RR LYRAE VARIABLES IN THE LOCAL GROUP DWARF GALAXY NGC 147

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Abstract

We investigate the RR Lyrae (RRL) population in NGC 147, a dwarf satellite galaxy of M31 (Andromeda). We used both Thuan–Gunn g-band ground-based photometry from the literature and Hubble Space Telescope Wide Field Planetary Camera 2 archival data in the F555W and F814W passbands to investigate the pulsation properties of RRL variable candidates in NGC 147. These data sets represent the two extreme cases often found in RRL studies with respect to the phase coverage of the observations and the quality of the photometric measurements. Extensive artificial variable star tests for both cases were performed. We conclude that neither data set is sufficient to confidently determine the pulsation properties of the NGC 147 RRLs. Thus, while we can assert that NGC 147 contains RRL variables, and therefore a population older than ~ 10 Gyr, it is not possible at this time to use the pulsation properties of these RRLs to study other aspects of this old population. Our results provide a good reference for gauging the completeness of RRL variable detection in future studies.

Key words: galaxies: dwarf – galaxies: individual (NGC 147) – methods: analytical – methods: data analysis – stars: horizontal-branch – stars: Population II – stars: variables: other

Online-only material: color figure

1. INTRODUCTION

Local Group dwarf galaxies exhibit diversity in their star formation histories (Da Costa & Mould 1988; Grebel 1999). Most of these galaxies show evidence for intermediate age stars and some have even younger populations along with significant amounts of gas and dust. The broad red giant branch (RGB) morphology shown in their color-magnitude diagrams (CMDs) reflects a wide range of metallicities and/or ages, implying that these galaxies have experienced complex star formation histories. Despite their different and complex star formation histories, RR Lyrae (RRL) variables are believed to exist in most, if not all, dwarf galaxies in the Local Group. The existence of RRL populations in a given stellar system indicates that the system is older than ~ 10 Gyr. Furthermore, their pulsation properties and absolute magnitudes are correlated with their metallicities (Bono et al. 2003; Bono et al. 2007; Kunder & Chaboyer 2009). Therefore, detailed investigations of the physical properties of RRL variable stars are crucial to improve our understanding of the early stages of star formation in Local Group dwarf galaxies.

NGC 147 is one of the dwarf spheroidal (dSph) satellites of the Andromeda galaxy (M31). In terms of its morphology (see Table 1), NGC 147 is a typical dwarf elliptical or spheroidal galaxy. However, it is distinct from other dwarf galaxies in the Local Group, with the possible exception of Tucana (Fraternali et al. 2009), because NGC 147 is dominated by an old stellar population (Hodge 1989). There is a slight indication of intermediate age stars (e.g., extended asymptotic giant branch stars) concentrated in the central regions (Han et al. 1997), but their signature is weaker than the intermediate age stellar populations found in other Local Group dwarf galaxies. Furthermore, NGC 147 appears to show a complete deficit of gas and dust.

The presence of an RRL population in NGC 147 was reported by Saha et al. (1990, hereafter S90). They used Thuan–Gunn g-band ground-based photometry obtained from the Hale 5 m telescope equipped with the 4-Shooter CCD system to identify RRL variables in this galaxy. They found 32 RRL candidates and determined the distance modulus of NGC 147 to be (m − M)0 = 23.92 based on their mean apparent g-band magnitudes. Their periods and amplitudes were estimated by using a prototype of the phase dispersion minimization (PDM) method developed by Lafler & Kinman (1965), the so-called L−K method. Saha et al. (1990) did not present a comparison of the pulsation properties of these RRL candidates with those in other Local Group galaxies. One reason for this may be that the large photometric errors (> 0.15 mag) at the level of the horizontal branch (HB) of NGC 147 produced significant errors in the period determinations, especially for the shorter period RRLs (P < 0.4). However, the effect of the photometric errors on the period determination was not addressed because the L−K method ignores the photometric errors in the process of identifying the optimal period.

Saha et al.’s (1990) paper appears to be the only previous study of the RRL population in NGC 147. We are motivated to revisit the properties of these stars for two reasons. First, we have had good success in using a light-curve template-fitting algorithm (Layden & Sarajedini 2000) to determine the properties of RRLs such as periods, amplitudes, and mean magnitudes. This method includes the photometric errors in the analysis and has been streamlined and redesigned to be more user-friendly by Mancone & Sarajedini (2008). This will allow us to refine the determination of the RRL periods and place better constraints on the total number of such variables in NGC 147. Second, there are archival imaging data from the Hubble Space Telescope (HST) Wide Field Planetary Camera 2 (WFPC2) for NGC 147 that may allow us to update the list of RRLs published by S90. Although the WFPC2 data provide accurate photometry at the level of the HB in NGC 147, they exhibit poor phase coverage with a time baseline of ~0.4 days. However, it is still useful because it could help to identify the shorter period, lower amplitude RRL stars that may not have been detected by S90.

The next section describes the observational data sets that we will analyze. Sections 2 and 3 make it clear that neither the S90 data nor the WFPC2 data are ideal for the purpose.
Table 1
Physical Properties of NGC 147

| Property          | Value            | Reference                          |
|-------------------|------------------|------------------------------------|
| R.A.              | 00$^h$33$^m$11$^s$9 |                                   |
| Decl.             | +48$^\circ$30'24"9 |                                   |
| ($l, b$)          | 119.82, -14.25   |                                   |
| $V_r$             | $-193 \pm 3$ km s$^{-1}$ | Bender et al. (1991) |
| $m - M_{0}$       | 23.95            | Sharina et al. (2006)              |
| $M_{V,0}$         | -15.1            |                                   |
| $E(R - V)$        | 0.18 $\pm$ 0.03  | Schlegel et al. (1998)             |
| $A_V$             | 0.580            |                                   |
| $[\text{Fe}/\text{H}]_{\text{RGB}}$ | $-1.11 \pm 0.01$ | Nowotny et al. (2003)             |
| $[\text{Fe}/\text{H}]_{\text{GC}}$ | $-2.2 \pm 0.42$  | Da Costa & Mould (1988)            |

Table 2
WFPC2 Observing Log

| Data Set | Filter | Exp Time (s) | 24,50,000 – HJD |
|----------|--------|--------------|-----------------|
| u2ob0101t | F555W  | 2400         | 9890.01465      |
| u2ob0102t | F555W  | 1300         | 9890.06934      |
| u2ob0103t | F555W  | 1300         | 9890.08594      |
| u2ob0104t | F555W  | 1300         | 9890.13672      |
| u2ob0105t | F555W  | 1300         | 9890.15332      |
| u2ob0106t | F555W  | 2800         | 9890.21289      |
| u2ob0107t | F555W  | 2800         | 9890.27930      |
| u2ob0108t | F814W  | 1300         | 9890.33789      |
| u2ob0109t | F814W  | 1300         | 9890.35449      |
| u2ob010at | F814W  | 1300         | 9890.40527      |
| u2ob010bt | F814W  | 1300         | 9890.42188      |
| u2ob010ct | F814W  | 1300         | 9890.47168      |
| u2ob010dt | F814W  | 1300         | 9890.48828      |

of studying the RRLs in NGC 147, but they do complement each other nicely. As discussed in Section 4, it is important to carry out simulations to fully understand the biases and caveats inherent in the results obtained from each of the data sets. The conclusions are presented in Section 4 as well as the case for future work to better characterize the variable stars in NGC 147 and its M31 dwarf satellite cousin NGC 185.

2. OBSERVATIONS AND DATA REDUCTION

2.1. Ground-based Data

The $g$-band (Thuan & Gunn 1976) photometry of NGC 147 is available in data tables provided by S90. The target field, located 6' northwest of the galaxy’s center along the semimajor axis, was observed 15 times with 20 minute exposures in 1986, and 8 times with 30 minute exposures in 1987, both using the Hale 5 m telescope with the 4-Shooter CCD. The 30 minute exposures were obtained during four consecutive nights. The limiting magnitude of their photometry is $g = 26.5$, which is about 1.25 mag fainter than the HB magnitude of NGC 147. The photometric completeness of the HB stars (at $g \sim 25.5$) is 62% in the crowded regions and 72% in those that are less crowded. The photometric errors for the HB stars are $\sigma > 0.15$ mag, which is comparable to the amplitude of $c$-type or low-amplitude $ab$-type RRL variables. Bailey $ab$-type stars are fundamental mode pulsators which have a sawtooth-like, asymmetrical light-curve shape, while first-overtone $c$-type pulsators have sinusoidal light curves. RRL with $ab$-type (RRab) have longer periods ($0.5 \text{ days} < P < 1.2 \text{ days}$) than the $c$-type (RRc) stars ($0.2 \text{ days} < P < 0.5 \text{ days}$; Smith 1995)

2.2. Hubble Space Telescope Data

Observations taken with $HST$/WFPC2 of the outer regions of NGC 147 are available in the $HST$ archive (Han et al. 1997, program ID: GO-6233). The target field, located at 4' south of the galaxy’s center, was imaged seven times in F555W ($\sim V$) and six times in F814W ($\sim I$), with exposure times from 1300 s to 2800 s as detailed in Table 2. The time baseline of the data set spans 0.4 days. The observations were primarily intended to study the characteristics of the (nonvariable) stellar populations of NGC 147.
All of the WFPC2 images were photometered by using the HSTphot package (Dolphin 2000), which is designed for use on WFPC2 data. First, any image defects, such as bad pixels, cosmic rays, and hot pixels were removed by using the utility software included within HSTphot. Then, the photometric measurements were made on each image by running HSTphot in "point-spread function (PSF) fitting" mode. HSTphot uses a template-fitting FITLC method. In this and subsequent figures, it is apparent that a number of stars thought to be RRL variables could in fact be eclipsing or contact binaries.

Figure 3. Left panels show the RRL light curves phased using the period derived by Saha et al. (1990) via the L–K period determination method. The right panels show the same variables but phased using periods derived from the template-fitting FITLC method. In this and subsequent figures, it is apparent that a number of stars thought to be RRL variables could in fact be eclipsing or contact binaries.

Figure 1 shows the VI CMD of NGC 147 from the HST/WFPC2 data. The photometric limit reaches $V \sim 28.2$ mag. The broad RGB of NGC 147 primarily indicates a wide range of metallicity among the stellar populations in this galaxy. This figure also shows a blue horizontal branch (BHB) and a distinct instability strip gap which is the well-known location of RRL variable stars. We performed completeness tests of our photometry using HSTphot’s artificial star feature. This module creates a comparable number of artificial stars for each color-magnitude bin from the observed CMD and randomly distributes these in each of the original WFPC2 image. The artificial stars are photometered in exactly the same manner as the actual stars. Figure 2 illustrates the result of these completeness tests. At the magnitude of the HB ($V \sim 25.5$ mag), the completeness level is about 95%. Therefore, we do not expect photometric incompleteness to adversely affect the detection of RRL candidates identified in the WFPC2 data.

### Table 3

| Object | $P(LK)$ | $P(FITLC)$ | Type(LK) | Type(FITLC) |
|--------|---------|------------|----------|-------------|
| C1-V1  | 0.58543 | 24.65      | ab       | 24.60 EB    |
| C1-V2  | 0.49480 | 24.71      | ab       | 24.69 EB    |
| C1-V3  | 0.42978 | 25.05      | ab       | 24.95 EB    |
| C1-V4  | 0.72259 | 25.06      | ab       | 24.86 c     |
| C1-V5  | 0.38861 | 24.62      | c?       | 0.37888 25.20 ab |
| C1-V6  | 0.28260 | 24.46      | c?       | 0.64538 24.20 c |
| C1-V7  | 0.34835 | 24.55      | c?       | 0.41998 24.58 c |
| C1-V8  | 0.81660 | 24.95      | ab       | 0.84910 24.88 c |
| C1-V9  | 0.53655 | 25.04      | ab       | 0.53753 25.08 ab |
| C1-V10 | 0.86053 | 24.68      | ab       | 0.85044 24.86 ab |
| C1-V11 | 0.43104 | 24.80      | ab       | 0.43352 24.79 ab |
| C1-V12 | 0.27895 | 24.81      | c        | 0.55790 24.91 EB |
| C1-V13 | 0.71724 | 24.99      | ab       | 0.41037 24.95 ab |
| C1-V14 | 0.27355 | 25.11      | c        | 0.21888 25.04 EB |
| C3-V1  | 0.52933 | 25.44      | ab       | 0.51879 25.21 c |
| C3-V2  | 0.86729 | 25.25      | ab       | 0.83738 25.18 c |
| C3-V3  | 0.74508 | 24.54      | ab       | 0.66766 24.56 ab |
| C3-V4  | 0.60875 | 24.77      | ?        | 0.30549 24.80 c |
| C3-V5  | 0.54649 | 25.18      | ab       | 0.36870 25.37 ab |
| C3-V6  | 1.22297 | 24.84      | AC       | 0.76788 24.88 ab |
| C3-V7  | 1.23533 | 24.53      | AC       | 0.55284 24.57 ab |
| C3-V8  | 0.54194 | 24.54      | ab       | 0.53806 24.53 ab |
| C3-V9  | 0.69967 | 25.01      | ab       | 0.34991 24.88 c |
| C3-V10 | 0.67132 | 25.17      | ab       | 0.33587 25.36 ab |
| C3-V11 | 0.57346 | 24.69      | ab       | 0.45515 24.70 ab |
| C3-V12 | 0.71666 | 25.00      | ab       | 0.75819 24.96 ab |
| C3-V13 | 0.75816 | 24.70      | EB?      | 0.70529 24.65 c |
| C4-V1  | 0.77865 | 24.76      | ab       | 0.57333 24.68 ab |
| C4-V2  | 0.75304 | 25.58      | ab       | 0.59890 25.38 c |
| C4-V3  | 0.76366 | 25.38      | ab       | 0.40267 25.59 ab |
| C4-V4  | 0.46348 | 24.96      | ab       | 0.82539 25.02 c |
| C4-V5  | 0.77979 | 25.28      | ab       | 0.60954 25.02 c |
| C4-V6  | 0.64373 | 25.21      | ab       | 0.67994 25.30 c |
| C4-V7  | 0.57137 | 25.43      | ab       | 0.34560 25.52 ab |
| C4-V8  | 0.29731 | 25.22      | c        | 0.36375 25.08 EB |
| C4-V9  | 0.60459 | 25.35      | ab       | 0.55606 25.31 ab |

Note. * ab = ab-type RRL, c = c-type RRL, EB = eclipsing binary, and AC = anomalous Cepheid.

### 3. RR LYRAE PERIOD DETERMINATION

The previous study (Saha et al. 1990) used the Lafler–Kinman (L–K) algorithm (Lafler & Kinman 1965), a prototype of the PDM method for period determination. The L–K algorithm defines a test parameter, $\Theta$, the sum of the squares of the differences between two adjacent magnitudes rearranged in the ascending order of phases for each trial period. The algorithm then searches for the period that minimizes the test parameter. Since the L–K method uses only one free parameter (period) for the period optimization, the calculation is relatively simple, straightforward, and faster than other period finding routines. However, it does not take into account some important factors, such as the amount of photometric error. Large photometric errors can effectively mask intrinsic variability present in the
Figure 4. Same as Figure 3.

Figure 5. Same as Figure 3.

Figure 6. Same as Figure 3.

Figure 7. Same as Figure 3.
Figure 8. Same as Figure 3.

Figure 9. Same as Figure 3.

Figure 10. Same as Figure 3.

Figure 11. Same as Figure 3.
Figure 12. Comparison between periods determined from the L–K and FITLC methods using the g-band photometry of RRL candidates in NGC 147. The L–K periods are from Saha et al. (1990) while those from FITLC come from the present study. There appears to be little correlation between the two sets of values.

Figure 13. Results of RRL variable simulations based on the g-band photometry of Saha et al. (1990) with the L–K method are shown. The upper panel compares the input and output (recovered) periods while the lower panel shows the difference as a function of input period.

Second, the template-fitting method provides an assessment of the variable star classification based on the shape of the phased light curve. Whether the RRL is an ab-type or c-type naturally follows from the results of the method based on which template provides the best fit to the observational data.

3.1. Reanalysis of the Saha et al. Data

Given the advantages of template light-curve fitting over the L–K algorithm for cases where the number of observations is small, we have reanalyzed the g-band photometry of 32 RRL candidates in NGC 147 from S90 using the FITLC routine. Figures 3–11 show the best-fitting light curves for the RRL candidates from FITLC as compared with the results from S90. The actual periods determined by the two methods are compared in Figure 12 and listed in Table 3, which also shows the classification of each variable star and the mean magnitude. Overall, the resulting periods from the L–K and FITLC methods applied to the S90 g-band data bear little resemblance to each other. We found only six cases (C1-V9, C1-V10, C1-V11, C3-V8, C3-V12, and C4-V9) out of 32 RRLs, where L–K and FITLC agree reasonably well in both period and classification. However, we found that L–K periods tend to be longer than FITLC periods, especially in the short period (P < 0.6 days) and lower amplitude ranges (amplitude ≲0.75).

In order to further investigate the differences we see between the L–K method and FITLC, we have performed the following
set of simulations. We generated eighth-order Fourier decompositions of the template light curves of Layden (1998), six $ab$-types and two $c$-types, and calculated their Fourier parameters. With the functional forms of these eight light curves, we created synthetic RRL light curves with known periods and amplitudes that mimic the $g$-band observations of S90. We sampled each light curve at 23 different epochs (the maximum number in the S90 analysis) with measurement errors given by the mean value taken from the actual $g$-band data. Periods and amplitudes were randomly assigned to each synthetic RRL from reasonable period–amplitude ranges for typical RRL variables ($0.2 \text{ days} < P < 1.2 \text{ days}$, $0.2 \text{ mag} < \text{Amp} < 1.5 \text{ mag}$). In this way, the artificial RRL variables properly represent important observational conditions that can affect the period determination such as the time baseline, the number of observations, and the photometric errors. We then applied the L–K and FITLC methods to the synthetic light curves in exactly the same manner as our original period finding routines and compared the derived periods with the input ones.

Figures 13 (L–K method) and 14 (FITLC) illustrate the results of our simulations for the $g$-band observations of S90. They show that FITLC works better than the L–K method in finding periods using the S90 photometry; however, some systematic errors still remain in the FITLC results. The FITLC routine recovered $\sim 59\%$ of the input periods from the synthetic RRLs with a period error of $\pm 0.1 \text{ days}$, while the L–K method only recovered $\sim 15\%$ of the input periods with the same period error. Indeed, even though the $g$-band photometry of NGC147 from S90 covered a significant observational baseline ($\sim 4–5 \text{ days}$) and provided a reasonable number of observations ($\leq 23$ epochs), the period finding results are largely unreliable.
Figure 16. Same as Figure 15.

Figure 17. Same as Figure 15.
because of the relatively large errors in the photometry. If we reduce the errors by a factor of 2, then the recovery efficiency of the input periods from the FITLC routine is enhanced up to \( \sim 72\% \) but remains unchanged for the L–K method. We should note that the average photometric error of the \( g \)-band photometry at the level of the HB is \( \sim 0.2 \) mag. Even if we reduce the magnitude error by a factor of 2, most of the photometric data still exhibit errors of \( \sim 0.1 \) mag, which is still too large to facilitate accurate period determination. Thus, the properties of the RRL candidates derived from the \( g \)-band photometry must be interpreted with extreme caution.

3.2. Analysis of HST/WFPC2 Archival Data

As shown in Section 2.2, the HST WFPC2 data of NGC 147 are deep enough to provide accurate \( V \) magnitudes for RRL candidates. The average photometric error in the \( V \) band at the HB magnitude level \( (V \sim 25.5) \) is \( <0.05 \) mag. Therefore, unlike the \( g \)-band photometry of S90, period determination from the WFPC2 data should not be adversely affected by the photometric errors. However, the WFPC2 archival data for NGC 147 have a short observational baseline \( (\sim 0.4 \) days) with a small number of available epochs. The \( c \)-type RRLs, which have periods of \( \sim 0.2–0.4 \) days with relatively small amplitudes \( (\lesssim 0.3 \) mag), might be less affected by this short observational baseline.

Given these limitations of the data, we proceeded with caution in defining our set of candidate RRLs. First, we selected stars with a color-magnitude range \((-1 < (V-I) < 1, \text{ and} \ 24.5 < V < 26)\), shown as a rectangular box in Figure 1. Then, we calculated the reduced \( \chi^2 \) of the observed \( V \) and \( I \) magnitudes of each star as a variability index defined by the following formula:

\[
\chi^2 = \frac{1}{N_V + N_I} \times \left[ \sum_{i=1}^{N_V} \frac{(V_i - \bar{V})^2}{\sigma_V^2} + \sum_{i=1}^{N_I} \frac{(I_i - \bar{I})^2}{\sigma_I^2} \right].
\]

This diagnostic is distinct from the variability index of Welch & Stetson (1993) because the latter uses correlations in variability between different filter passbands. Stars with \( \chi^2 \) value greater than 2.0 were considered as variable candidates. Based on this criterion, 931 stars were selected. We applied the FITLC template light-curve fitting routine to the \( V \)–\( I \)-band observations of these variable candidates in order to find the best combination of period and amplitude. Of these, 36 RRLs (32 \( ab \)-type and four \( c \)-type) have colors and magnitudes that place them along the HB, where we would expect RRLs to be located. Figures 15–17 show the best-fitting light curves for these RRL candidates and Figure 18 illustrates their locations in the NGC 147 CMD. Table 4 gives their positions as measured from the world coordinate system information in the image headers as well as their individual mean magnitudes and colors. The mean \( V \) magnitude of all of the RRL candidates is \( \langle V \rangle = 25.40 \pm 0.16 \). Given the mean metallicity derived by Nowotny et al. (2003) and the RRL luminosity–metallicity relation from Chaboyer (1999), \( M(\text{RR}) = 0.23[\text{Fe/H}]+0.93 \), we find a distance modulus of \( (m-M)_0 = 24.16 \pm 0.16 \) by applying a reddening of \( E(B-V) = 0.18 \) from Schlegel et al. (1998). This value is in reasonable agreement with the distance quoted in Table 1 from Sharina et al. (2006) and the value of \( (m-M)_0 = 24.39 \pm 0.05 \) from Han et al. (1997); our distance places NGC 147 approximately 100 kpc in front of M31.

In order to assess the effects of the observing window on the FITLC periods derived from the WFPC2 photometry, we carried out synthetic light-curve simulations as we did on the
In this study, we present an investigation of the RRL population in the Local Group dwarf galaxy, NGC 147 using available time-series photometry from both the ground and *HST*. Based on our period finding analysis and artificial variable star tests, we draw the following conclusions.

1. The *g*-band photometry from the work of Saha et al. (1990) likely possesses an adequate observational baseline and available epochs. However, our simulations showed that the photometric errors at the level of the HB significantly hinder the accurate determination of the pulsation periods of the RRL candidates in NGC 147.

2. Our template light-curve fitting technique (FITLC) detected 36 probable RRL candidates from *HST*/WFPC2 archival data. However, our simulations reveal that the short observational baseline and small number of observations severely affect the accurate characterization of RRL periods longer than ∼0.4 days, which are essentially the *ab*-type RRLs.

3. The *g*-band photometry and the WFPC2 archival data analyzed herein present two extreme cases often found in period finding studies, good phase coverage but with large photometric errors, and high-quality photometry with poor phase coverage. Our investigation of these two extreme cases not only provides a good reference for interpreting the pulsation properties of RRL variables in other similar situations, but also calls attention to a strong need for new high quality time-series observations of NGC 147. Thus, while we can confidently assert that NGC 147 contains RRL variables, and therefore a population older than ∼10 Gyr, it is not possible at this time to use the pulsation properties of these RRLs to study other aspects of this old population.

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Table 4

Characteristics of RR Lyrae Candidates

| Object | R.A.(J2000.0) | Decl.(J2000.0) | \(V\) | \((V - I)\) |
|--------|---------------|---------------|--------|-----------|
| V18120 | 03 13.41      | 48 28 50.22   | 25.137 | 0.537     |
| V15719 | 03 11.18      | 48 28 06.05   | 25.072 | 0.753     |
| V16803 | 03 12.61      | 48 27 51.49   | 25.079 | 0.740     |
| V17600 | 03 13.28      | 48 28 23.10   | 25.224 | 0.529     |
| V18304 | 03 09.60      | 48 28 10.86   | 25.169 | 0.331     |
| V20325 | 03 09.83      | 48 28 11.68   | 25.293 | 0.278     |
| V20731 | 03 11.69      | 48 28 21.55   | 25.459 | 0.435     |
| V20834 | 03 11.69      | 48 28 50.55   | 25.309 | 0.588     |
| V22046 | 03 14.32      | 48 28 27.68   | 25.389 | 0.447     |
| V22251 | 03 13.13      | 48 27 45.58   | 25.431 | 0.204     |
| V22308 | 03 13.43      | 48 27 44.47   | 25.484 | 0.099     |
| V22660 | 03 13.26      | 48 28 37.32   | 25.392 | 0.155     |
| V23104 | 03 11.66      | 48 28 47.19   | 25.632 | 0.682     |
| V23505 | 03 14.28      | 48 28 22.03   | 25.388 | 0.519     |
| V24080 | 03 12.82      | 48 28 56.96   | 25.657 | 0.219     |
| V37537 | 03 14.89      | 48 27 32.23   | 25.161 | 0.636     |
| V38170 | 03 16.90      | 48 27 08.75   | 25.234 | 0.684     |
| V38302 | 03 19.96      | 48 27 53.65   | 25.300 | 0.727     |
| V38757 | 03 22.22      | 48 27 43.15   | 25.317 | 0.170     |
| V38944 | 03 15.98      | 48 27 20.24   | 25.303 | 0.538     |
| V39451 | 03 23.75      | 48 27 40.43   | 25.338 | 0.508     |
| V39591 | 03 17.03      | 48 28 01.65   | 25.368 | 0.596     |
| V39668 | 03 19.29      | 48 27 46.54   | 25.440 | 0.792     |
| V39906 | 03 21.73      | 48 27 35.56   | 25.435 | 0.420     |
| V40264 | 03 20.47      | 48 27 52.46   | 25.471 | 0.600     |
| V40315 | 03 20.74      | 48 27 36.23   | 25.510 | 0.596     |
| V40378 | 03 18.59      | 48 27 36.31   | 25.513 | 0.418     |
| V41094 | 03 18.34      | 48 27 10.21   | 25.568 | 0.412     |
| V41232 | 03 18.79      | 48 27 21.51   | 25.600 | 0.434     |
| V56535 | 03 14.15      | 48 26 39.45   | 25.395 | 0.516     |
| V56641 | 03 11.18      | 48 26 17.77   | 25.406 | 0.409     |
| V56868 | 03 14.99      | 48 25 42.19   | 25.399 | 0.329     |
| V57185 | 03 13.88      | 48 26 36.28   | 25.519 | 0.714     |
| V57231 | 03 14.95      | 48 25 51.15   | 25.498 | 0.650     |
| V57831 | 03 16.45      | 48 25 56.11   | 25.684 | 0.721     |
| V58117 | 03 14.23      | 48 26 14.76   | 25.639 | 0.310     |
