

Little Bear's pulsating stars: Variable star census of UMi dSph Galaxy

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Abstract. Recent observations and a photometric search for variable stars in the Ursa Minor dwarf spheroidal galaxy (UMi dSph) are presented. Our observations were taken at Apache Point Observatory in 2014 and 2016 using the 0.5m ARCSAT telescope and the West Mountain Observatory (WMO) 0.9m telescope of Brigham Young University in 2016. Previously known RR Lyrae stars in our field of view of the UMi dSph are identified, and we also catalog new variable star candidates. Tentative classifications are given for some of the new variable stars. We have conducted period searches with the data collected with the WMO telescope. Our ultimate goal is to create an updated catalog of variable stars in the UMi dSph and to compare the RR Lyrae stellar characteristics to other RR Lyrae stars found in the Local Group dSph galaxies.

1 Introduction

The Ursa Minor dwarf spheroidal galaxy (UMi dSph) is a Local Group member with a rich variable star population. RR Lyrae (RRL), anomalous Cepheids (AC), and eclipsing binary stars have been found and identified ([1, 4, 7]). Two different epochs of star formation are indicated via the RRL (older population) and the ACs (intermediate age). The UMi dSph is a metal-poor galaxy, and from the analysis of the RRL, it has been classified as an Oosterhoff-II (OoII) type object. UMi is one of a handful of known dwarf galaxies with a clear Oosterhoff classification.

The goals of this project are to revisit the UMi dSph galaxy and reinvestigate the variable star population. We present our variable star census based on the northeast portion of the galaxy. With our photometric data, we will reevaluate and recalculate many of the stellar characteristics, in particular the pulsational characteristics.

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2 Data acquisition and reduction

Data sets were collected at the 0.5m Astrophysical Research Consortium Small Aperture Telescope (ARCSAT) at Apache Point Observatory and at the 0.9m telescope at the West Mountain Observatory (WMO) of Brigham Young University. Due to the field coverage of the telescopes, we focused our survey on the northeast portion of the galaxy, centered at $\alpha = 15:09:11.34$ and $\delta = 67:15:51.7$. With the ARCSAT telescope, we obtained ~ 100 epochs, and at WMO, over 200 epochs were observed.

Standard data reduction techniques were implemented, and to standardize the magnitudes, Landolt standards ([2]) were observed. Photometry was performed using DAOPHOT/ALLSTAR packages ([6]), and period analysis was done primarily with the dataset collected at WMO. Period solutions were obtained using the Supersmoother program ([5]), which uses a running linear regression algorithm. For amplitude, we used a basic measurement of the difference between maximum and minimum, omitting outliers 2.5σ from the mean.

Table 1. Identified variable stars in the north portion of UMi dSph.

Star	α_{2000} (deg)	δ_{2000} (deg)	V	Period (d)	type
V5	227.48149	67.474992	19.69	0.766705	ab
V6	227.49143	67.464966	18.17	0.725528	AC
V7	227.44961	67.454614	19.61	0.690328	ab
V8	227.294	67.451651	19.70	0.553879	ab
V9	227.53442	67.419453	19.59	0.356460	c?
V10	227.58564	67.405209	19.69	0.617496	ab
V11	227.63938	67.417687	18.88	0.673431	AC
V12	227.63475	67.395875	19.65	0.771735	ab
V13	227.46745	67.403259	19.66	0.646050	ab
V19	227.53903	67.357643	19.67	0.341565	c
V24	227.54186	67.310734	19.83	0.301081	c?
V28	227.6731	67.278736	19.70	0.308163	c?
V29	227.62463	67.252691	19.73	0.409747	c?
V41	227.46443	67.232054	19.84	0.490488	ab
V42	227.59471	67.209778	19.74	0.646473	ab
V45	227.35121	67.207436	19.02	0.216662	?
V48	227.18208	67.218741	19.69	0.687258	ab
V49	227.18687	67.212797	19.73	0.415464	c?
V78	227.29384	67.38137	19.69	0.372640	c?
V79	227.38367	67.328828	19.70	0.313023	c?
V80	227.41875	67.3245	18.74	0.512738	?
v1540*	227.88001	67.426652	19.79	0.714490	ab
v1678*	227.19679	67.413053	19.75	0.336900	c?
v1895*	227.09781	67.386081	19.45	0.490887	ab
v2078*	227.83088	67.361948	19.73	0.719031	ab
v3176*	227.32619	67.236128	19.81	0.327060	c?

* Newly identified star.

3 RR Lyrae results

From the 543 objects identified and photometered, we find 22 RR Lyrae candidates. Cross-matching with the finding charts and variable star catalog of [4], we find 12 ab-type and 10 c-type RRL stars. We additionally find 2 ACs, V6 and V11 (using Nemeč's IDs). In Table 1, we provide our identified variable stars' IDs, equatorial coordinates (as determined from *astrometry.net*, [3]), mean *V* magnitude, period solution, and variable star type. The star ID is the same as in [4], unless it is denoted with an asterisk, then it is a newly identified star.

4 Curious case of V80

The variable star identified as V80 in [1, 4, 7] has an unclear classification. This star's variability appears real in our datasets from 2016. We find the amplitude of this star to be closer to the published value in [4], but the periodicity is longer than in any of the published literature. The period solution for V80 was 0.512738 days. We cannot conclusively classify this variable star at this time. Applying frequency analysis will help understand the nature.

5 Future Work

Additional data are expected to be collected in March 2017 and will cover the southern regions of UMi dSph that has been missed. With the fairly complete coverage of the pulsation cycle to many of the RRab stars, we will calculate the [Fe/H] metallicities through Fourier decomposition parameters. This work will allow us to obtain an independent measurement of the dSph galaxy's metallicity.

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