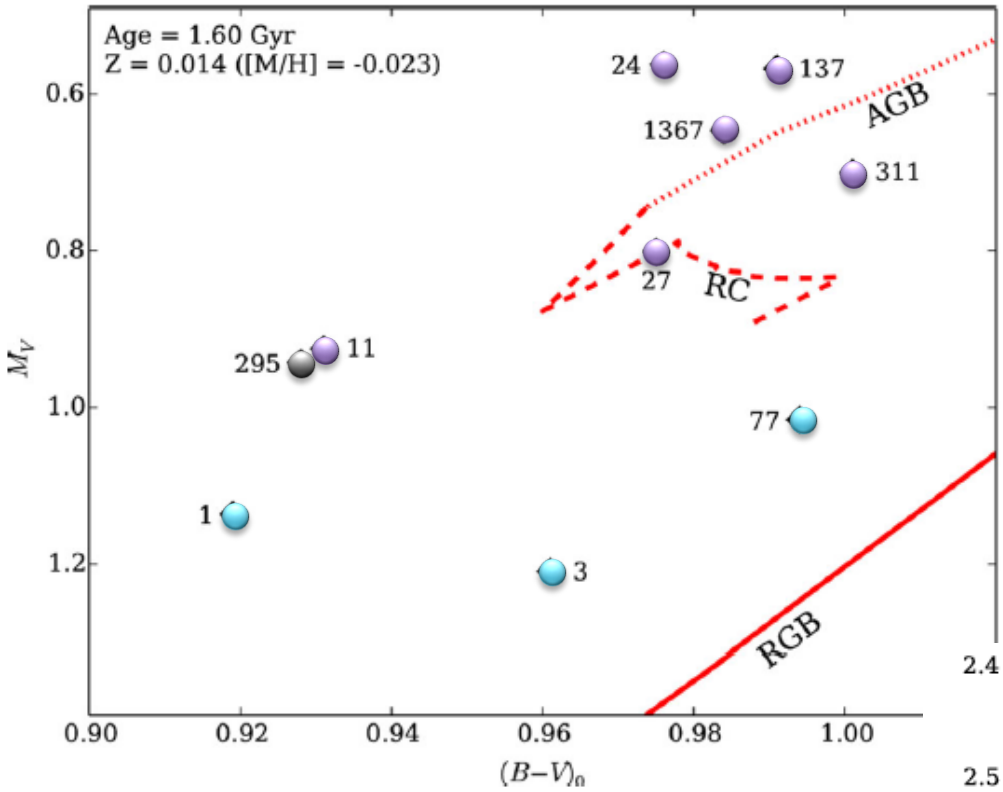




$^{12}C/^{13}C$=15 (Gilroy, 1989)

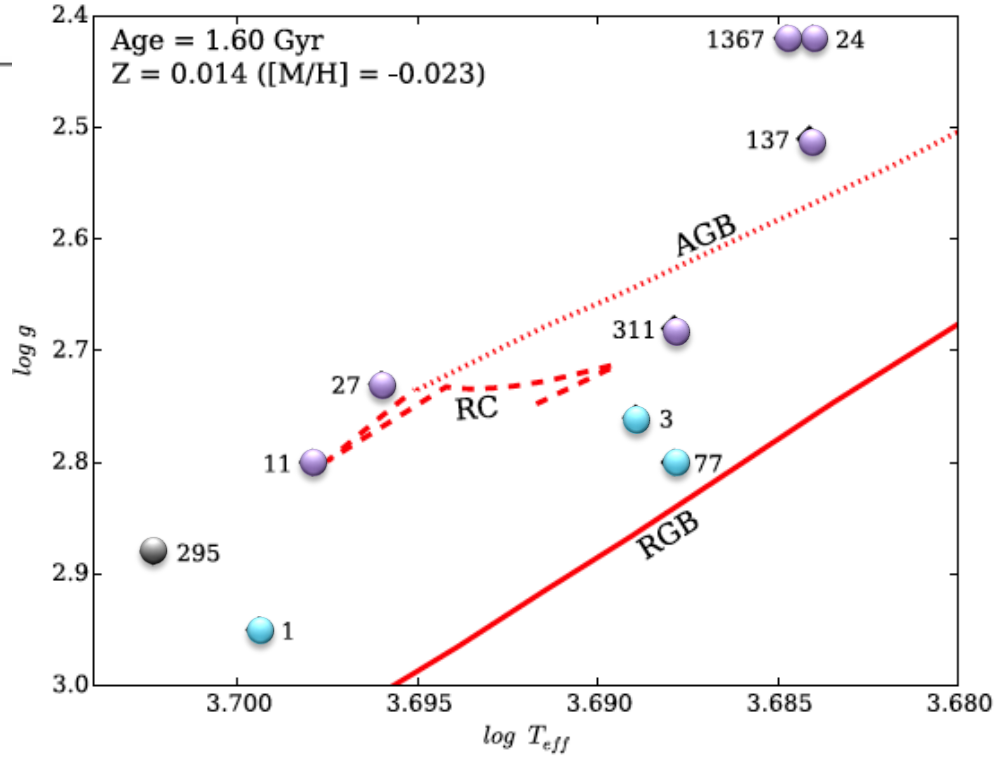


- CN – "klasik" yıldız evrimi teorileriyle uyumlu.
- V – Sc – Co için ters-güneş analizi yapıldı.
- Daha doğru/hassas log gf değerlerine ihtiyaç var.

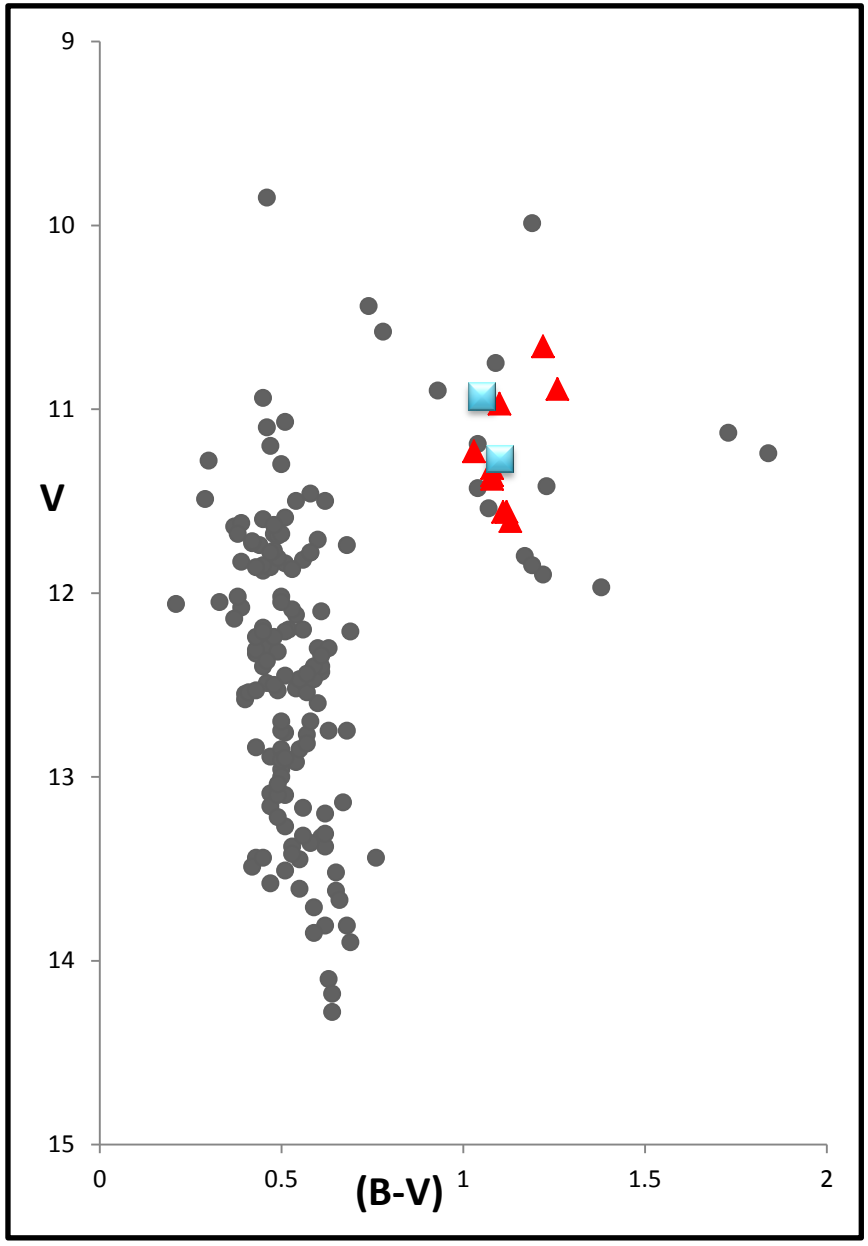


Yıldız	log ε (Li)	$^{12}C/^{13}C$	Evrim
MMU 1	0.15	25	RGB
MMU 3	1.25	25	RGB
MMU 77	1.34	25	RGB
MMU 295	<0	20	RHB

Yıldız	log ε (Li)	$^{12}C/^{13}C$	Evrim
MMU 11	1	25	RC
MMU 24	<0	15	RC
MMU 27	0.95	17	RC
MMU 137	<0	15	RC
MMU 311	0.78	20	RC
MMU 1367	<0	17	RC



NGC 6940



Sağ Açıklık	**20 34 26**
Dik Açıklık	+28 17 00
Galaktik Enlem	69.860
Galaktik Boylam	-7.147
Uzaklık	770 pc
E(B-V)	0.214
$(m-M)_0$	10.10
log Yaş	8.94
Dönme noktası kütlesi	1.5 $M_\odot$

- [Fe/H] = -0.12±0.1 (Friel et al. 2002)
- [Fe/H] ≈ -0.1 (Thogersen et al. 1993)
- [Fe/H] = 0.013±0.13 (Kharchenko+, 2013)

- [Fe/H] = 0.06±0.02 (Bu çalışma)

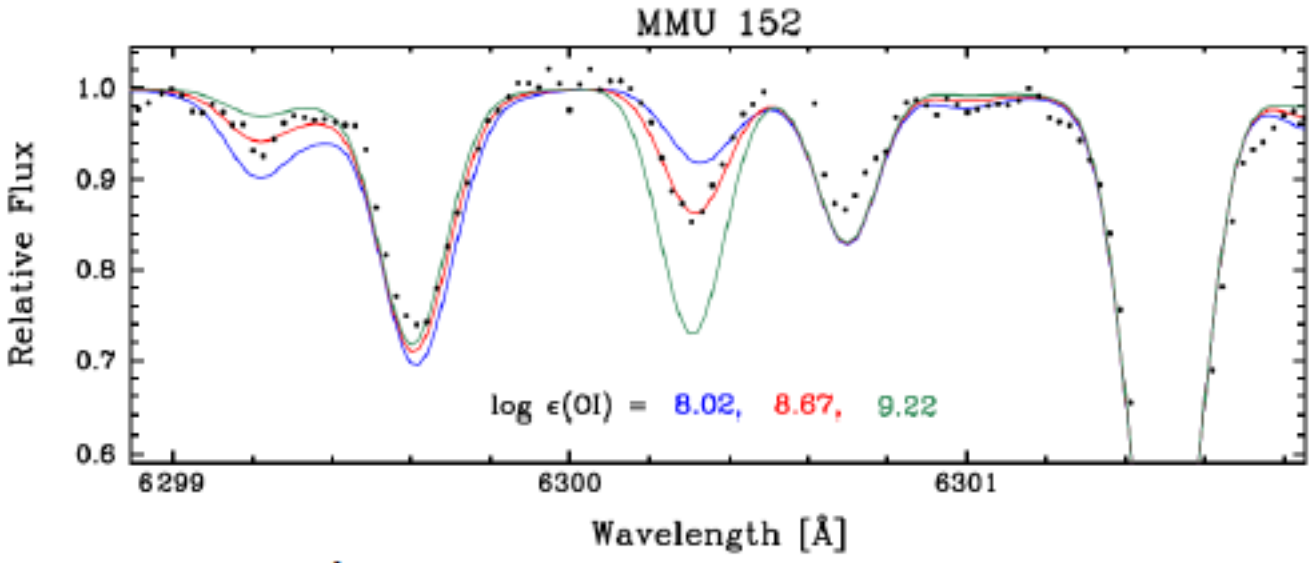
(1961) Publ. Us. Nav. Obs. XVII part VII, 347

	RV	RV (Mermilliod+, 2008)
NGC 6940	8.02±0.56	7.89±0.14
MMU 28	8.90±0.22	
MMU 30	7.96±0.20	7.63±0.15
MMU 60	7.66±0.22	7.27±0.18
MMU 69	8.08±0.24	7.56±0.15
MMU 87	7.98±0.27	7.45±0.16
MMU 101	7.74±0.23	6.81±0.14
MMU 105	7.74±0.23	7.58±0.13
MMU 108	7.39±0.25	6.76±0.13
MMU 132	7.76±0.42	7.17±0.14
MMU 138	8.22±0.23	7.55±0.15
MMU 139	7.53±0.23	7.12±0.16
MMU 152	9.28±0.24	8.50±0.15

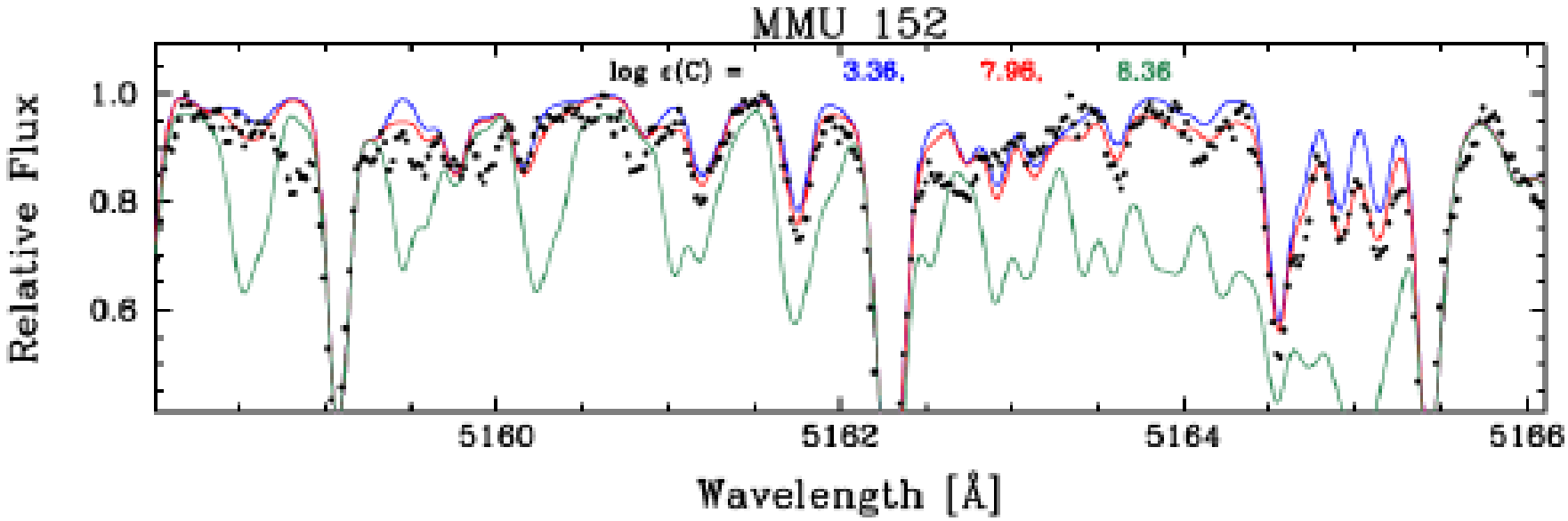
	Teff	logg	[M/H]	Vt
MMU 101	5047	3.04	-0.05	1.05
MMU 152	4950	2.74	-0.07	1.29

Yıldız	[Fe I/H]	[Fe II/H]	[Ti I/Fe]	[Ti II/Fe]
MMU 101	0.11±0.07	0.04±0.05	-0.05±0.06	-0.04±0.10
MMU 152	0.08±0.07	0.01±0.06	-0.07±0.08	-0.03±0.04

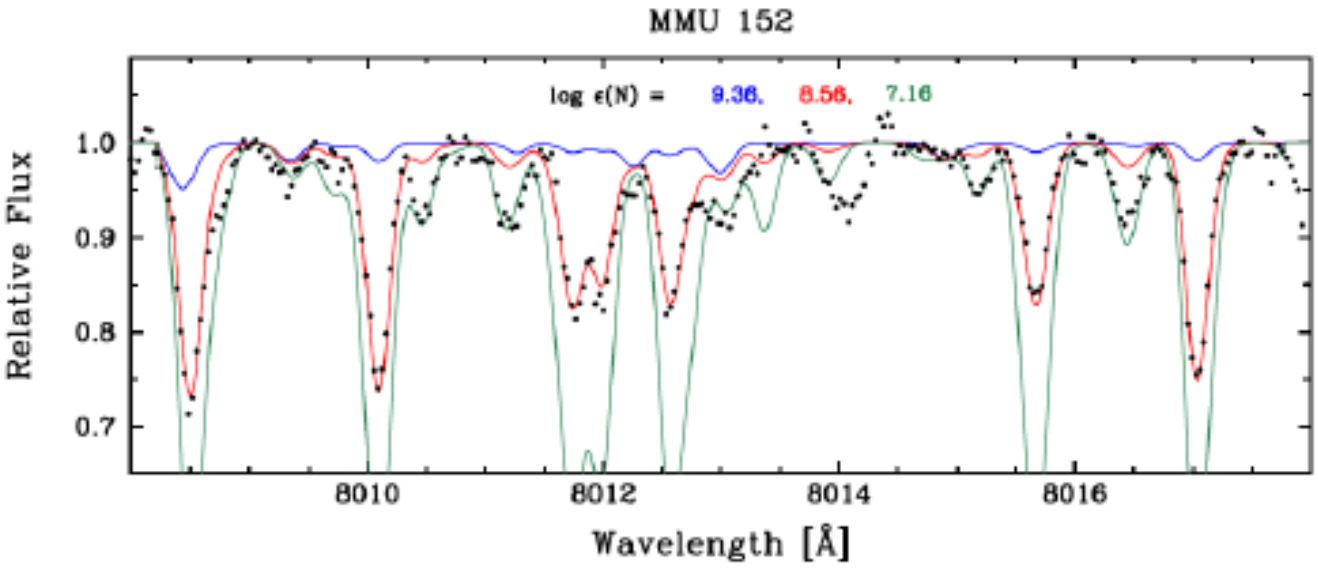
Yıldız	[Si I/Fe]	[Ca I/Fe]	[Cr I/Fe]	[Cr II/Fe]	[Ni I/Fe]
MMU 101	0.09±0.07	0.10±0.05	-0.04±0.08	0.05±0.06	0.03±0.07
MMU 152	0.16±0.09	0.10±0.08	0.06±0.07	0.06±0.02	0.03±0.09



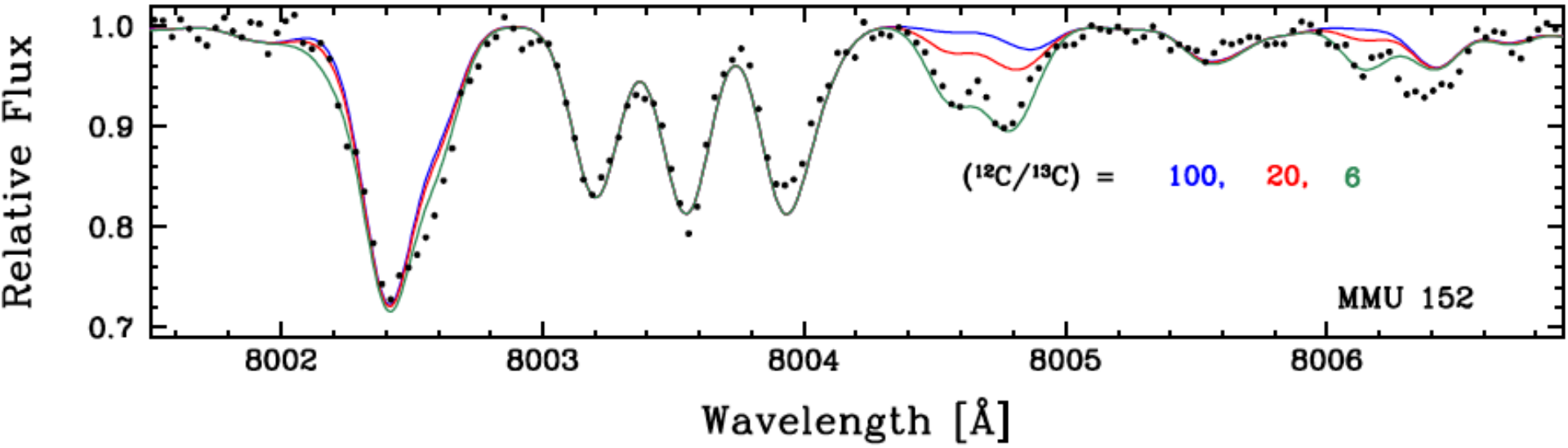
[O/Fe] = -0.07



[C/Fe] = -0.52



[N/Fe] = 0.38



✧ **Bu derece yüksek metal bolluguna sahip açık küme üyeleri arasinda şu ana kadar belirlenen en düşük $^{12}C/^{13}C$ degeri.**

$^{12}C/^{13}C$ ~ 5-6

Bu çalışma 112T929 nolu TUBİTAK projesi tarafından desteklenmiştir.

Teşekkür Ederim….