THE NATURE OF THE RED GIANT BRANCHES IN THE URSA MINOR AND DRACO DWARF SPHEROIDAL GALAXIES

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ABSTRACT

Spectra for stars located redward of the fiducial red giant branches of the Ursa Minor and Draco dwarf spheroidal galaxies have been obtained with the Hobby-Eberly telescope and the Marcario Low Resolution Spectrometer. From a comparison of our radial velocities with those reported in previous medium-resolution studies, we find an average difference of 10 km s$^{-1}$ with a standard deviation of 11 km s$^{-1}$. On the basis of these radial velocities, we confirm the membership of five stars in Ursa Minor, and find two others to be nonmembers. One of the confirmed members is a known carbon star which lies redward of RGB; three others are previously unidentified carbon stars. The fifth star is a red giant which was found previously by Shetrone et al. (2001) to have [Fe/H] = −1.68 ± 0.11 dex. In Draco, we find eight nonmembers, confirm the membership of one known carbon star, and find two new members. One of these stars is a carbon star, while the other shows no evidence for C$_2$ bands or strong atomic bands, although the signal-to-noise ratio of the spectrum is low. Thus, we find no evidence for a population of stars more metal-rich than [Fe/H] ≃ −1.45 dex in either of these galaxies. Indeed, our spectroscopic survey suggests that every candidate suspected of having a metallicity in excess of this value based on its position in the color-magnitude diagram is, in actuality, a carbon star. Based on the census of 13 known carbon stars in these two galaxies, we estimate of the carbon star specific frequency to be $\epsilon_{dSph} \approx 2.4 \times 10^{-5} L_{V,\odot}^{-1}$, 25-100 times higher than that of Galactic globular clusters.

Subject headings: galaxies: abundances — galaxies: dwarf — galaxies: individual (Draco, Ursa Minor) — stars: carbon

1. INTRODUCTION

To fully appreciate the Closed or Leaky Box nature of dwarf galaxies, their full nucleosynthetic and star forming histories must be established. Doing so requires that stars lying in the extreme low- and high-metallicity tails of their host galaxies be found and studied. Unfortunately, the coupling of age and metallicity with position on the red giant branch (RGB) makes a photometric search for such stars difficult. Even for systems characterized by a single burst of star formation, identifying bona fide metal-rich stars on the basis of photometry alone is challenging since carbon stars — by virtue of their strong molecular absorption in the ultraviolet and the resulting flux redistribution to longer wavelength — have colors which can mimic those of more metal-rich objects. The carbon stars belonging to Pop II systems are usually of the CH-type (Aaronson et al. 1983), named for the spectral characteristics of metal-poor but carbon-rich stars. It is commonly believed that they result from mass transfer in compact binary systems (McCune 1984). Thus, carbon stars provide insights into binary formation and evolution.

The Ursa Minor and Draco dwarf spheroidal (dSph) galaxies have long been suspected of showing an intrinsic dispersion in abundance (e.g., Zinn 1978). Recently, high-resolution spectroscopy for a dozen stars in these galaxies has provided unmistakable evidence for an intrinsic spread in metallicity in both objects: i.e., $\Delta$[Fe/H] = 0.73 and 1.53 dex for Ursa Minor and Draco, respectively (Shetrone, Côté & Sargent 2001). In each case, the most metal-rich member was found to have [Fe/H] $\approx$ −1.45 dex. However, recent photometric studies of these galaxies reveal a number of objects which fall redward of their fiducial giant branches, so it is conceivable that their metallicity distribution functions extend to still higher metallicities. This is particularly true of Ursa Minor, which has been the subject a proper motion survey by Cudworth, Seitzer & Majewski (2002). These authors find a small number of ostensibly members whose location in the color-magnitude diagram (CMD) makes them prime candidates for metal-rich stars.

\footnote{This work is based on observations obtained with the Hobby-Eberly Telescope, which is a joint project of the University of Texas at Austin, the Pennsylvania State University, Stanford University, Ludwig-Maximilians-Universität München, and Georg-August-Universität Göttingen.}
In this paper, we present the results of a small survey of stars redward of the fiducial giant branches of the Ursa Minor and Draco galaxies to determine whether these objects are metal-rich RGB stars, carbon stars or nonmembers. We find no evidence for a population of stars more metal-rich than [Fe/H] $\simeq -1.45$ dex in these galaxies. Every radial velocity member which falls further to the red of the RGB fiducial sequences, and for which adequate spectroscopic material is available, is found to be a carbon star.

2. OBSERVATIONS AND REDUCTIONS

Program stars in the direction of Ursa Minor and Draco were selected from the photometric catalogs of Stetson (2002) and Cudworth et al. (2002), respectively. Since this latter study also reports proper motion measurements, we only selected stars with membership probabilities in excess of 50%. Since our aim was to establish the full range in metallicity spanned by stars in these galaxies, we targeted objects displaced from the canonical red giant branches (RGBs), with particular emphasis on the red, potentially metal-rich objects. Note that some stars redward of the fiducial RGBs have published radial velocities (e.g. Armandroff, Olszewski & Pryor 1995; hereafter A95), and a few are classified as carbon stars (Aaronson et al. 1982; Azzopardi et al. 1986; Olszewski et al. 1995; Aaronson et al. 1983; Canterna & Schommer 1978; Zinn 1981, A95). We re-observed a number of these stars to confirm the precision of our radial velocities, to use as carbon star abundance standards, and to look for weak carbon star features missed by previous, lower signal-to-noise analyses.

The observations were conducted at the Hobby-Eberly telescope during the second queue observing period of 2000. The Marcardo Low Resolution Spectrograph (LRS; Hill et al. 1998) was used in its highest resolution mode — a 600 l/mm grating, 1” slit, and 2x2 binning — to produce a resolution of $R = 1200$. In this configuration, a 0.1 binned pixel velocity precision would be 25 km s$^{-1}$. The program was conducted in a wide range of seeing conditions, lunar phases and atmospheric transparencies. Despite the variety of observing conditions, the spectra had typical signal-to-noise ratios of S/N $\sim 20$, obtained in single exposures of less than 20 minutes; the total time spent with the shutter open on the sky for this program was four hours. For each spectrum, flat-field and line calibration lamps were taken. The spectra were reduced with standard IRAF long-slit extraction packages. The initial wavelength scales were applied using HgCdZn and Ne lamps.

3. RADIAL VELOCITY AND ABUNDANCE ANALYSIS

Velocity zero-point corrections were made by using the many weak night emission lines in this portion of the spectrum (Osterbrock et al. 1996). The spectrum of each star was inspected visually to identify any strong molecular features such as TiO, CaH, C$_2$, CN, or CH. For those stars lacking strong molecular features, a synthetic spectrum was created using the colors given in Table 1 and our own color-temperature-gravity relationship for an assumed metallicity of [Fe/H] = -1.8 dex.

A synthetic template spectrum was generated for those stars with visible molecular features. For objects with visible TiO and CaH features, we created a solar metallicity synthetic spectrum, using an incomplete TiO line list. Stars showing C$_2$, CN, and CH features, were modeled using a synthetic spectrum with [Fe/H] = -1.8 dex and an enhanced carbon abundance: i.e., log $\epsilon$(C) $> \log \epsilon$(O). Radial velocities were measured via cross-correlation with these templates. Previous radial velocity analysis (e.g. A95 and Olszewski et al. 1995) employed radial velocity standards instead of synthetic templates. Analyses which employ radial velocity standards are able to remove some intrinsic systematic instrumental biases but sometimes suffer from flexure zero point errors and spectral type mismatches. Using synthetic templates and the night time emission or absorption lines allows one to side step the latter problems but does not give any information about the former. A similar technique was employed in Shetrone (1994) with high resolution spectra. The use of synthetic templates for cross-correlation is also useful for programs which are queue scheduled on large telescopes when instrument setups change hour to hour and the data is acquired over the course of months and telescope time does not need to be spent on bright radial velocity standards. Data for the confirmed members of Ursa Minor and Draco are reported in Table 1, which gives the star ID, previous identifications following the naming scheme in A95, right ascension, declination, S/N per 2 pixel resolution element, and LRS radial velocity. Comments concerning the classification of the stars are given in the final column.

The upper panel of Figure 1 compares our LRS velocities with those measured by A95. There is a systematic offset of 10 km s$^{-1}$ with a standard deviation of 11 km s$^{-1}$ around that offset. The lower panel of Figure 1 shows the velocity differences, $\Delta v_r = v_r$(LRS) $- v_r$(A95), plotted against S/N per resolution element. If the offset in these differences is taken to be the result of zero-point difference, then we find that LRS in its highest resolution mode can achieve a velocity accuracy of $\sim 15$ km s$^{-1}$. Recall that a 0.1 binned pixel velocity error would be 25 km s$^{-1}$, as indicated by the dashed lines.

A comparison was made between the synthetic carbon star spectrum and those of known carbon stars in Ursa Minor and Draco. Although the absolute carbon and nitrogen abundances from this ad hoc model can not be trusted, the carbon abundance is higher than the oxygen abundance, and the fit is visually similar to the observed spectra of the known carbon stars. For each star, we created a pair of synthetic spectra: i.e., one with, and one without, enhanced carbon abundances. For the coolest stars, the C$_2$ features are the strongest features in the spectrum; among the hotter stars, the C$_2$ features are similar in strength to the atomic features. Given the signal-to-noise of our spectra, we are able to detect the hot carbon stars that previous investigations would have missed.

Figure 2 shows our LRS spectra for five stars be-
longing to Ursa Minor. The sample includes one previously recognized carbon star, three new carbon stars, and one apparently normal RGB star. In this galaxy, we therefore confirm the carbon star identification of one giant, UM152 (30614), and detect several additional carbon stars: UM1545 (37759, N42), UM1859 (35869), and UM536 (32961, J112). In Draco, we confirm the classification of one carbon star, J (C2, 20733), and identify one new carbon star: 68. A complete list of the 13 carbon stars in these two galaxies is presented in Table 2.

The radial velocity members of Draco which fall on the galaxy’s fiducial giant branch are 195, S37 and M. All stars with visible TiO and CaH bands were found to be nonmembers. We find eight nonmembers which fall redward of the RGB in Draco, including two stars (90 and 193) previously identified as nonmembers from their proper motions (Stetson 1980). A single star located to the blue of the RGB was also found to be a nonmember. Likewise, two stars located redward of the RGB in Ursa Minor were found to be nonmembers.

For Ursa Minor, only one radial velocity member in our sample has an abundance pattern which is definitely not that of a carbon star. This star, UM1846 (347, 35606, 297Q3), was studied by Shetrone et al. (2001) as #297 using high-resolution spectra from the Keck I Telescope. They found it to have \[\text{[Fe/H]} = -1.68 \pm 0.11 \text{ dex} \]. Using our low resolution spectra we can constrain the abundance to \[\text{[m/H]} = -1.8 \pm 0.3 \text{ dex} \]. With the exception of this star, we note that all of the proper motion members located redward of the RGB in this galaxy are now classified as carbon stars. This situation may also hold in Draco although there are a number of additional objects located redward of the RGB for which spectroscopy is not available. Unfortunately, our spectrum for star 194 in Draco lacks the S/N needed to determine if it too is a carbon star. We can merely constrain the abundance of this star to be \[\text{[m/H]} < -1.1 \text{ dex} \] based upon the depth of the blended atomic features. Additional spectroscopy for this star, as well as for the remaining objects located on the red side of the Draco RGB, might prove profitable.

In Figure 3, we show CMDs for both Ursa Minor and Draco. In the right panel, radial velocities of Draco from A95 and our LRS survey have been used to separate members from nonmembers in the photometric catalog of Stetson (2002). The CMD of radial velocity and/or proper motion members in Ursa Minor is shown in the left panel of this figure. The new carbon stars are indicated by the filled stars, while the previously known carbon stars are denoted by the filled squares. In both galaxies, the new objects fall below the tip of the RGBs — similar to the known carbon stars which, from infrared photometry, have bolometric magnitudes of \[M_{bol} \lesssim -3.5 \text{ M}_\odot\]. Thus, the bulk of these stars are almost certainly CH-type carbon stars (McClure 1985) rather than the more luminous N- and R-type carbon stars found in some Local Group dwarf galaxies which contain intermediate-age populations (Aaronson & Mould 1985). Possible exceptions to this claim may be stars J (C2, 20733) and 461 in Draco, which we find to be photometric variables (at the 10 and 4σ levels, respectively). Such variability is common among asymptotic giant branch (AGB) stars belonging to intermediate-age populations. The existence of a small, intermediate-age component in Draco has been suggested by Carney & Seitzer (1986) and Grillmair et al. (1998), who noted the presence of a population of stars above the main-sequence turnoff. On the other hand, radial velocity monitoring of stars J (C2, 20733) and 461 (Olszewski et al. 1996) show no evidence for the variations which might be expected in either scenario for their enhanced carbon abundances: i.e., mass-transfer from evolved close secondaries or dredge-up during AGB evolution, an evolutionary phase characterized by thermal pulsations.

The solid curves in each panel of Figure 3 show 12 Gyr isochrones from Bergbusch & VandenBerg (1992) having \[\text{[Fe/H]} = -2.26 - 2.03 - 1.78 \text{ and } -1.48 \text{ dex} \] and shifted according to the reddenings and distances given in Mateo (1998). As mentioned above, almost every star which is radial velocity and/or proper motion member of these galaxies, and which falls redward of the RGB expected for an old, \[\text{[Fe/H]} \simeq -1.45 \text{ population} \], is classified as a carbon star.

The three carbon stars discovered by Armandroff et al. (1995) in these two galaxies increased the number of such objects from six to nine. Our LRS survey brings their census to \(N_{\text{dSph}} = 13\). It is interesting to compare the frequency of carbon stars in these dSph galaxies with those in Galactic globular clusters. Côte et al. (1997) identified a total of three stars in globular clusters which show strong C\(_2\) bands (two in ω Cen and one in M14), among a sample of \(N_{\text{GC}} = 147\) clusters (Harris 1996). If the selection criterion is relaxed to include hotter stars which show strong CN and CH absorption but no C\(_2\) bands, then \(N_{\text{dSph}} = 10\) (McClure 1984). Since the mean luminosity of Galactic globular clusters is \(\langle L_V \rangle \simeq 7.5 \times 10^4 \text{ L}_\odot\), the specific frequency of CH stars in globular clusters,

\[
\epsilon_{\text{GC}} = N_{\text{GC}}^{\text{C}} [N_{\text{GC}} (\langle L_V \rangle)^{-1}],
\]

is found to be

\[1 \times 10^{-6} L_V^{-1} \lesssim \epsilon_{\text{GC}} \lesssim 2.7 \times 10^{-7} L_V^{-1}.\]

Mateo (1998) reports luminosities of \(2.9 \times 10^5\) and \(2.6 \times 10^5\) \(L_V\) for Ursa Minor and Draco, respectively. Thus, the specific frequency of CH stars in these galaxies is

\[\epsilon_{\text{dSph}} \simeq 2.4 \times 10^{-5} L_V^{-1},\]

or 25-100 times higher than that for globular clusters. Since field CH stars are known to be the end-products of mass transfer between contact binaries (McClure 1984), the disparity between these specific frequencies may be evidence that in the denser globular-cluster environments, binaries are either disrupted or driven toward orbital shrinkage and eventual coalescence long before the primary can

\(^3\)For Draco, the IDs are from Armandroff et al. (1995) and Baade & Swope (1961) unless preceded by an “S” in which case they refer to the catalog of Stetson (2002). For Ursa Minor, the IDs are from Cudworth et al. (2002). When available, cross-identifications for these stars are given.

\(^4\)In Draco, the most metal-poor star found by Shetrone et al. (2001) has \([\text{Fe/H}] = -2.97 \pm 0.15 \text{ dex} \) — considerably lower than the most metal-poor metallicity isochrone of Bergbusch & VandenBerg (1992). However, the offset relative to the most-poor isochrone is expected to be relatively modest since, at low abundances, isochrone shapes are largely independent of metallicity.
become an AGB star and experience carbon dredge-up and subsequent mass transfer. Binary systems in the looser dwarf spheroidal systems and in the field, on the other hand, can normally survive long enough to reach this phase of evolution. Renewed searches for additional CH stars in Local Group dwarf galaxies might prove worthwhile, given that the census of such stars in Ursa Minor and Draco, once thought to be complete, has increased by nearly 50%.

4. SUMMARY

We have used the Hobby-Eberly telescope and Marcario LRS to carry out a search for metal-rich stars in the Ursa Minor and Draco dSph galaxies. From a comparison of our radial velocities for stars in common with those targeted by previous higher-resolution studies, we find that LRS is sufficiently stable to achieve a radial velocity accuracy of approximately 1/15 pixel, or 15 km s$^{-1}$ at $S/N \simeq 25$ per resolution element. Although a number of members were found redward of the fiducial RGB in this survey, there is no evidence for a population more metal-rich than [Fe/H] $\simeq -1.45$ dex in these galaxies. Indeed, nearly every radial velocity member redward of the fiducial RGB is found to be a carbon star. Combining our sample of four new carbon stars with those previously known, we find a total of seven carbon stars Ursa Minor and six in Draco. Thus, relative to Galactic globular clusters, these galaxies appear to be overabundant in carbon stars by a factor of 25-100.

We extend our thanks to the staff of the Hobby-Eberly telescope and, in particular, to Grant Hill, Brian Roman, Gabrielle Saurage, and Teddy George for providing the high quality service observations that made this project possible. Thanks also to Kyle Cudworth for providing the photometry for Ursa Minor prior to publication.

REFERENCES

McClure, R.D. 1985, JRASC, 79, 277
Stetson, P.B. 2002, in preparation
Fig. 1.— (Upper Panel) Comparison of our LRS radial velocities with those of Armandroff et al. (1995; A95). The dashed line indicates the one-to-one relation. The velocity uncertainty for our LRS measurements is taken to be $\sigma(v_r) = 15$ km s$^{-1}$ based on the results below. (Lower Panel) Radial velocity difference, $\Delta v_r = v_r(\text{LRS}) - v_r(\text{A95})$, for stars in common with Armandroff et al. (1995). The dashed lines show 0.1 binned pixel velocity errors for LRS in this configuration; the distribution of points is consistent with a $0.06 \sim 1/15$ binned pixel velocity error, corresponding to $15$ km s$^{-1}$. Error bars show this uncertainty added in quadrature to those reported by Armandroff et al. (1995).
Fig. 2.— LRS spectra for radial velocity members of the Ursa Minor dSph galaxy. UM 152 (30614) is a previously recognized carbon star; UM 536 (32961, J12), 1545 (37759, N42) and 1859 (35869) are newly discovered carbon stars. The lower panel shows the LRS spectrum of UM 1846 (347, 35606, 297Q3), a normal RGB star. The strong C$_2$ band in UM 152 (30614) which was used to identify the C-stars is marked in the upper panel. The Mg$b$ feature, which blend with the red most part of the C$_2$ band in C-stars, is marked in the lower panel.
Fig. 3.— $BV$ color magnitude diagrams for the Ursa Minor and Draco dSph galaxies, based on photometry from Cudworth et al. (2002) and Stetson (2002), respectively. The various symbols are explained in the legends at the top of the panels. The solid curves in each panel show 12 Gyr isochrone from Bergbusch & VandenBerg (1992) having $[\text{Fe/H}] = -2.26 - 2.03 - 1.78$ and $-1.48$ dex, and shifted according to the reddenings and distances given in Mateo (1998). For comparison, Shetrone et al. (2001) find weighted mean metallicities for Ursa Minor and Draco of $[\text{Fe/H}] = -1.90 \pm 0.11$ and $-2.00 \pm 0.21$ dex, respectively. The most metal-poor star found by Shetrone et al. (2001) in Ursa Minor has $[\text{Fe/H}] = -2.18$ dex, while the most metal-poor star in Draco has $[\text{Fe/H}] = -2.97$ dex. For both galaxies, the most metal-rich star in the study of Shetrone et al. (2001) has $[\text{Fe/H}] \simeq -1.45$ dex.
Table 1

URSA MINOR AND DRACO MEMBER STARS OBSERVED WITH LRS

<table>
<thead>
<tr>
<th>Name</th>
<th>Other</th>
<th>α(J2000)</th>
<th>δ(J2000)</th>
<th>S/N</th>
<th>(v_r) (km s(^{-1}))</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>UM1545</td>
<td>37759, N42</td>
<td>15:08:35.67</td>
<td>67:03:41.1</td>
<td>24</td>
<td>-236</td>
<td>New carbon star</td>
</tr>
<tr>
<td>UM536</td>
<td>32961, J12</td>
<td>15:11:36.35</td>
<td>67:18:07.2</td>
<td>28</td>
<td>-253</td>
<td>New carbon star</td>
</tr>
<tr>
<td>UM152</td>
<td>30614</td>
<td>15:11:55.47</td>
<td>67:25:08.6</td>
<td>23</td>
<td>-262</td>
<td>Known carbon star</td>
</tr>
<tr>
<td>UM1846</td>
<td>347, 35606, 297Q3</td>
<td>15:08:27.16</td>
<td>67:10:07.3</td>
<td>81</td>
<td>-238</td>
<td>RGB star</td>
</tr>
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</table>

Draco

<table>
<thead>
<tr>
<th>J</th>
<th>Draco C2, 20733</th>
<th>17:20:00.68</th>
<th>57:53:46.7</th>
<th>40</th>
<th>-332</th>
<th>Known carbon star</th>
</tr>
</thead>
<tbody>
<tr>
<td>194</td>
<td></td>
<td>17:20:27.24</td>
<td>57:56:12.1</td>
<td>20</td>
<td>-293</td>
<td>RGB star</td>
</tr>
<tr>
<td>68</td>
<td></td>
<td>17:19:57.29</td>
<td>57:55:04.7</td>
<td>25</td>
<td>-246</td>
<td>New carbon star</td>
</tr>
<tr>
<td>195</td>
<td></td>
<td>17:20:24.18</td>
<td>57:56:26.0</td>
<td>20</td>
<td>-259</td>
<td>RGB star</td>
</tr>
<tr>
<td>S37(^2)</td>
<td></td>
<td>17:19:05.58</td>
<td>57:53:58.4</td>
<td>13</td>
<td>-365</td>
<td>RGB star</td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>17:20:07.44</td>
<td>57:54:32.8</td>
<td>10</td>
<td>-208</td>
<td>RGB star</td>
</tr>
</tbody>
</table>

\(^1\)Identifications from Cudworth et al. (2002).

\(^2\)Identification from Stetson (2002).

Table 2

OBSERVED PROPERTIES OF CARBON STARS IN URSA MINOR AND DRACO

<table>
<thead>
<tr>
<th>Name</th>
<th>α(J2000)</th>
<th>δ(J2000)</th>
<th>V (mag)</th>
<th>B – V (mag)</th>
<th>(\langle v_r\rangle) (km s(^{-1}))</th>
<th>Other</th>
</tr>
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<tr>
<td>UM1378</td>
<td>15:07:38.60</td>
<td>67:13:56.4</td>
<td>17.50</td>
<td>1.66</td>
<td>-256.1±3.6(^2) vA335, 34227</td>
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</tr>
<tr>
<td>UM1859</td>
<td>15:08:08.99</td>
<td>67:09:21.4</td>
<td>17.92</td>
<td>1.18</td>
<td>-249.9±5.9(^2) 35869</td>
<td></td>
</tr>
<tr>
<td>UM1545</td>
<td>15:08:35.67</td>
<td>67:03:41.1</td>
<td>17.26</td>
<td>1.38</td>
<td>-237.1±0.9(^2) 37759, N42</td>
<td></td>
</tr>
<tr>
<td>UM1750</td>
<td>15:08:55.36</td>
<td>67:15:16.1</td>
<td>10.98</td>
<td>1.35</td>
<td>-253.7±2.4(^2) K, 33839, COS215</td>
<td></td>
</tr>
<tr>
<td>UM1167</td>
<td>15:09:31.92</td>
<td>67:19:03.6</td>
<td>18.05</td>
<td>1.34</td>
<td>-245.7±2.3(^2) 32613, COS122, 70Q1</td>
<td></td>
</tr>
<tr>
<td>UM536</td>
<td>15:11:36.35</td>
<td>67:18:07.2</td>
<td>17.58</td>
<td>1.39</td>
<td>-247.6±1.4(^2) 32961, J112</td>
<td></td>
</tr>
<tr>
<td>UM152</td>
<td>15:11:55.39</td>
<td>67:25:09.3</td>
<td>17.62</td>
<td>1.33</td>
<td>-248.5±4.6(^2) 30614</td>
<td></td>
</tr>
</tbody>
</table>

Draco

| 461\(^3\) | 17:19:42.40 | 57:58:37.8 | 17.19 | 1.74 | -299.9±1.5\(^2\) |                             |
| 68       | 17:19:57.29 | 57:55:04.7 | 18.35 | 1.13 | -246±15           |                             |
| 3203     | 17:19:57.66 | 57:50:05.8 | 17.31 | 1.44 | -297.1±1.1\(^2\) | Draco C1, 22025             |
| J\(^4\)  | 17:20:00.68 | 57:53:46.7 | 17.36 | 1.59 | -300.9±0.6\(^2\) | Draco C2, 20733             |
| 3237     | 17:20:33.56 | 57:50:19.7 | 17.50 | 1.55 | -280.5±0.7\(^2\) | Draco C3, 21892             |
| 578      | 17:20:38.86 | 57:59:34.7 | 18.25 | 1.49 | -291.0±1.4\(^2\) | Draco C4, 18402             |

\(^1\)Identifications from Cudworth et al. (2002).

\(^2\)Radial velocity from Armandroff et al. (1995).

\(^3\)Possible photometric variable.

\(^4\)Definite photometric variable.