Analysis of Two Binary Stars and a Blue Straggler in Messier 67

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1. Introduction

The old open cluster M67 (NGC 2682) contains a significant population of blue straggler stars that lie above and/or blueward of the cluster's main sequence turnoff. A variety of scenarios involving binary mergers, mass transfer, or stellar collisions have been invoked to account for the origin of these late bloomers, and studies of the stars' compositions may provide evidence about their origins. While some have been analyzed using high dispersion optical spectroscopy, infrared spectroscopy can provide additional evidence to constrain their formation.

2. Observations and Data Reduction

Figure 1 shows data from the Geller et al. (2015) M67 membership study, along with our program blue straggler stars.

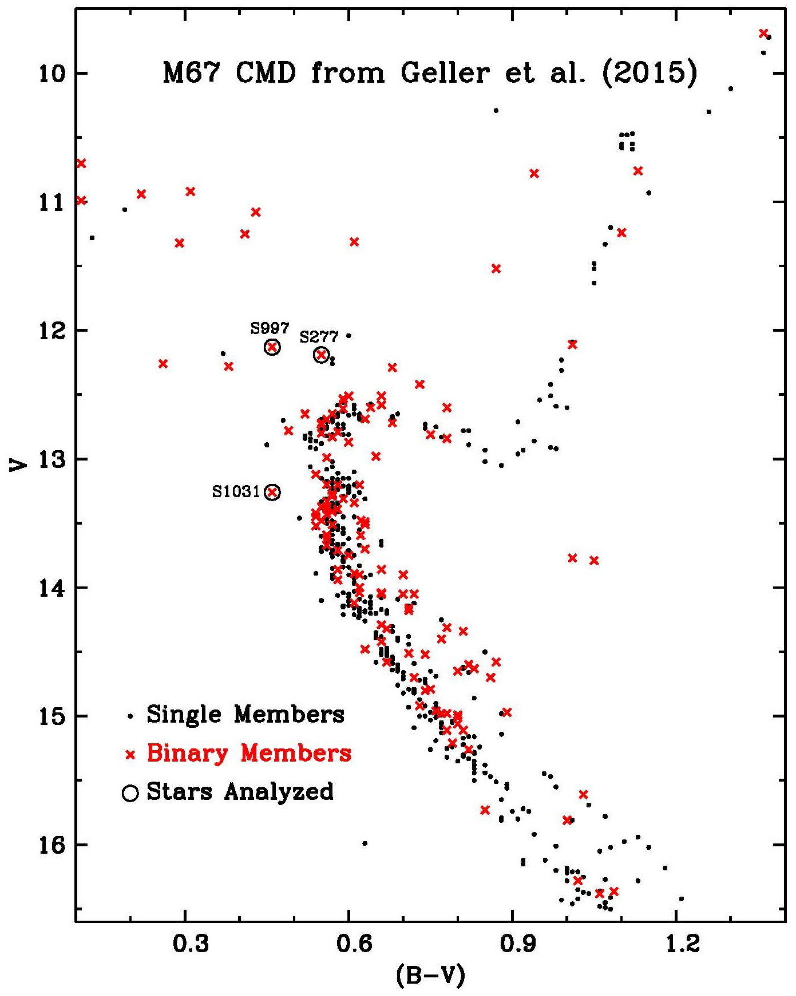

Figure 1: The Geller et al. (2015) data including 80% or higher membership probability is shown. Our program stars are circled.

The IGRINS spectra cover the H (1.5-1.7 microns) and K (2.0-2.4 microns) bands. Multiple integrations totaling 4800 seconds were obtained for each star, with the star shifted along the slit to record simultaneous sky spectra. Spectra were reduced using the IGRINS pipeline and telluric lines were removed using spectra of an A0V standard star.

Three stars in M67 selected for analysis like on the blue side or above the cluster's main sequence as shown in Figure 1. Sanders (1977) identifications are used in the discussion below.

- S277 was identified as a single-lined binary member with spectral type F6V by Geller et al. (2015). This star has not previously been analyzed for composition. Its radial velocity and proper motion suggest that the probability of membership in M67 is above 80%.
- S997 lies above the turnoff and is also a single line binary star of spectral type F5 IV, classified as a blue straggler by Geller et al. (2015), and Girard et al. (1989) estimated its membership probability at 99%. This star was previously chemically analyzed by Shetrone & Sandquist (2000).
- S1031 is classified as F7V, and lies on the blue side of the main sequence turnoff. This star has not previously been analyzed for composition. Girard et al. estimated its membership probability at 99%.

3. Analysis

We have adopted color temperatures using V-J, V-H, and V-K colors and the relations of Gonzalez Hernandez & Bonifacio (2009). We adopted a value of [Fe/H]=0.0 based on recent determinations in the literature. Surface gravities have been computed from the known distance to the cluster assuming a mass of 1.1 solar masses for all three stars.

Table 1. Program Stars

Sanders No.	Spectral Type	T_{eff} (K)	log g	ξ (km s^{-1})
S277	F6 V	6120	3.6	3.6
S997	F5 IV	6440	3.6	2.9
S1031	F7 V	6400	4.1	2.0

Abundances were determined from spectral line equivalent widths using the Moog spectrum analysis program (Sneden 1973, 2019 version) with MARCS model atmospheres (Gustafsson et al. 2008). Atomic line data for the spectral lines come from Afsar et al. (2018), the atomic and molecular line list generator explinemake (Sneden et al. 2020), the SDSS-III APOGEE Spectral Line List (Shetrone et al. 2015), and the Kurucz database.

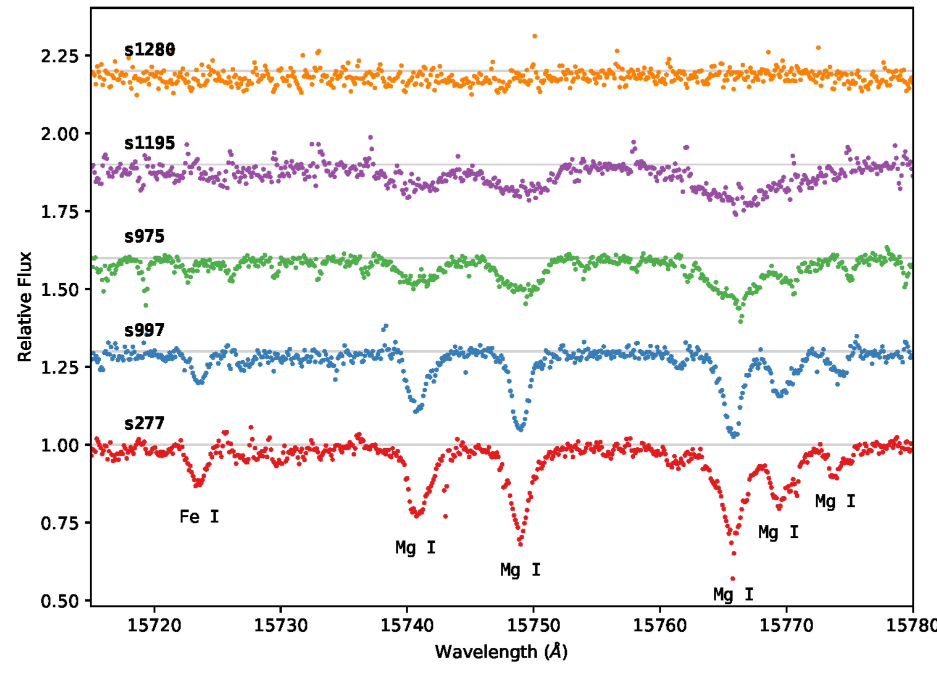

Figure 2: Sample spectral region from 15715-15780 Angstroms. The spectra are arranged in order of decreasing T_{eff} from top to bottom.

4. Results

Table 2. Program Star Abundances

	[M/H]			
Element	S277	S997	S1031	σ
C	-0.23	-0.19	0.03	0.2
Mg	0.15	-0.05	0.21	0.2
Al	-0.07	-0.48	0.26	0.2
Si	-0.09	0.01	0.44	0.16
S	0.08	-0.08	0.04	0.16
Ca	0.17	0.15	–	0.2
Fe	-0.03	-0.04	0.04	0.06
Ni	-0.08	-0.14	0.41	0.16

Our preliminary results (Table 2) suggest our program stars are similar in metallicity to main sequence turnoff stars in M67. The abundances of the analyzed species are approximately solar within the error estimates. These results agree with the abundance analysis of S997 by Shetrone & Sandquist (2000) within the errors. Future work will involve further abundance analysis of these stars, using synthetic spectra to fit abundances for additional absorption lines. In addition to the three stars discussed here, two more blue straggler stars, S975 and S1195, will be analyzed for a total of five blue straggler stars.

5. References

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