



NGC 6940 Açık Yıldız Küme Üyesi Kırmızı Dev Yıldızların Kimyasal Bolluk Analizi

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Açık küme üyeleri;

- ★ kimyasal bakımdan homojen olan aynı moleküler buluttan oluşur
- ★ hem yıldız hem de Gökada diskinin kimyasal evriminin araştırılmasında büyük öneme sahip
- ★ alan yıldızlarına kıyasla daha duyarlı parametre ölçümü:
yaş, dönme-kütlesi, yıldızlar arası kızılilaşma, ısıtma v.b.
- ★ CMD + Hafif element (C, N, O, Li) bollukları ve $^{12}\text{C}/^{13}\text{C}$ oranı ile daha doğru yaklaşımla evrim durumu çalışabilme

NGC 6940 ve Hyades

(^aWEBDA, <http://www.univie.ac.at/webda>)

| Quantity | NGC 6940 ^a | Hyades ^a |
|------------------------|-----------------------|---------------------|
| Right Ascension (2000) | 20 34 26 | 04 26 54 |
| Declination (2000) | +28 17 00 | +15 52 00 |
| Galactic longitude | 69.860 | 180.064 |
| Galactic latitude | -7.147 | -22.343 |
| Distance | 770 pc | 45 pc |
| $E(B - V)$ | 0.21 | 0.01 |
| $(m - M)$ | 10.10 | 3.30 |
| log Age | 8.86 | 8.90 |

➤ Gözlemler: ($R=\lambda/\Delta\lambda\approx 60.000$) **9.2m HET** **2.7m Harlan J. Smith**

kırmızı: 5100–6900 Å

(4000–8000 Å)

➤ İndirgemeler : **IRAF**

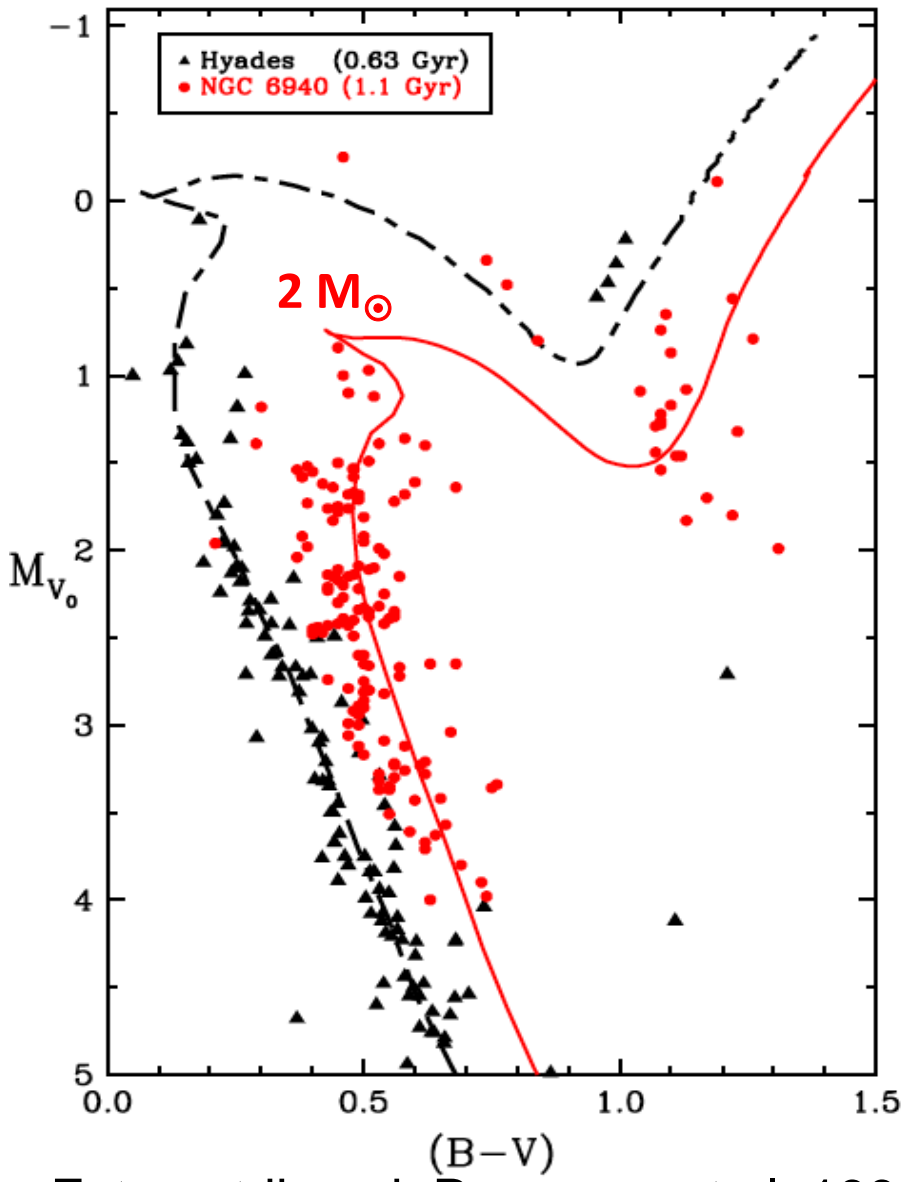
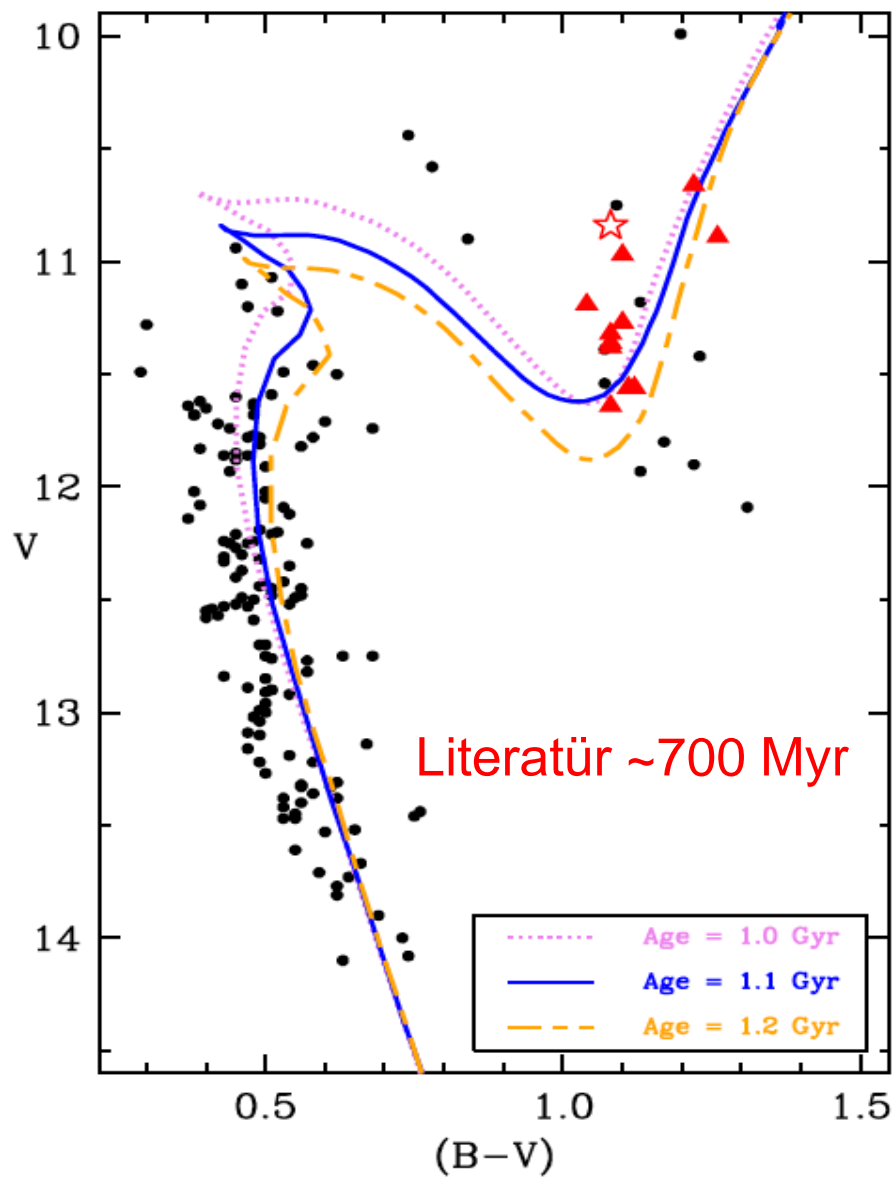
mavi: 7000–8800 Å

Dikine Hızların Ölçümü

| Star | Exp. (s) | S/N @6948 Å | RV^a (km s ⁻¹) | RV^b (km s ⁻¹) |
|---------|-------------|----------------|---------------------------------|---------------------------------|
| MMU 28 | 1000 | 130 | 8.90±0.22 | 7.99±0.16 |
| MMU 30 | 700 | 113 | 7.96±0.20 | 7.63±0.15 |
| MMU 60 | 1050 | 121 | 7.66±0.22 | 7.27±0.18 |
| MMU 69 | 1050 | 93 | 8.08±0.24 | 7.56±0.15 |
| MMU 87 | 900 | 103 | 7.98±0.27 | 7.45±0.16 |
| MMU 101 | 900 | 155 | 7.74±0.23 | 6.81±0.14 |
| MMU 105 | 650 | 116 | 7.74±0.23 | 7.58±0.13 |
| MMU 108 | 900 | 145 | 7.39±0.25 | 6.76±0.13 |
| MMU 132 | 700 | 129 | 7.76±0.42 | 7.17±0.14 |
| MMU 138 | 900 | 82 | 8.22±0.23 | 7.55±0.15 |
| MMU 139 | 900 | 136 | 7.53±0.23 | 7.12±0.16 |
| MMU 152 | 650 | 144 | 9.28±0.24 | 8.50±0.15 |

Böcek Topcu et al. 2016: $\langle RV \rangle = 8.02 \pm 0.16 \text{ kms}^{-1}$

Mermilliod et al., 2008: $\langle RV \rangle = 7.89 \pm 0.14 \text{ kms}^{-1}$



Fotoğrafik veri: Larsson-Leander (1960)

Fotometrik veri: Perryman et al. 1998

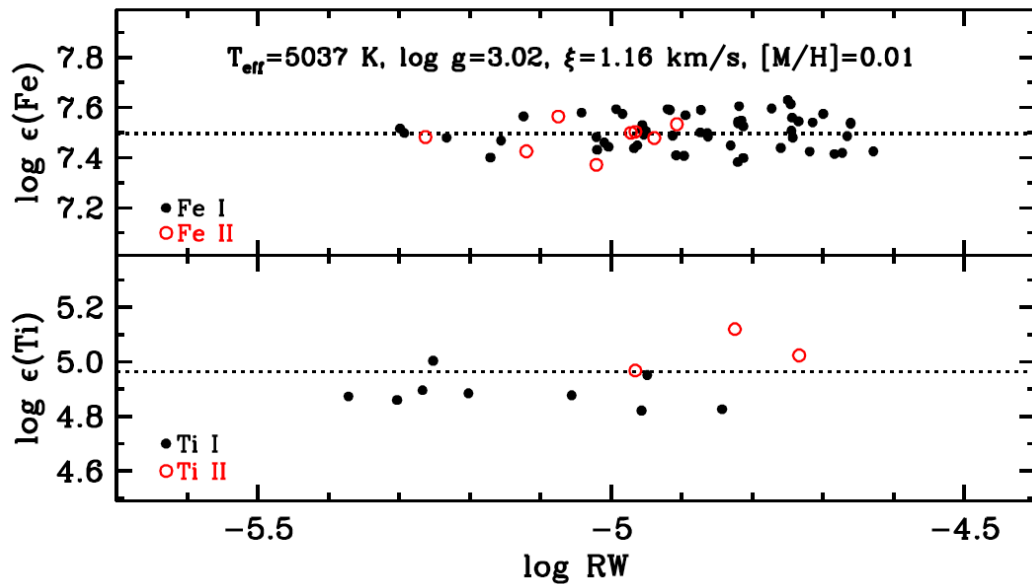
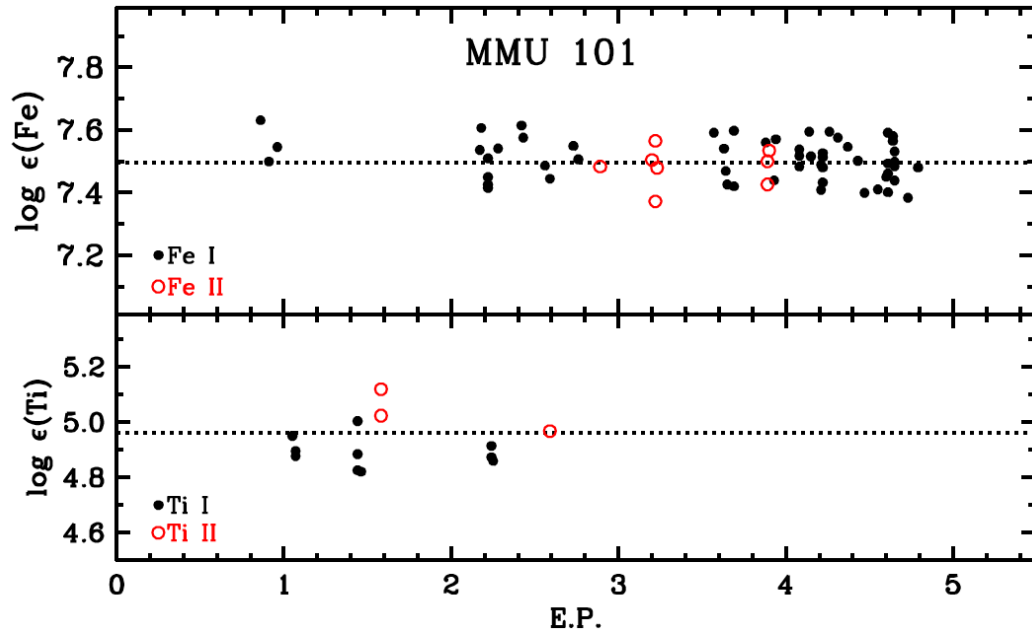
$M_{TO} = 2.3 M_{\odot}$ (Weidemann et al. 1992)

Kimyasal Bolluk Analizi

- ★ Çizgi listeleri (dalga boyu – log gf)
- ★ Kurucz atmosfer modelleri (ATLAS9) (Castelli & Kurucz 2003)
- ★ $R \approx 150.000$ Güneş tayfı, Kurucz et al. (1984)
- ★ EW ölçümleri
- ★ EW ve sentetik tayf analiz kodu MOOG (Snedden, 1973)

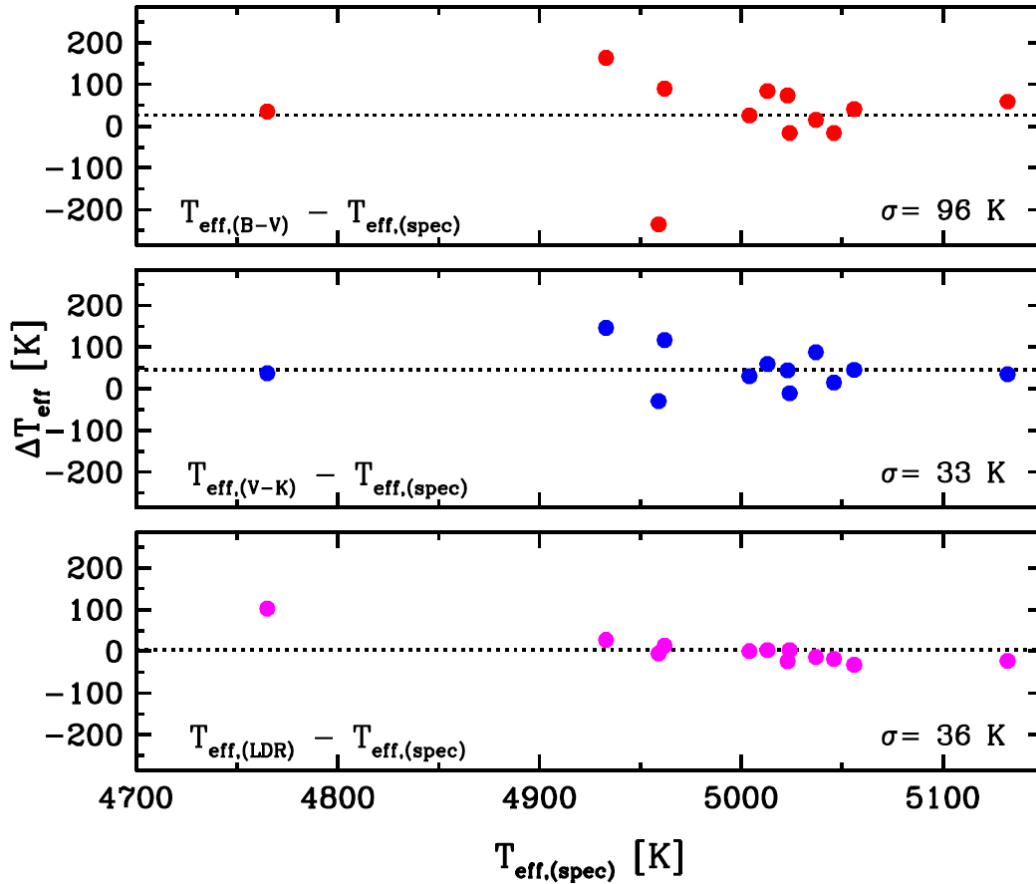
Amaç

- ★ Model atmosfer parametreleri:
 T_{eff} , $\log g$, $[M/Fe]$, 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)
- ★ $^{12}\text{C}/^{13}\text{C}$
- ★ Evrim durumu tahminleri



Model atmosferlerin belirlenmesi:

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



(B-V)
 $\langle \Delta T_{\text{eff}} \rangle = 28 \pm 27 \text{ K}$

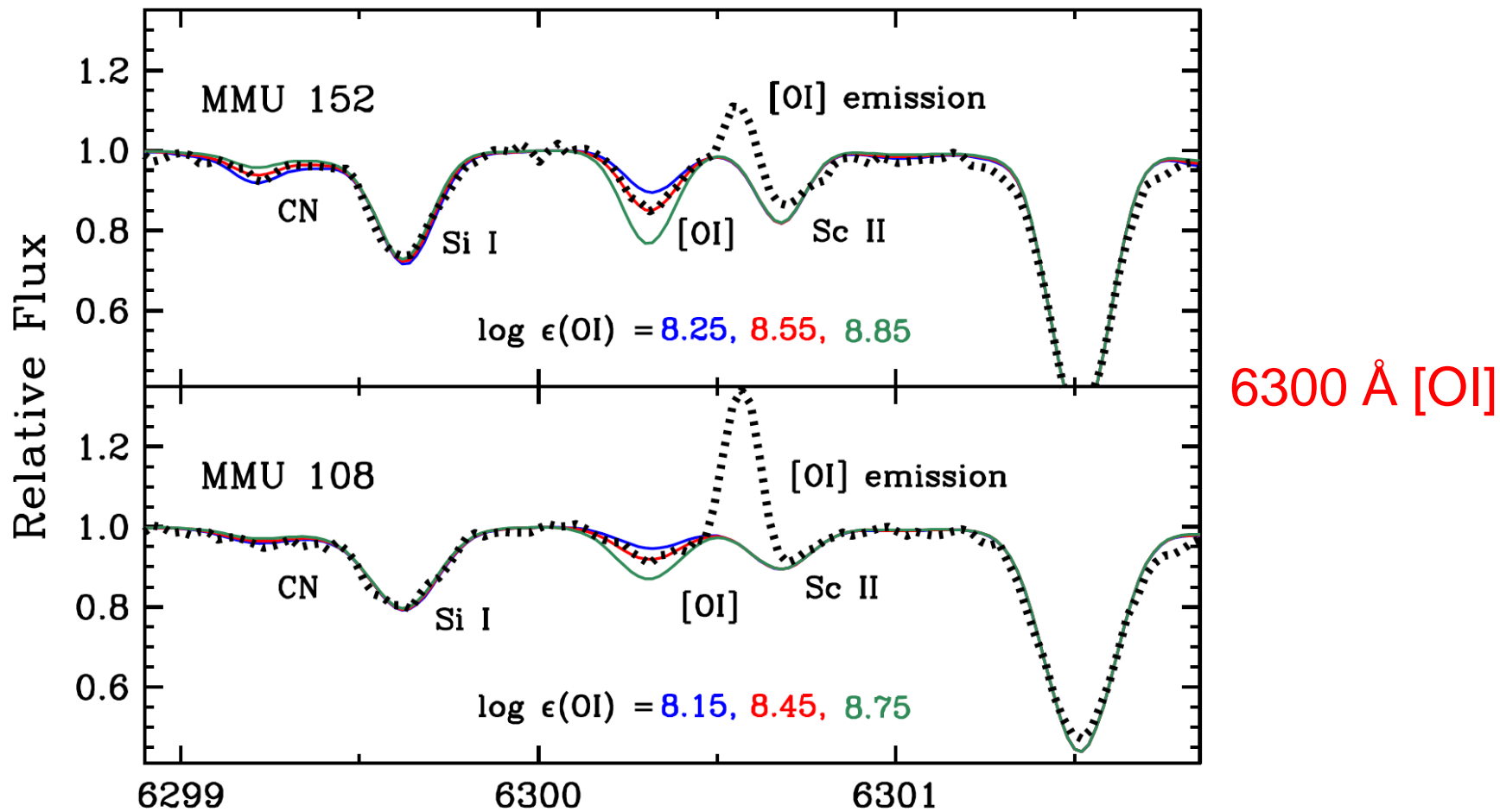
(V-K)
 $\langle \Delta T_{\text{eff}} \rangle = 48 \pm 12 \text{ K}$

(LDR)
 $\langle \Delta T_{\text{eff}} \rangle = 2.8 \pm 10 \text{ K}$

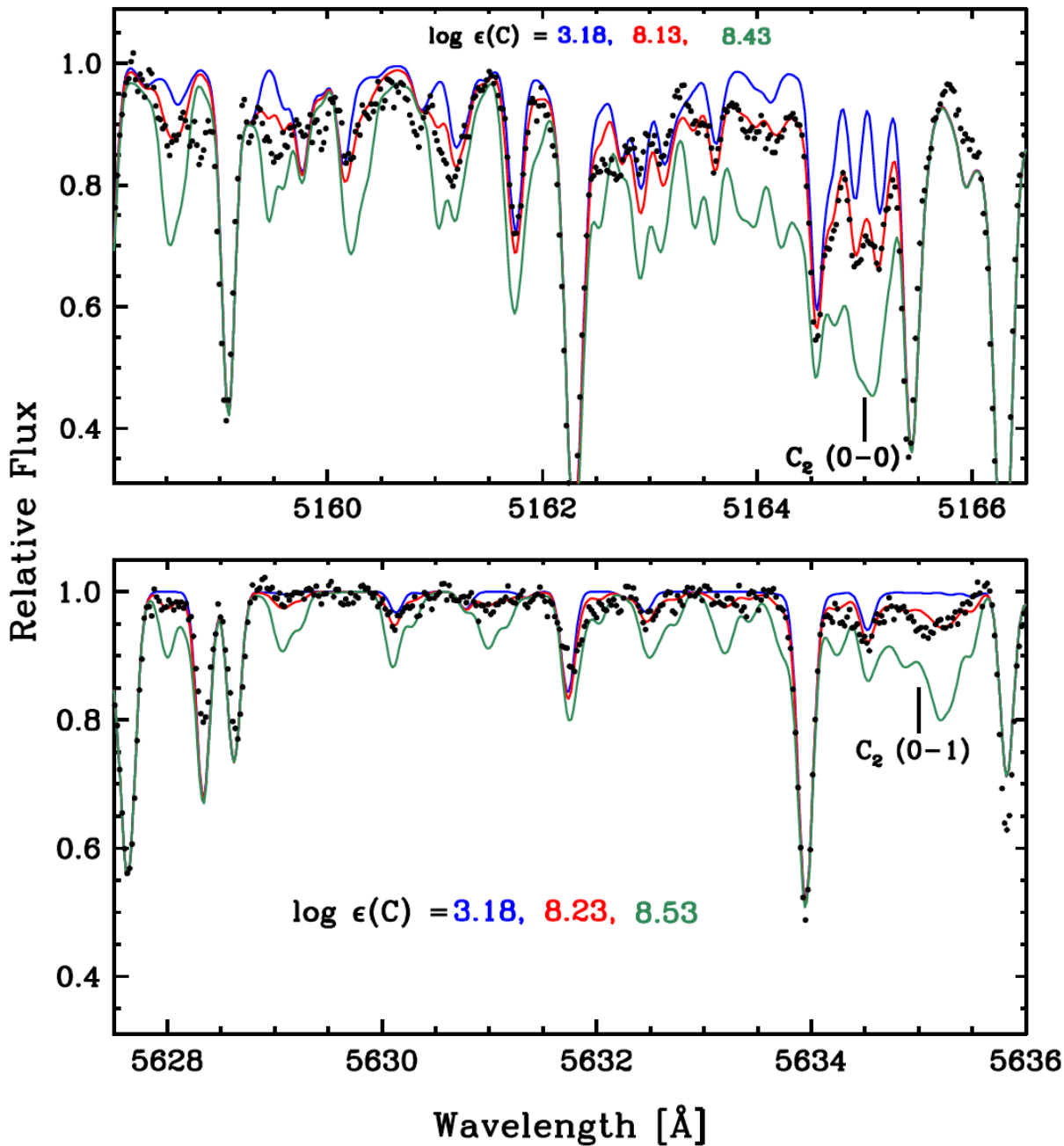
$$\log g_{\text{phy}} = 0.4 (M_{V\star} + BC - M_{\text{Bol}\odot}) + \log g_{\odot} + 4 \log\left(\frac{T_{\text{eff}\star}}{T_{\text{eff}\odot}}\right) + \log\left(\frac{m_{\star}}{m_{\odot}}\right)$$

| Star | $T_{eff,(B-V)}$ (K) | $T_{eff,(V-K)}$ (K) | $T_{eff,(LDR)}$ (K) | $\log g_{,phy}$ (cm s^{-2}) | $T_{eff,spec}$ (K) | $\log g_{,spec}$ (cm s^{-2}) | ξ_{spec} (km s^{-1}) | $[M/H]$ |
|----------------|------------------------|------------------------|------------------------|---|-----------------------|--|--|---------|
| NGC 6940 | | | | | | | | |
| MMU 28 | 5008 | 5013 | 5027 ± 33 | 3.06 | 5024 | 2.89 | 1.03 | -0.05 |
| MMU 30 | 4724 | 4929 | 4954 ± 39 | 2.77 | 4959 | 2.85 | 1.32 | -0.06 |
| MMU 60 | 5030 | 5061 | 5028 ± 19 | 3.08 | 5046 | 2.97 | 0.97 | -0.02 |
| MMU 69 | 5030 | 5034 | 5004 ± 29 | 3.06 | 5004 | 2.90 | 1.05 | -0.03 |
| MMU 87 | 5097 | 5067 | 4999 ± 43 | 2.98 | 5023 | 2.85 | 1.07 | 0.03 |
| MMU 101 | 5052 | 5125 | 5023 ± 22 | 2.98 | 5037 | 3.02 | 1.16 | 0.01 |
| MMU 105 | 4800 | 4802 | 4867 ± 36 | 2.60 | 4765 | 2.34 | 1.35 | -0.15 |
| MMU 108 | 5191 | 5167 | 5109 ± 17 | 2.98 | 5132 | 2.8 | 1.28 | -0.16 |
| MMU 132 | 5052 | 5079 | 4976 ± 37 | 2.83 | 4962 | 2.65 | 1.29 | -0.12 |
| MMU 138 | 5097 | 5101 | 5024 ± 30 | 3.01 | 5056 | 3.00 | 1.10 | 0.00 |
| MMU 139 | 5097 | 5072 | 5016 ± 28 | 3.01 | 5013 | 2.99 | 1.10 | 0.01 |
| MMU 152 | 5097 | 5079 | 4960 ± 12 | 2.78 | 4933 | 2.66 | 1.36 | -0.16 |
| Hyades | | | | | | | | |
| δ Tau | 4872 | 4918 | 4962 ± 33 | 2.65 | 4878 | 2.57 | 1.34 | -0.03 |
| ϵ Tau | 4812 | 4868 | 4921 ± 30 | 2.53 | 4870 | 2.67 | 1.46 | -0.01 |
| γ Tau | 4852 | 4928 | 4942 ± 32 | 2.60 | 4945 | 2.78 | 1.42 | -0.03 |
| θ Tau | 4956 | 4980 | 4941 ± 43 | 2.69 | 4961 | 3.00 | 1.28 | 0.01 |

CNO

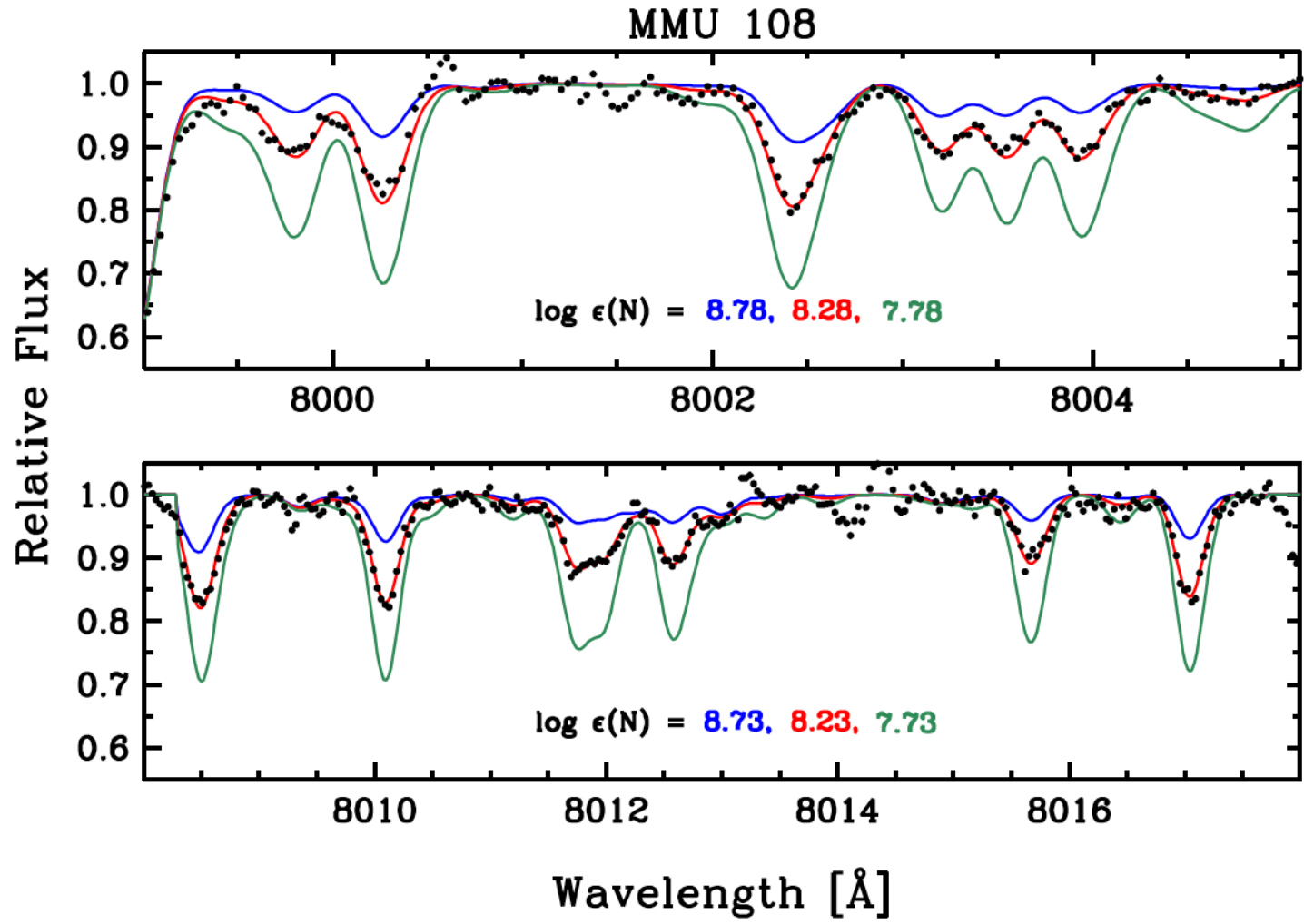


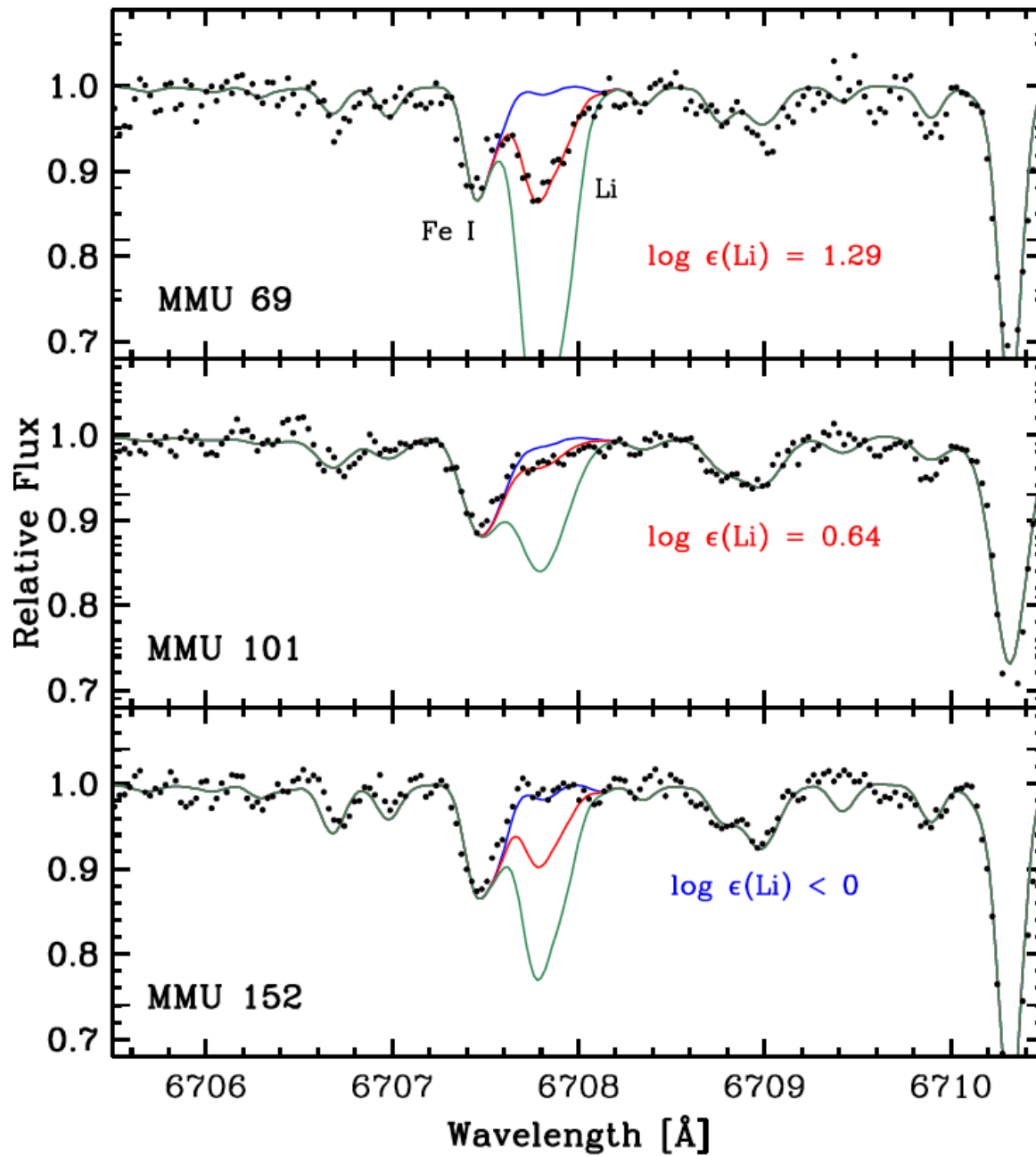
MMU 101



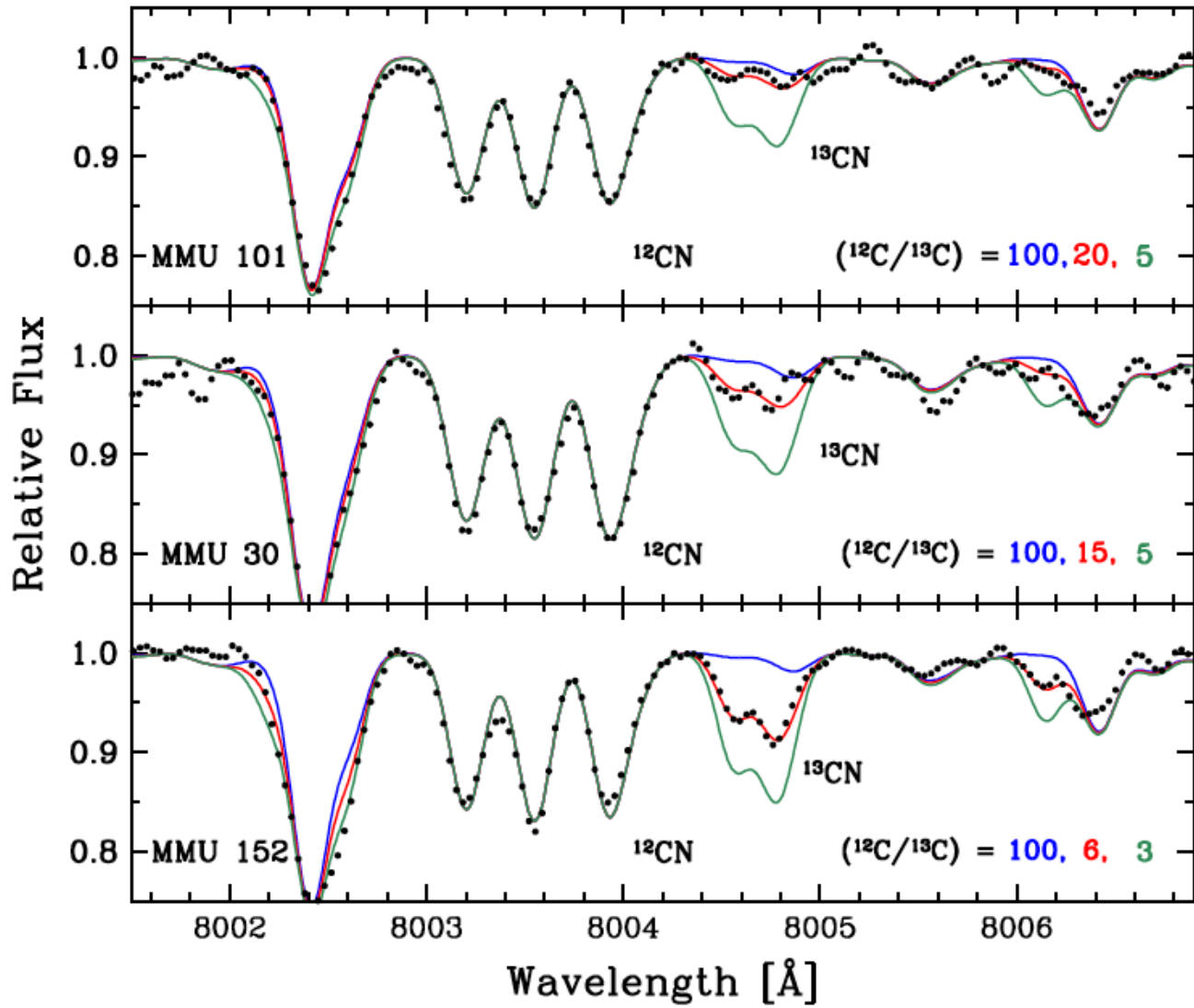
C_2 Swan

7995–8040 Å ^{12}CN ve ^{13}CN





6707 Å, Li I

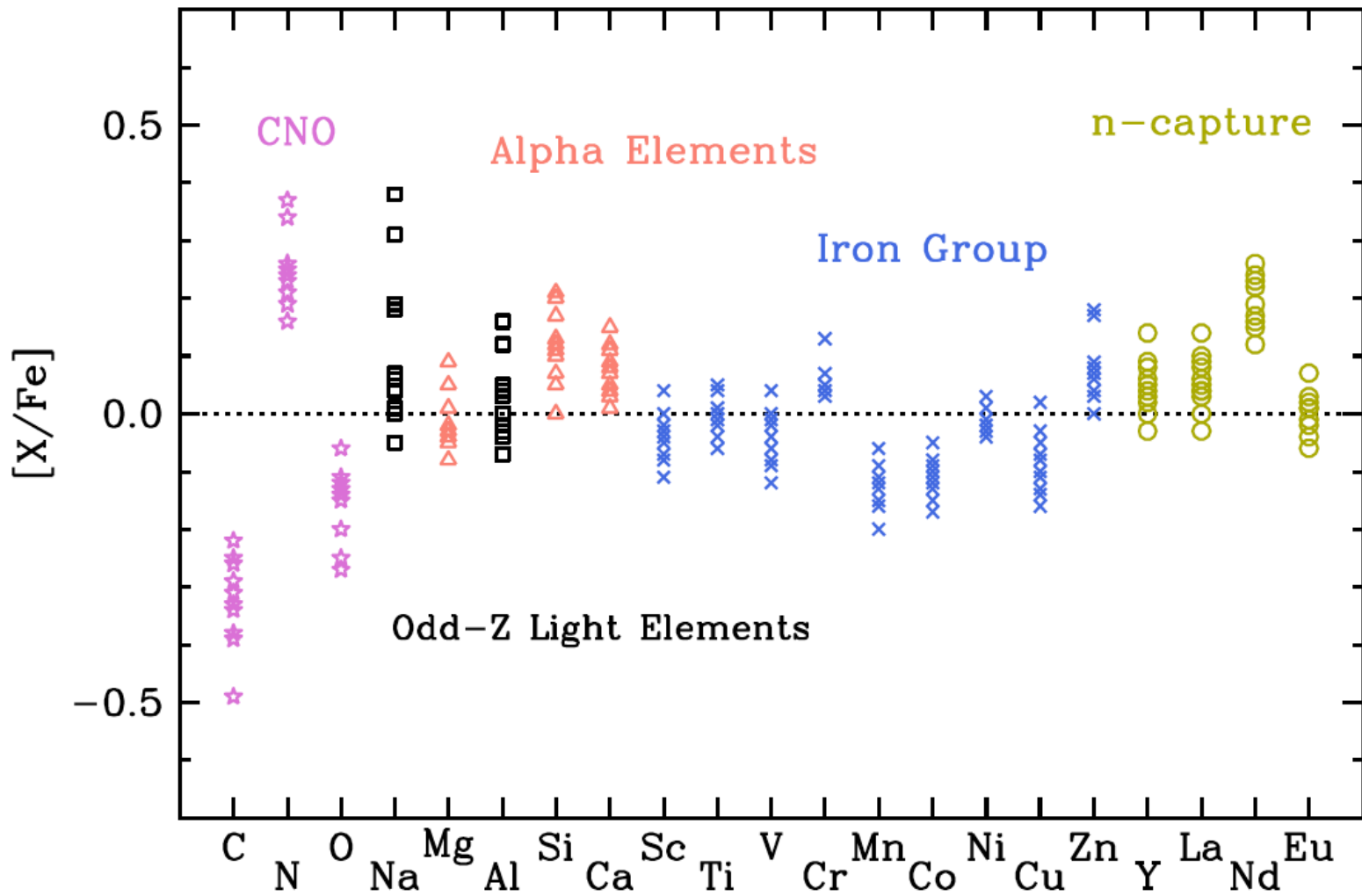


$^{12}\text{C}/^{13}\text{C}$

7995–8040 \AA ^{12}CN – ^{13}CN

Böcek Topcu et al. 2016

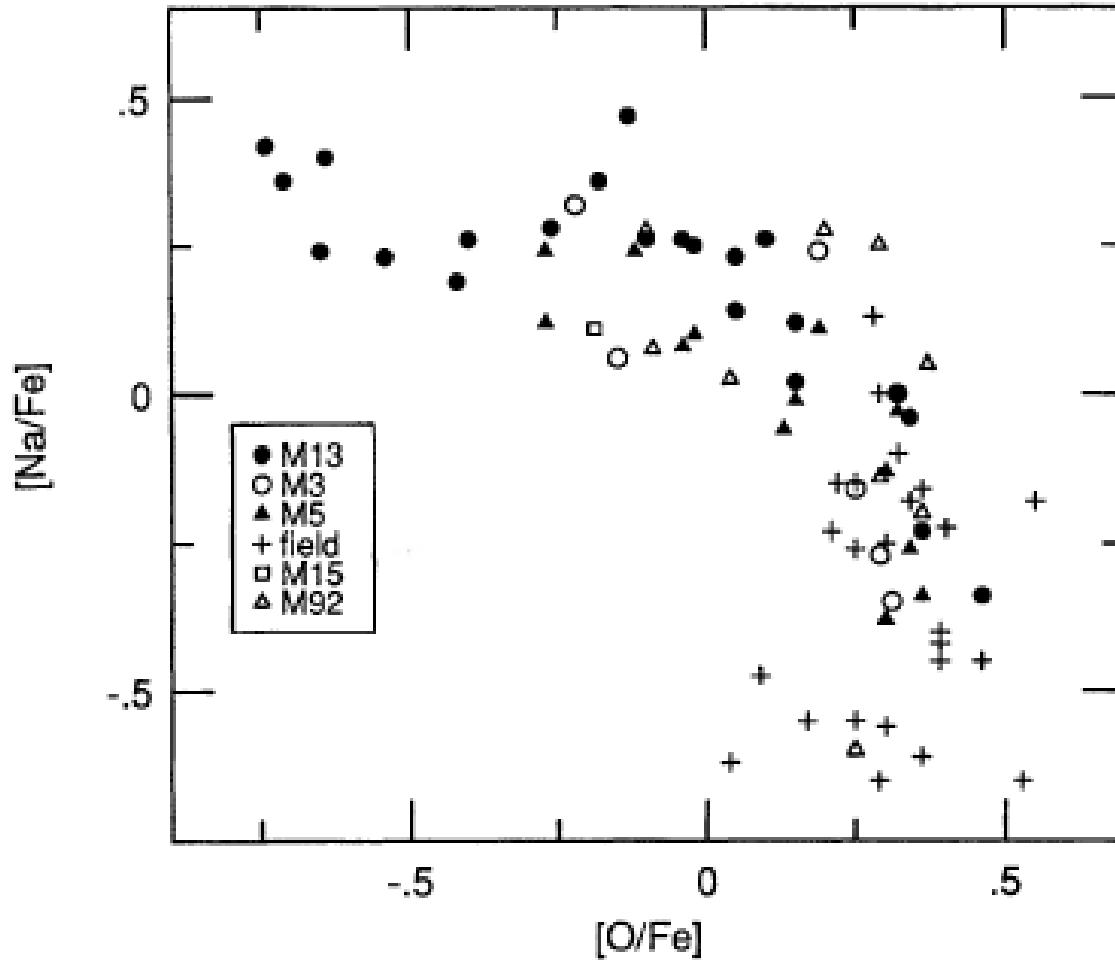
| | | | | | | | | | | |
|--------|------|--------|--------|--------|------|--------|--------|--------|--------|------|
| 8004.6 | 8006 | 8010.4 | 8015.2 | 8016.4 | 8036 | 8048.2 | 8050.5 | 8051.7 | 8056.5 | 8065 |
|--------|------|--------|--------|--------|------|--------|--------|--------|--------|------|



NGC 6940 - SONUÇLARI

| Yıldız | $\log \varepsilon(\text{Li})$ | $^{12}\text{C}/^{13}\text{C}$ | N/C | [O/Fe] | [N/Fe] | [Na/Fe] | [Al/Fe] |
|---------|-------------------------------|-------------------------------|------|--------|--------|---------|---------|
| MMU 28 | 1.05 | 20 | 0.48 | -0.15 | 0.19 | 0.06 | -0.02 |
| MMU 30 | < 0 | 15 | 0.44 | -0.11 | 0.19 | 0.06 | -0.04 |
| MMU 60 | 1.23 | 20 | 0.61 | -0.25 | 0.23 | 0.01 | -0.07 |
| MMU 69 | 1.29 | 10 | 0.57 | -0.14 | 0.26 | 0.07 | 0.03 |
| MMU 87 | 0.56 | 25 | 0.48 | -0.12 | 0.19 | -0.05 | -0.02 |
| MMU 101 | 0.64 | 20 | 0.58 | -0.12 | 0.25 | 0.06 | -0.03 |
| MMU 105 | < 0 | 15 | 0.53 | -0.20 | 0.19 | 0.18 | 0.04 |
| MMU 108 | < 0 | 20 | 0.63 | -0.14 | 0.37 | 0.31 | 0.16 |
| MMU 132 | 0.33 | 20 | 0.61 | -0.27 | 0.21 | 0.19 | 0.05 |
| MMU 138 | 1.05 | 12 | 0.46 | -0.06 | 0.24 | 0.00 | 0.00 |
| MMU 139 | 0.86 | 13 | 0.45 | -0.12 | 0.16 | 0.04 | 0.00 |
| MMU 152 | < 0 | 6 | 0.83 | -0.13 | 0.34 | 0.38 | 0.12 |

NGC 6940 - SONUÇLARI



| [O/Fe] | [Na/Fe] | [Al/Fe] |
|--------|---------|---------|
| 0.19 | 0.06 | -0.02 |
| 0.19 | 0.19 | 0.06 |
| 0.23 | 0.20 | 0.06 |
| 0.26 | 0.20 | 0.06 |
| 0.19 | -0.05 | -0.02 |
| 0.25 | 0.06 | -0.03 |
| 0.19 | 0.18 | 0.04 |
| 0.37 | 0.31 | 0.16 |
| 0.21 | 0.19 | 0.05 |
| 0.24 | 0.00 | 0.00 |
| 0.16 | 0.04 | 0.00 |

• 0 – Ne – Mg ↘
 • N – Na – Al ↗

0.19 0.23 0.26

0.19

0.25

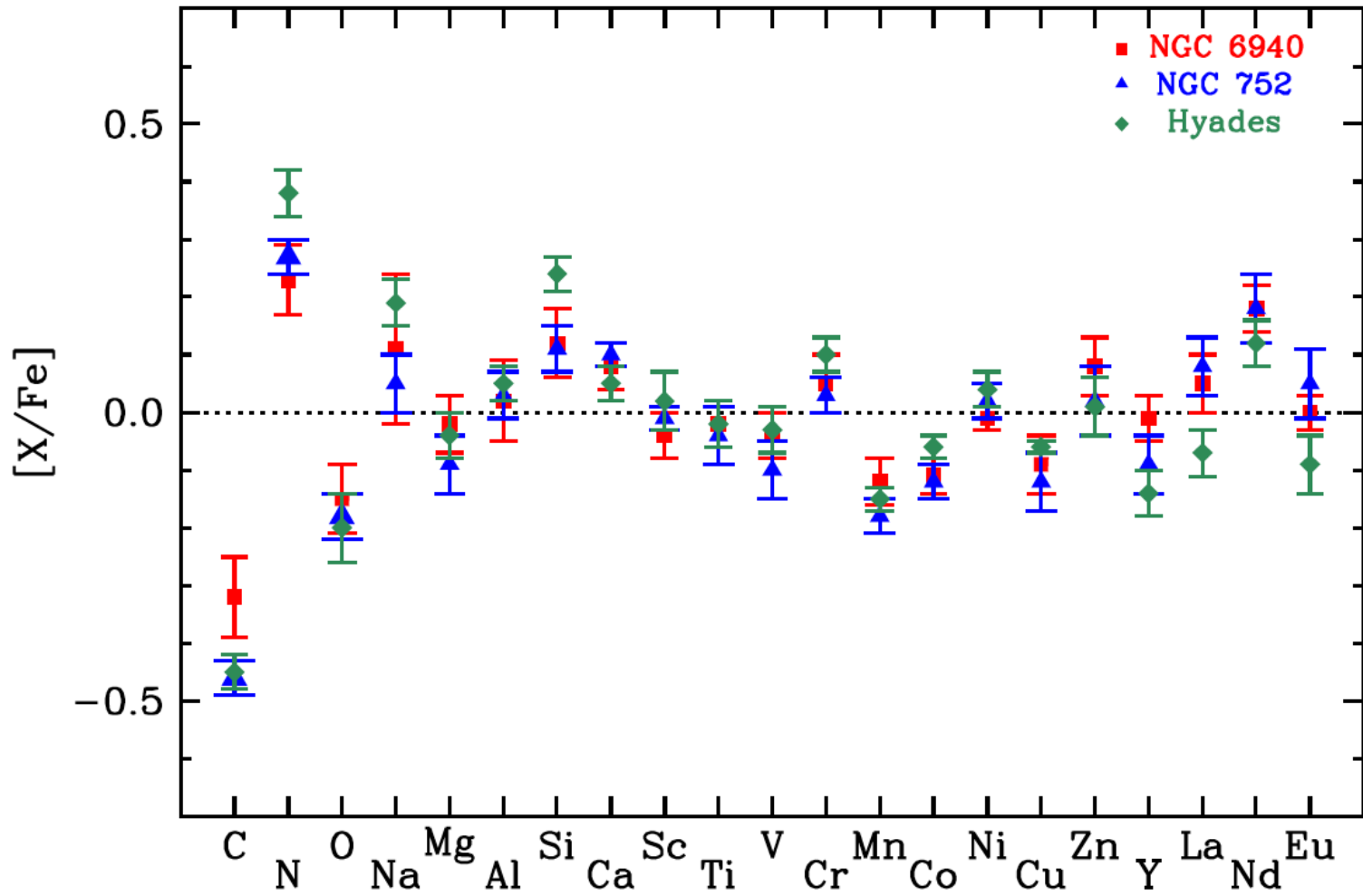
0.19

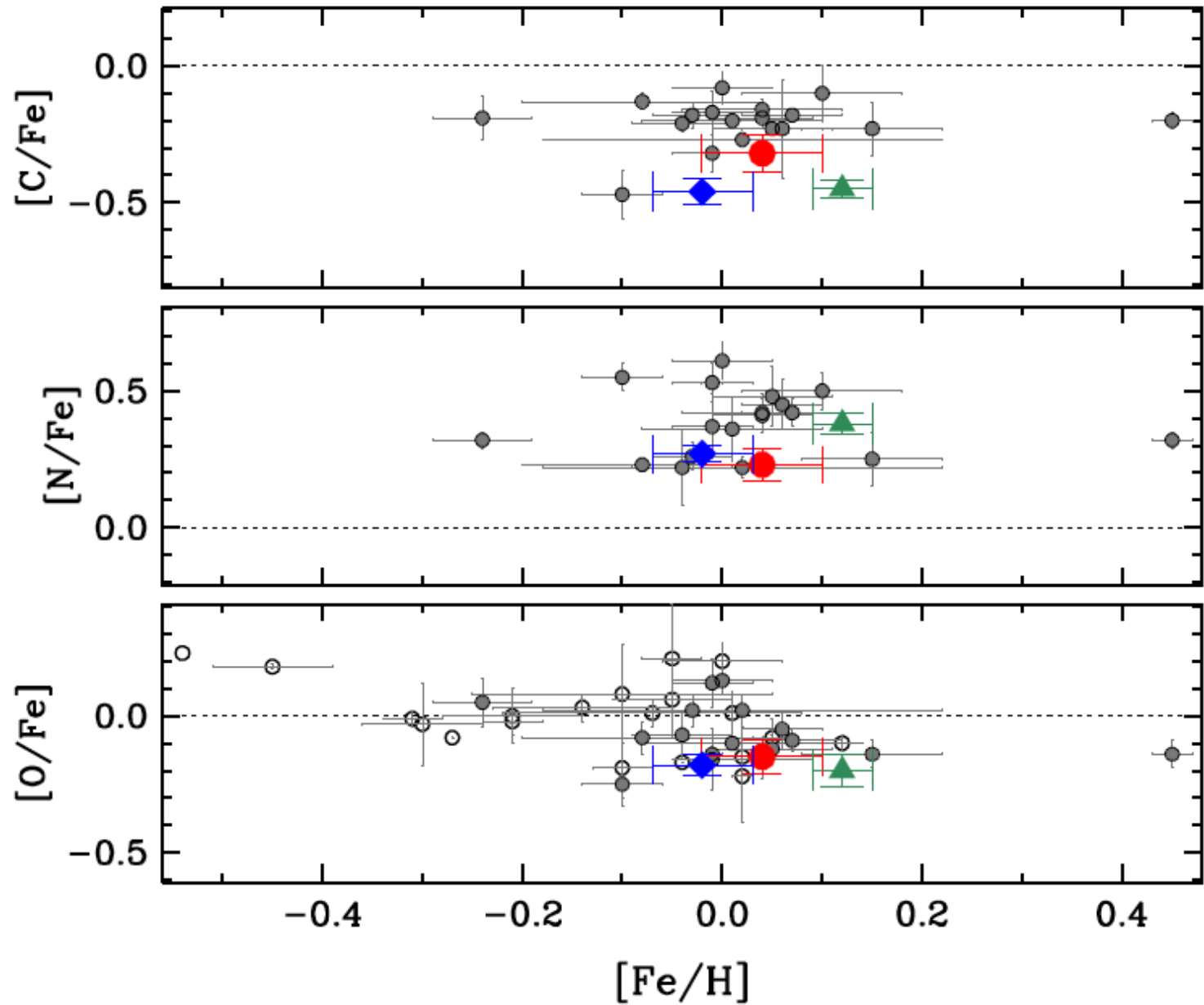
0.25

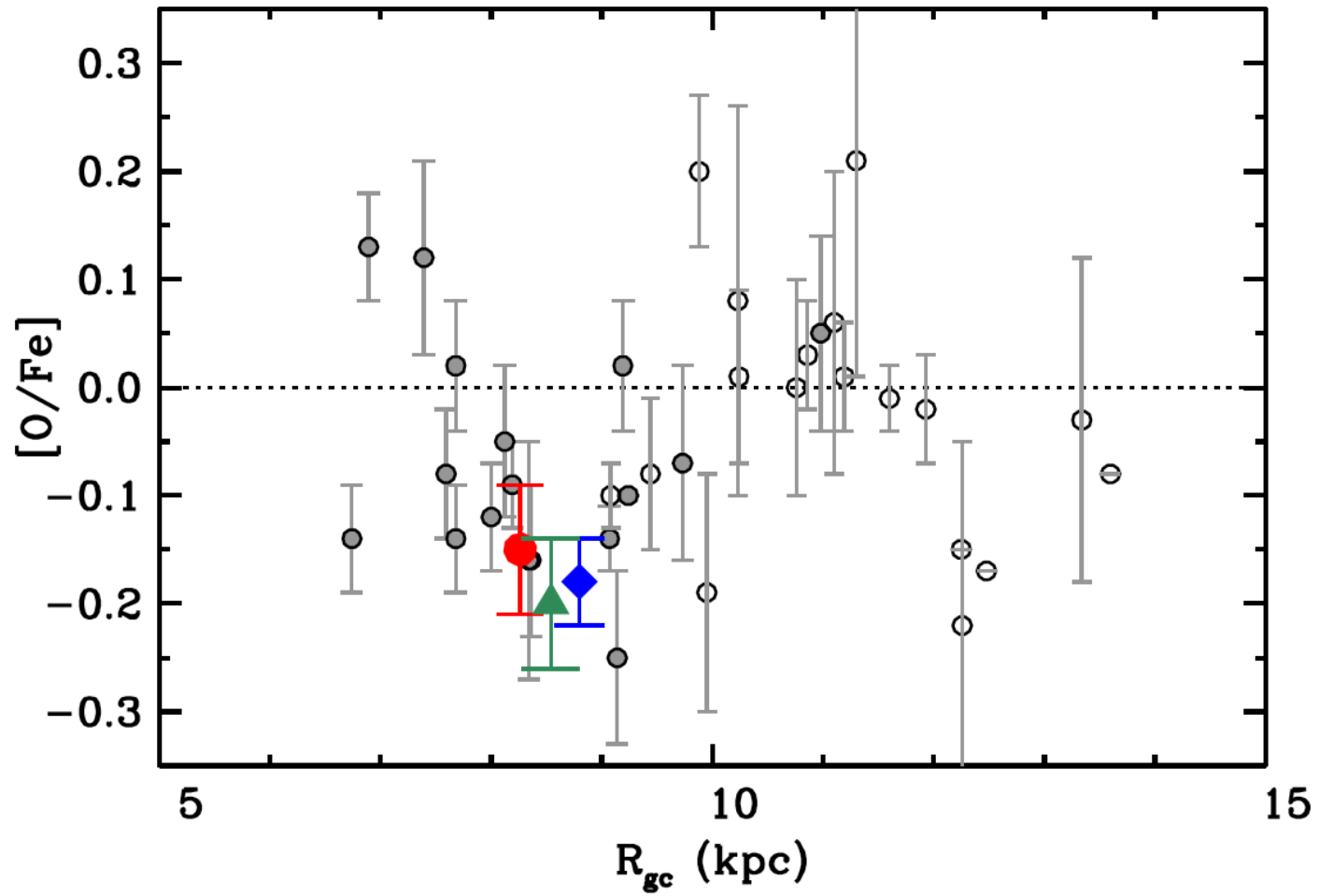
0.19

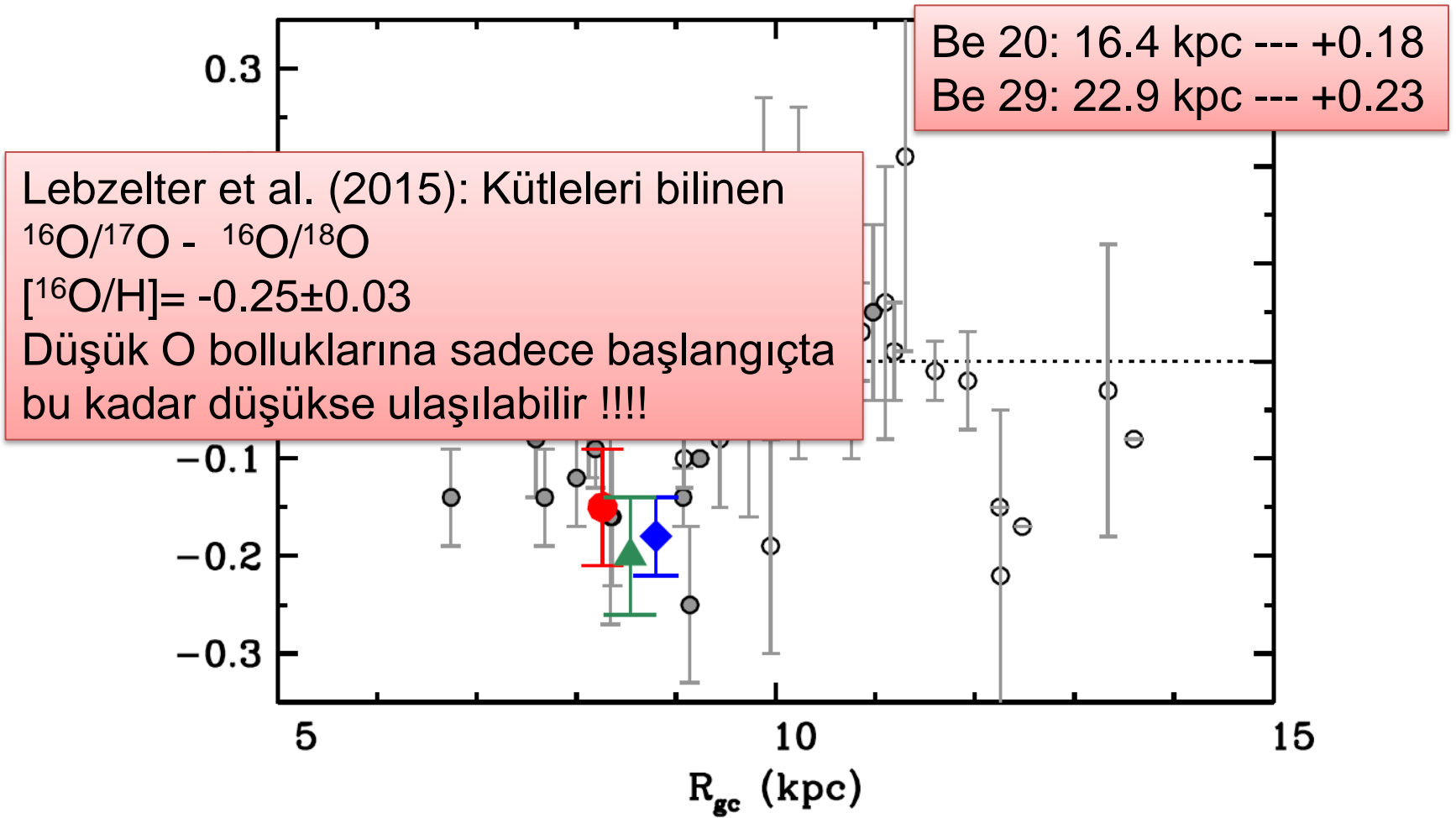
0.37

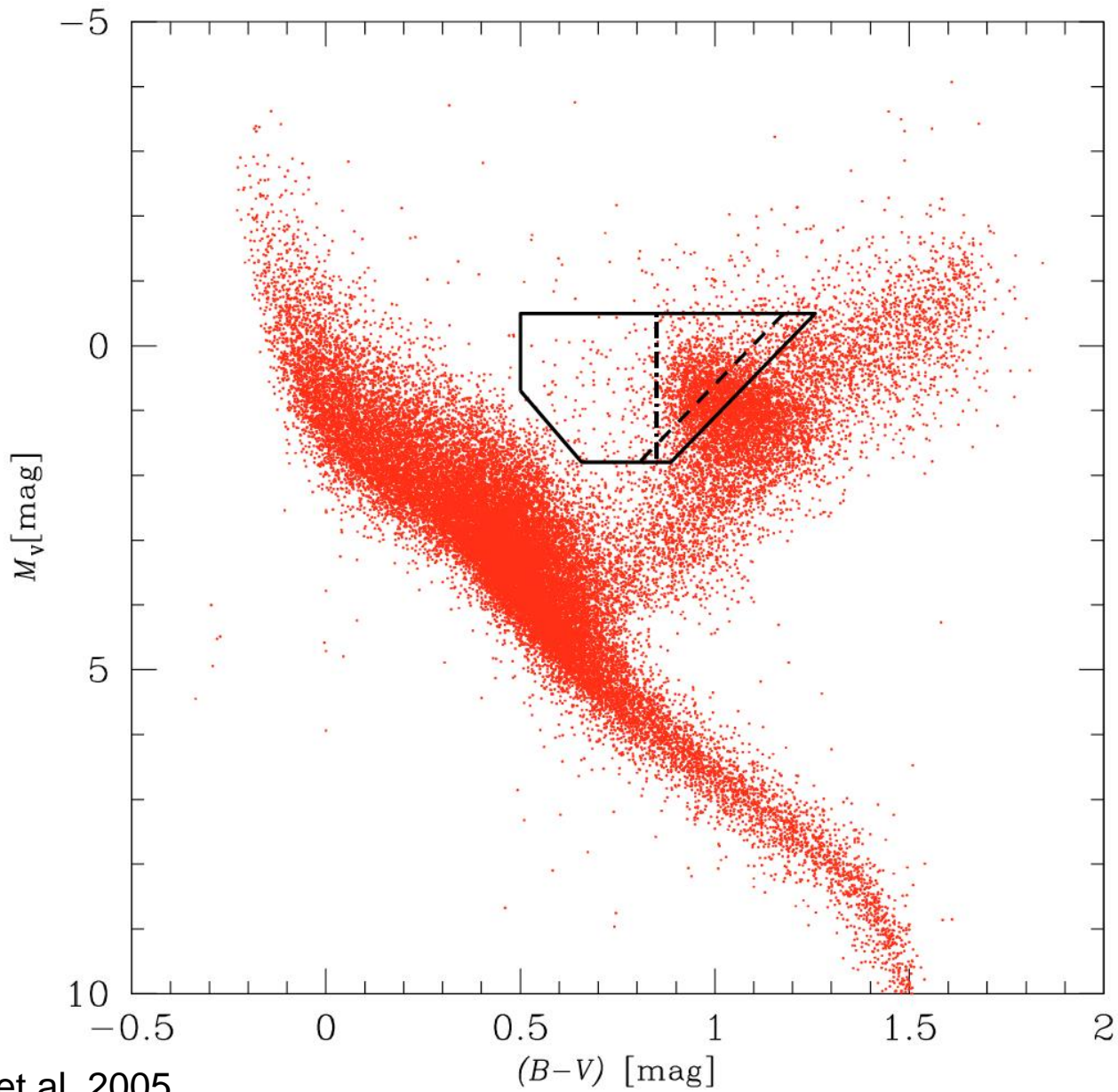
0.21



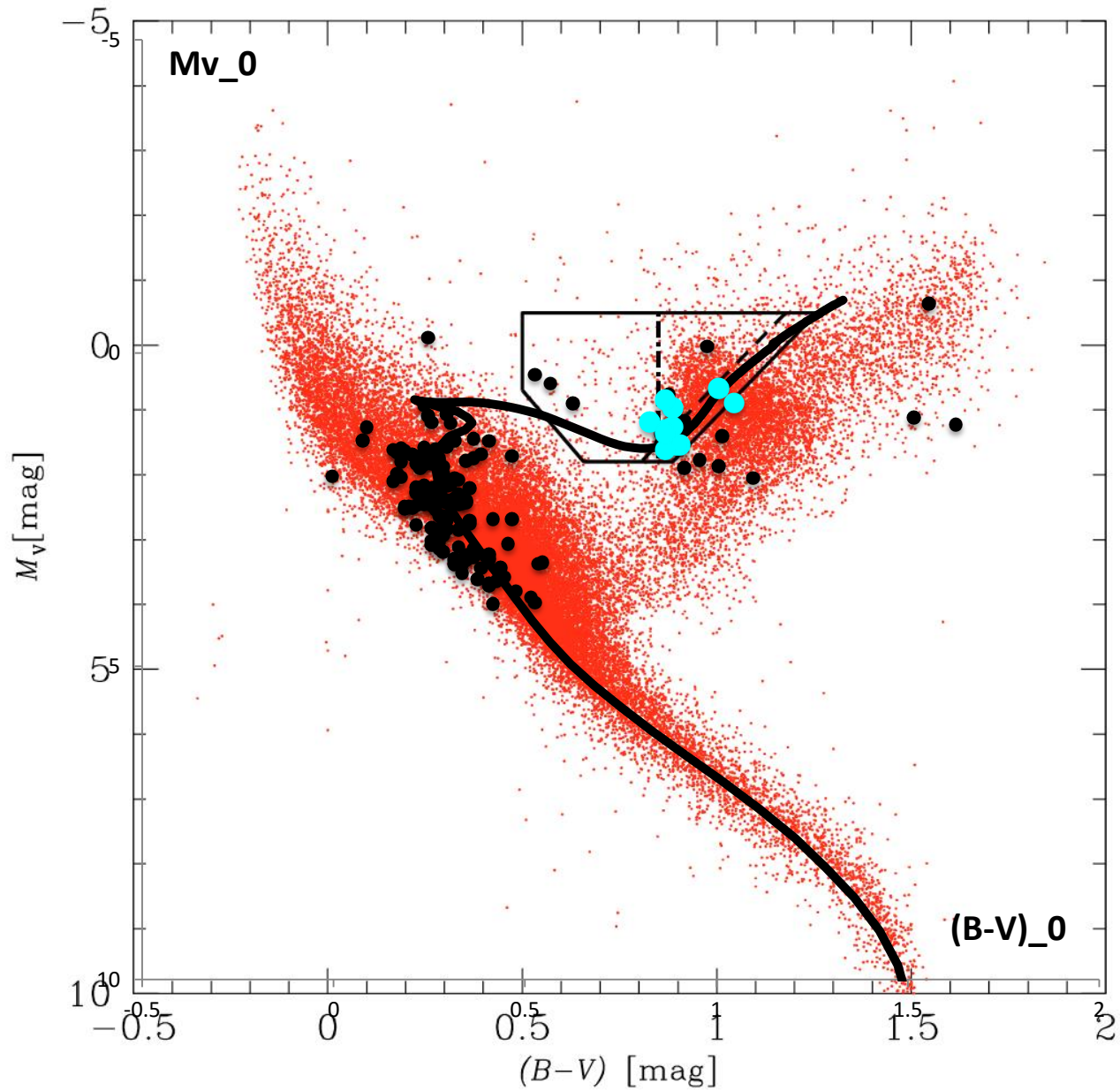








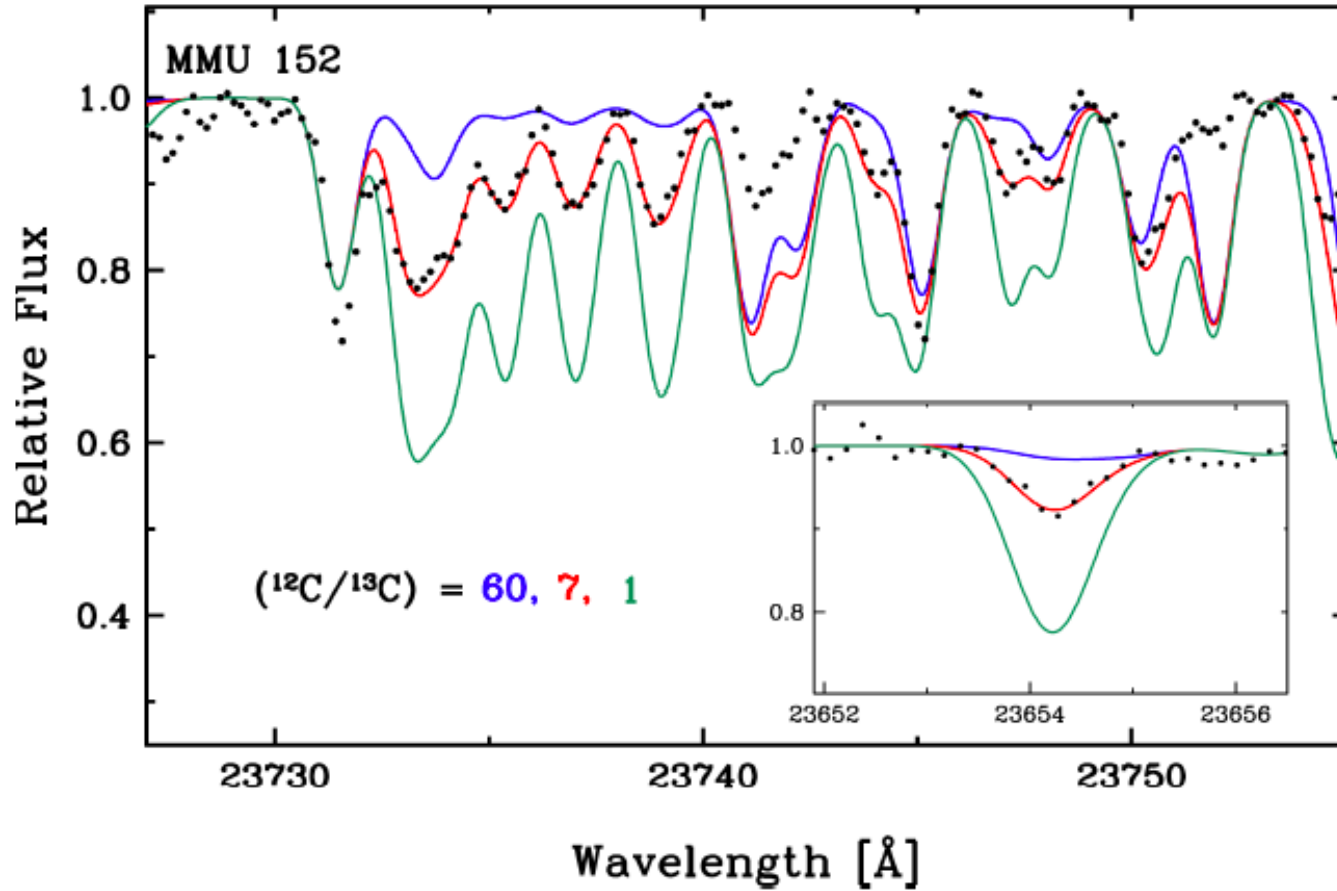
Kaempf et al. 2005



EVİRİM TAHMİNLERİ

- NGC 6940: 12 KD yıldız
Kırmızı Yığın Devleri
- HYADES: 4 KD yıldız
İlk Çıkış Devleri

IGRINS K-Bandı



Gamze Böcek TOPCU, Melike AFŞAR, Sergen ÖZDEMİR, Chris SNEDEN, hazırlık aşamasında..!

Teşekkürler...