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The variability of carbon stars in the Sagittarius dwarf spheroidal galaxy*

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ABSTRACT

Context. Stars have been forming in massive dwarf spheroidal galaxies continuously for several Gyr. The detection of AGB carbon stars indicates that an intermediate-age population is present. Sagittarius, the most massive, contains some 100 carbon stars. Most of them are probably variable.

Aims. Using photometric monitoring we intend to detect long period variables among Sagittarius carbon stars. We should be able to identify mira variables, semi-regular and irregular variables, and to determine their period and age group.

Methods. We have obtained K and J images over four semesters. These images are centered on a sample of 27 photometrically identified C stars to follow their variation and determine their periodicity.

Results. We have established the period of 14 program stars and have identified 13 miras among them. From their periods we determined that most of them are in the 3−5 Gyr age group.

Conclusions. The known miras, distributed over a wide area within Sagittarius dwarf spheroidal galaxy (Sgr), belong to populations of various ages and, most probably, various metallicities.

Key words. stars: AGB and post-AGB – stars: carbon – stars: variables: general – galaxies: individual: Sagittarius dwarf spheroidal

1. Introduction

Sagittarius is unique among the Local Group members. It was discovered serendipitously by Ibata et al. (1994), and it was found that it is being torn apart by the gravitational forces of the Milky Way. Its exact distance is difficult to pinpoint because its stellar population is stretched out along the line of sight. A compilation of distance estimates of Sgr by Kunder & Chaboyer (2009) lists fifteen determinations ranging from 22 to 28.4 kpc. Ever since the discovery of Sgr, the globular cluster M54 was assumed to be located at its core with a distance matching the average distance of Sgr. This assumption has been recently challenge by Siegel et al. (2011) who put M54 ∼2 kpc in front of Sgr and pushed the dwarf galaxy to ∼29 kpc from the Sun. Sagittarius is now the second nearest galaxy to the Sun after the ultra-faint Segue 1 dwarf galaxy, located at 23 kpc. The Segue 1 galaxy was first believed to be a globular cluster (Belokurov et al. 2007), but radial velocities of its ∼100 stars indicate that it is a galaxy with a substantial amount of dark matter (Geha et al. 2009; Simon et al. 2011).

With an estimated absolute visual magnitude of $M_V \sim -14$, Sgr is the brightest dwarf spheroidal galaxy of the Local Group. It is more that twice as bright as Fornax and must have been even brighter before being disrupted by the Galaxy. Like Fornax and Leo I, the bulk of its stellar population is made of intermediate-age stars (Bellazzini et al. 2006). Intermediate-age stars are characterized by the presence of AGB stars and, among them, carbon stars. N-type stars, the cool C stars, are the brightest members of that population. The number of C stars in a galaxy is closely related to the mass of the system (Battinelli & Demers 2005). Among the Local Group dwarf galaxies the numbers of C stars range from a few units to several hundred. Mira and semi-regular (SR) variables make up a subset of the C stars.

The number of spectroscopically confirmed C stars associated with Sgr is at present rather small; Whitelock et al. (1999) list only 26 C stars, with only a few of them found to be variable. Lagadec et al. (2009) have spectroscopically identified six additional C stars in Sgr. Their membership is confirmed by their radial velocity. These stars were found to be miras and their period and light curve obtained.

Many more N-type C stars can now be photometrically identified with the 2MASS survey. We explain in the next section how we established a list of candidates to monitor their variability.

2. Targets and observations

The program stars were selected, independently of the Whitelock et al. (1999) list of Sgr carbon stars. From the 2MASS point source catalogue, we first produced a list of N-type carbon stars approximately located at the distance of Sgr. This is done following the well-established technique (Demers & Battinelli 2007) of selecting N-type C stars and obtaining a crude estimate of their distances. We assume that only N-type C stars have $(J-K)_0 > 1.4$. With this approach we have identified some 60 carbon stars over the major extent of Sgr as mapped by Mateo et al. (1998), and located roughly at the distance of Sgr, $(m-M)_0 = 16.9$ where the reddening is relatively low $E(B-V) = 0.15$ (Mateo et al. 1998). These Sgr C stars are bright

* Based on observations made with the REM Telescope, INAF, Chile.

Table 1. Coordinates of selected targets.

Id	RA	Dec	r°	$E(J-K)$	Cross Id
Sgr-1	18:22:16.5	−25:52:07	8.7	0.21	
Sgr-2	18:22:18.2	−29:37:47	7.2	0.18	
Sgr-4	18:29:20.3	−23:16:41	9.3	0.23	
Sgr-6	18:36:08.6	−23:57:20	7.9	0.18	
Sgr-7	18:38:04.1	−30:18:25	3.7	0.07	
Sgr-8	18:38:42.3	−27:22:25	4.8	0.15	
Sgr-9	18:39:36.3	−24:49:15	6.7	0.17	
Sgr-10	18:43:28.2	−27:31:48	4.0	0.12	
Sgr-11	18:47:19.1	−29:00:58	2.3	0.09	
Sgr-12	18:52:51.4	−30:34:59	0.5	0.16	
Sgr-13	18:53:29.4	−29:38:24	1.0	0.08	C2
Sgr-13a	18:53:41.0	−29:34:22	1.0	0.08	
Sgr-14	18:57:21.5	−29:07:54	1.5	0.10	UKST-16
Sgr-15a	18:59:35.3	−31:47:17	1.5	0.06	
Sgr-15	18:59:57.9	−31:44:28	1.5	0.06	
Sgr-16	18:59:59.1	−30:42:02	1.0	0.08	
Sgr-17	19:00:36.6	−31:23:27	1.4	0.06	
Sgr-18	19:02:23.3	−32:54:42	2.8	0.05	
Sgr-19	19:04:58.4	−31:42:43	2.4	0.05	
Sgr-20	19:08:08.2	−33:38:48	4.1	0.04	
Sgr-21	19:09:39.0	−29:56:56	3.2	0.07	W18
Sgr-22	19:11:07.3	−32:32:17	3.9	0.06	
Sgr-23	19:11:14.9	−31:53:10	3.7	0.06	W19
Sgr-23a	19:11:33.9	−31:51:27	3.7	0.06	
Sgr-24	19:15:58.1	−30:32:48	4.4	0.06	
Sgr-25	19:19:05.4	−30:54:26	5.1	0.04	
Sgr-26	19:31:38.5	−30:02:30	7.9	0.07	m50, W25

enough ($9 < K < 10.5$) to be easily observed with our small telescope described below. We then produced a list of variable star candidates by cross-identifying the selected N-type C stars with the DENIS database (Epchtein et al 1997). We compared the J magnitudes from the DENIS and 2MASS databases. Note that not all our 60 C stars have been observed by DENIS, its sky coverage is not complete. Twenty-six stars with $\Delta J > 0.15$ were selected as candidates for our observing program. Early in the observing program, two stars were dropped, Sgr-3 because its field contains a very bright star ($K = 0.3$ mag) that overwhelms the chip, and Sgr-5 because it blends with a much brighter star.

Program stars are listed in Table 1 along with their equatorial coordinates and their angular distance to the center of Sgr (r°). We adopt $\alpha = 18^{\rm h}55^{\rm m}19.5^{\rm s}, \delta = -30°32'43''$ (J2000.0) for the center of Sgr, as determined by Majewski et al. (2003) from a power law plus core fit. This more or less coincides with the globular cluster M54. The reddening in the direction of the targets is taken from Schlegel et al. (1998); we adopt their transformations $E(J-K) = 0.526E(B-V)$ and $A_K = 0.367E(B-V)$. The right column gives the cross identifications; all of them are from Whitelock et al. (1999), while m50 is a Galactic halo target observed by Battinelli & Demers (2012). While analyzing the images, three additional variable C stars were discovered in the fields of our targets. We add them to our list and name them Sgr-13a, Sgr-15a, and Sgr-23a.

The observations were secured with the Rapid Eye Mount (REM) a robotic 60 cm telescope located on La Silla. The telescope hosts two instruments, REMIR, an infrared imaging camera with a 512×512 array giving a scale of 1.221″ per pixel, and ROSS, a visible imager that contains a 1024×1024 CCD giving a scale of 0.575″ per pixel. The two cameras can observe simultaneously thanks to a dichroic placed before the telescope focus. The field of view is $10' \times 10'$. The Observatory is operated for INAF by the REM Team[1].

Observations were obtained every ∼15 days, weather permitting, during the long observing season of Sgr. One observation consists of two K' and two J exposures of 30 s each. The images were analysed with Sextractor (Bertin & Arnouts 1996). Since the differences between K' and K_s are of the order of a few hundredths, we omit the prime and the s. The NIR instrumental magnitudes are calibrated with 2MASS point source observations seen in the field. Battinelli & Demers (2012) discussed the accuracy achieved by our procedure. Since the Sgr targets are relatively bright the uncertainties in K and J are better than ±0.03.

3. Results

The J magnitudes of the program stars are plotted as a function of time in Fig. 1. To facilitate the amplitude comparison the Y axis covers 2 mag in J, unless the observed amplitude is larger than 2 mag. The fields of view in the direction of Sgr are often very crowded; some fields contain as many as 800 stars. When the seeing is poor, sometimes a target may be blended with one or more nearby stars. This explains why some stars have few observations.

3.1. Comments on selected program stars

A few of our targets, namely Sgr-13, 13a, 21 and 26 are among the Sgr AGB stars observed by Lagadec et al. (2008). No radial velocities to confirm their Sgr membership have been published, however.

Sgr-1 has a close companion that is often blended with it. When it is impossible to individually measure the two stars we attempted to remove the magnitude of the companion using its 2MASS J or K magnitude. This operation did not work and we obtained magnitudes for Sgr-1 that are too bright. Keeping only the J magnitudes obtained when Sgr-1 is well isolated (see Fig. 1) we conclude that it is a low-amplitude irregular variable.

Sgr-6 is on the outskirts of the globular cluster M22. It also has a nearby companion, but the companion is fainter than Sgr-6. They are never well separated. Sgr-6 does not show any pronounced light variations.

Sgr-10 is between two stars of similar brightness and quite often just cannot be measured alone. For most of the 2012 observations the three stars are blended, Sextractor identified and measured the three stars. However, even with well-calibrated magnitudes we obtained magnitudes for the companions that differ by ∼0.2 mag from their 2MASS magnitudes. It is, therefore, impossible for us to obtain a reliable magnitude estimate of Sgr-10 and its surrounding stars. This explains why we have so few data points for the object. They do show that Sgr-10 is a large amplitude variable.

Sgr-11 also has two nearby stars of similar brightness but the two companions are farther away than those of Sgr-10. Again we had to reject some poor seeing observations.

Sgr-13 Whitelock et al. (1999) classify this star as a mira with a period of 228 days. It has been confirmed spectroscopically to be a C star by McDonald et al. (2012).

Sgr-21 and Sgr-23 are both classified as SR by Whitelock et al. (1999).

Sgr-26 was previously identified by Battinelli & Demers (2012) as m50. In Fig. 2 we display the J magnitude and

[1] http://www.rem.inaf.it

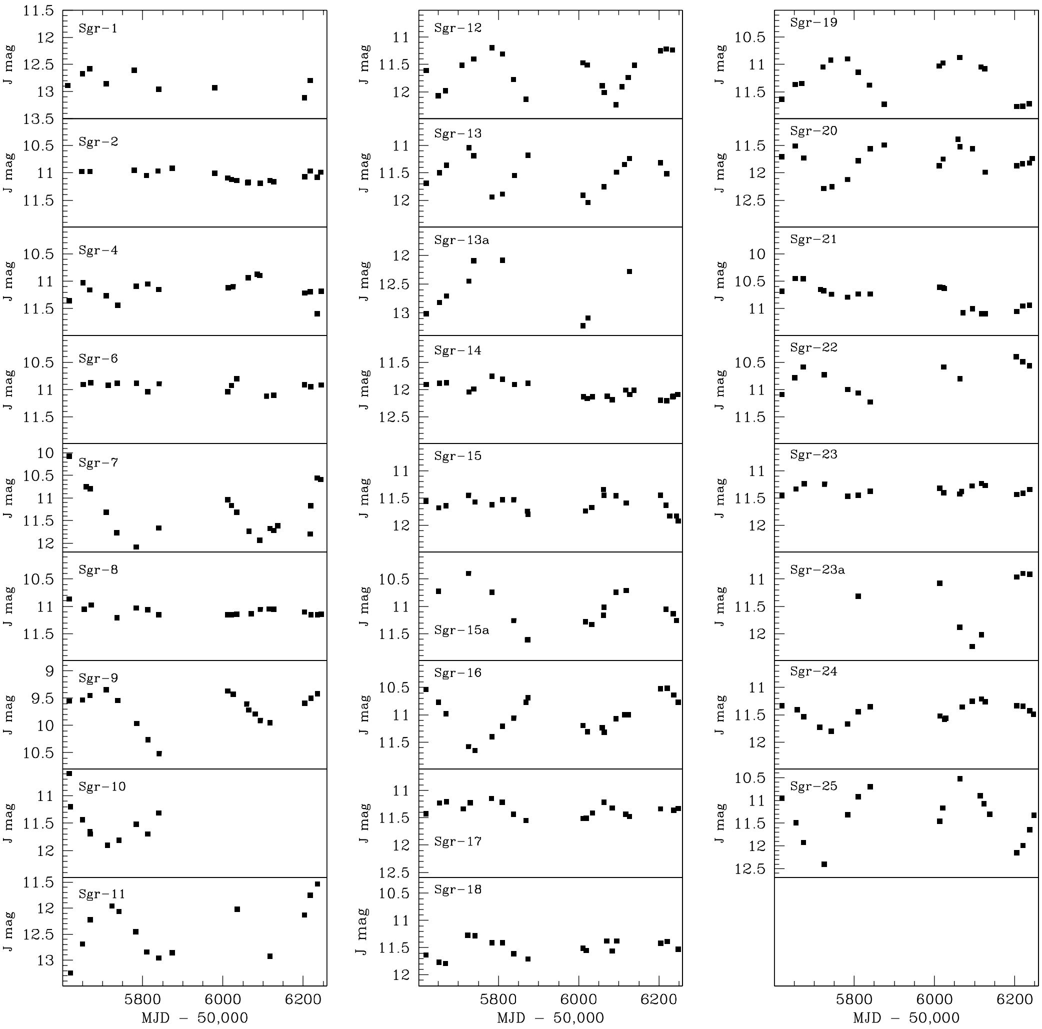

Fig. 1. J magnitude light variations of the program stars. Note that the magnitude axis covers no less than two magnitudes.

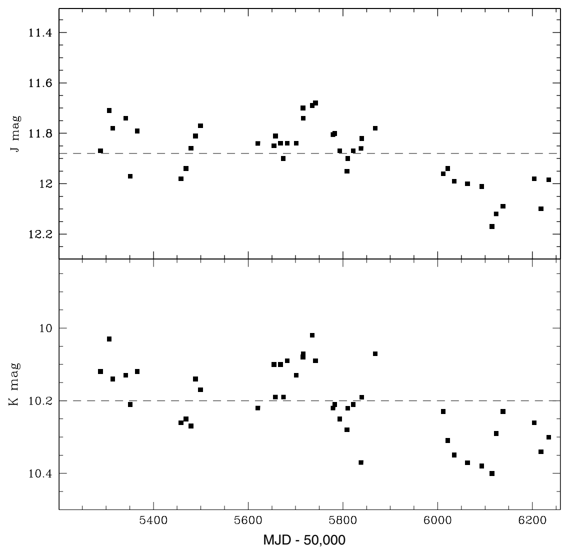

Fig. 2. J and K magnitude light variations of Sgr-26. Here we combine two data sets. The dashed lines correspond to the overall mean magnitude.

the K magnitude variations of Sgr-26 combining the two data sets, both obtained with the REM telescope. The star has been monitored for over one thousand days. It varies in an irregular fashion, with a K amplitude less than 0.4 mag, but shows a secular dimming at the present epoch. Whitelock et al. (1999) classify this variable a mira, but our J and K observations do not confirm this classification.

3.2. Period search

We search for periodicity using the J magnitudes because variables have a larger amplitude in J than in K. A simple sine curve is fitted to the data points. The quality of the fit is defined by the χ^2 parameter which corresponds essentially to the mean squared deviation between the observed points and the fitted sine curve. We adopt the period yielding the smallest χ^2. We are confident that the accuracy of the adopted periods is better than 10 days. Periods are seen to fluctuate within this range as we add a new data point. A second method was also attempted, the Phase Dispersion Minimization code (Stellingwerf 1978). Periods found with this approach did not produce better light curves. We cannot, obviously, determine periods larger than the time interval covered by our observations. We do not see long secular trends which would suggest periods of 600+ days, except for Sgr-26.

Table 2 gives the time interval (days) covered by the observations (ΔT), the periods found (in days), the χ^2 parameter

Table 2. Period and mean magnitudes of targets.

Id	ΔT	P	χ^2	$\langle K\rangle$	$\langle J\rangle$	ΔJ	ΔK	Classification
Sgr-1	605			10.33	12.82	0.4	0.4	low amp. irregular
Sgr-2	596			9.40	11.06	0.3	0.2	low amp. irregular
Sgr-4	628			9.50	11.15	0.6	0.4	irregular
Sgr-6	593			10.13	10.94	0.3	0.4	low amp. irregular
Sgr-7	627	330	0.08	9.40	11.30	2.0	0.6	Mira
Sgr-8	628			9.26	11.09	0.3	0.2	not variable?
Sgr-9	619	299	0.18	8.40	9.69	1.2	0.9	Mira
Sgr-10	405			9.60	11.58	1.2	0.5	large amp. variable
Sgr-11	616	258	0.10	9.95	12.40	1.75	0.9	Mira
Sgr-12	614	210	0.11	10.05	11.64	1.0	0.4	Mira
Sgr-13	518	227	0.20	9.85	11.52	1.0	0.5	Mira
Sgr-13a	506	396	0.04	9.85	12.64	1.0	0.5	Mira
Sgr-14	627			10.30	12.03	0.45	0.35	low amp. irregular
Sgr-15a	593	398	0.15	8.80	11.07	1.2	0.8	Mira
Sgr-15	629			9.90	11.62	0.6	0.8	low amp. irregular
Sgr-16	629	299	0.11	9.45	11.01	1.1	0.5	Mira
Sgr-17	629			9.62	11.35	0.4	0.3	variable low amp.
Sgr-18	629			9.82	11.45	0.5	0.5	variable
Sgr-19	618	316	0.07	9.50	11.28	0.8	0.4	Mira
Sgr-20	625	210	0.11	10.10	11.78	0.9	0.6	Mira
Sgr-21	617			9.01	10.79	0.7	0.3	variable
Sgr-22	475	257	0.08	9.37	10.78	0.8	0.4	Mira
Sgr-23	618			9.71	11.36	0.3	0.45	variable
Sgr-23a	428	225	0.02	9.87	11.41	1.35	0.5	Mira
Sgr-24	627	280	0.32	9.63	11.45	0.6	0.3	semi regular
Sgr-25	628	241	0.06	9.50	11.37	2.0	0.8	Mira
Sgr-26	946			10.19	11.88	0.6	0.4	low amp. irregular

indicating the quality of the sine fit, the mean K and J magnitudes of the light curve, the J and K amplitudes, and our classification. Following the Whitelock (2012) classification, we consider any periodic variable with a K amplitude larger than 0.4 mag to be a mira variable. Even for genuine large amplitude variables the χ^2 can be large if the light curve does not repeat well from cycle to cycle. As a rule, we can says that if χ^2 is greater than ≈0.15 the light curve shows a substantial amount of scatter.

4. Discussion

4.1. PL relation and distances

We present in Fig. 3 the period-luminosity (PL) relation of the known Sgr mira variables. Black squares correspond to our observations, while the star symbols are six miras that belong to Sgr because of their radial velocities (Lagadec et al. 2009). The circle represents Sgr-9, which appears from its apparent magnitude, to be located in front of Sgr. Although, miras which lie above the PL relation do exist, they may be experiencing hot-bottom burning (Whitelock 2012) or be pulsating in the first overtone. The second possibility seems to be ruled out because the K amplitude of Sgr-9 is ~0.6 mag, too large for an overtone pulsator.

We have determined the $\langle K\rangle$ of Lagadec's miras from the published K mag curves. For both sets, the mean magnitudes are corrected for the reddening (Schlegel et al. 1998). Their $\langle K\rangle$ are also colour corrected using the Ita & Matsunaga (2011) relation. The line corresponds to the LMC miras PL relation established by Whitelock et al. (2008) adjusted to our black squares, assuming 18.50 as the distance modulus for the LMC (contrary to 18.39 adopted by Whitelock et al. 2008). The fit yields a distance modulus of 17.01 (25.2 kpc), a value in reasonable agreement with the currently accepted distance for Sgr. Hundreds of giants in the direction of Sgr have published radial velocities; however, large programs such as the one of Frinchaboy et al. (2012) or Giuffrida et al. (2010) target K and M giants. Very few C stars have radial velocities to confirm their Sgr membership.

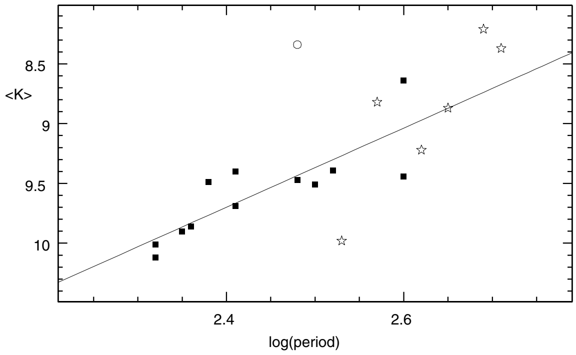

Fig. 3. Period-luminosity relation of the LMC miras is fitted to the newly identified miras (black squares) toward Sgr. Lagadec et al. (2009) (shown as stars) and Sgr-9 (open circle) are excluded from the fit.

Table 3. Distances of our miras and the Lagadec et al. miras.

Id	D(kpc)	Id	D(kpc)	Id	D(kpc)
Sgr-7	27.9	Sgr-16	26.9	L-3	27.1
Sgr-9	16.1	Sgr-19	28.6	L-7	23.8
Sgr-11	26.9	Sgr-20	28.4	L-9	23.2
Sgr-12	27.0	Sgr-22	23.5	L-15	30.4
Sgr-13	26.7	Sgr-23a	26.9	L-18	21.3
Sgr-13a	32.4	Sgr-25	23.4	L-29	37.3
Sgr-15a	22.6				

The miras represented by stars are excluded in the P-L fit because most of them have periods larger than 400 days. The Whitelock et al. (2008) PL relation is not well calibrated for miras with $P > 400$ days. Furthermore, their colour corrections are poorly determined. These stars certainly have a substantial colour correction because they are extremely red, two of them with $(J - K) > 4.0$. Moreover, only one $(J - K)$ observation is published for each mira rather than their mean colour. Mira Sgr-9 is also excluded from the fit. Table 3 lists the distances of the newly discovered miras, calculated following the procedure, described above. We also list the Lagadec et al. (2009) miras with their distances calculated in the same way, keeping in mind the above mentioned caveat.

The sky distribution of the miras, listed in Table 3 and displayed in Fig. 4, reveals that both L-29 and Sgr-9 are located in the outer periphery of the 20° × 20° field. There is no obvious East-West distance gradient among these variables. The square near the center represents the 1° × 1° area observed by Bellazzini et al. (2006) where they established that the bulk of the stars are older than 5 Gyr.

4.2. Period distributions

In recent years evidence has accumulated suggesting that the period of an O-rich or C-rich mira is related to its mass and its age. Long period miras are expected to have high-mass progenitors, thus belonging to a younger population (Iben & Renzini 1983). Feast (2009) briefly summarized the period-age relationship. Evidence comes from the kinematics of miras around the Sun (Feast et al. 2006) and the study of LMC globular

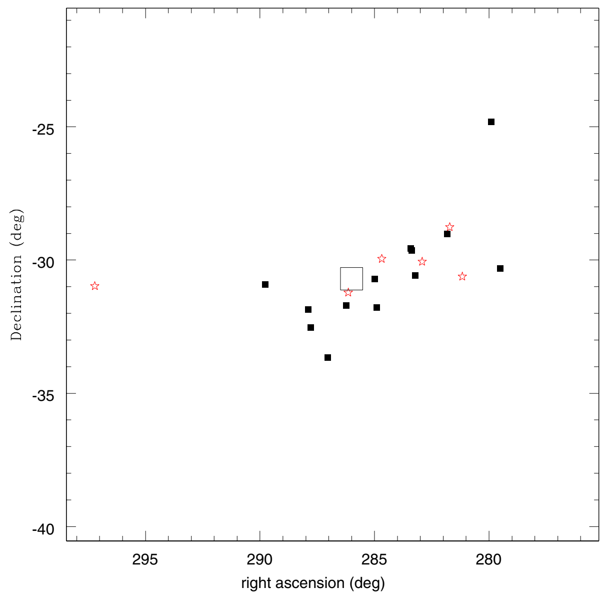

Fig. 4. Sky distribution of our miras (black squares) and Lagadec et al. miras (red stars). The field is $20^\circ \times 20^\circ$. It is interesting to note that the two outer miras, L-29 on the far left and Sgr-9, on the upper right, have distances deviating the most from the canonical distance of Sgr. The big square indicates the $1^\circ \times 1^\circ$ field observed by Bellazzini et al. (2006).

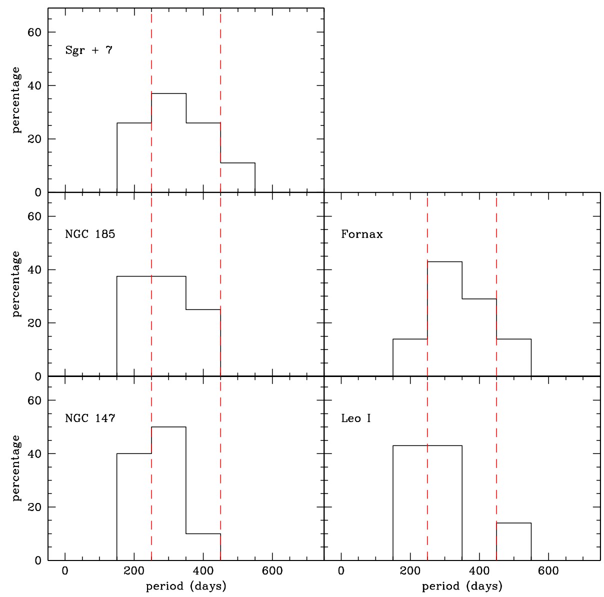

Fig. 5. Comparison of the period distributions of C-rich miras. The dashed lines define the three age groups described in the text.

clusters, of known age, containing miras (Nishida et al. 2000; van Loon et al. 2003; Kamath et al. 2010). Periods of miras in dwarf spheroidal galaxies are also compatible with the known star formation history of these galaxies (Menzies et al. 2011). Essentially, low-mass old giants have short periods, while young ones (<1 Gyr) have periods well over 500 days. Thus, the detection of the variability and the period determination of the Sgr C stars will provide additional information on the age distribution of its stellar populations

Therefore, the period of a mira can be used as a proxy of its age, as suggested by Habing & Whitelock (2004). Hereafter, we adopt their period/age groups: miras with $P < 255$ days are older than ~5 Gyr; variables with periods between 255 and 450 days are of intermediate age, between 1 and 3 Gyr; longer periods correspond to miras of 1 Gyr or younger. There is, however, a caveat to this age-period approach that must be mentioned. Cioni et al. (2001) and also Feast et al. (1989) have observed that the period distributions of C-rich and O-rich miras in the Large Magellanic Cloud are not the same. There are more O-rich miras among the short period variables. Lorenz et al. (2011) have also seen such dichotomy among the miras of NGC 185. For this reason, we shall select only the C-rich miras for the following comparison.

The effect of metallicity on the period of a mira is somewhat uncertain; very little has been done to investigate this relationship. Using O-rich miras and SR variables in globular clusters, Feast & Whitelock (2000) established a maximum period versus metallicity relation. Since globular cluster stars are old, 96% of the Feast & Whitelock (2000) sample have $P < 255$ days. We do not know whether this trend extends to longer periods and whether C-rich variables also follow such a trend. We are, therefore, obliged to neglect the metallicity effect for the time being.

In Fig. 5, we compare the mira period distributions in Sgr and in dwarf galaxies without current star formation. The upper-left panel shows the period distribution of our 13 miras in Sgr. We add the six miras identified by Lagadec et al. (2009) and the one discovered by Whitelock et al. (1999); these added miras are C-rich stars. Data for the dwarf spheroidal galaxies are: Leo I, Menzies et al. (2010); Fornax, Whitelock et al. (2009); NGC 185 and NGC 147, Lorenz et al. (2011). Following Soszyński et al. (2009), we consider the last two to be mira variables with $\Delta I > 0.8$. The C-rich miras are selected by cross identifying the variables with the samples of C stars in these galaxies identified with narrow-band observations by Battinelli & Demers (2004a,b).

As expected for galaxies with very little or no current star formation, few if any long period miras are seen. In Leo I, Fornax, and Sgr there has been significant star formation over the whole period of 1−12 Gyr. We see that the period distribution of miras in Sgr is similar to the distribution of Fornax, a slightly less massive galaxy. Fornax is a galaxy with an interesting star formation history. Deep Hubble observations (Siegel et al. 2006) have revealed an amazing array of stellar populations of various ages and abundances. Similarly, Giuffrida et al. (2010) have detected several populations of different metallicities and presumably ages in a few fields in Sgr. According to Bellazzini et al. (2006) the mean age of the population in the central region of Sgr is larger than 5 Gyr with a best estimate of 8 ± 1.5 Gyr. Sagittarius also has an impressive number of RR Lyrae stars (Kunder & Chaboyer 2009) indicating the presence of a much older population. Since our mira survey covers a large area of Sgr, the presence of different ages is expected.

The large area VVV survey (Saito et al. 2010) is likely to yield dozens of miras in Sgr. This will certainly allow us to obtain a better representation of the age distribution of its stellar population than the presently limited number of variables can give.

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References

Battinelli, P., & Demers, S. 2004a, A&A, 417, 479
Battinelli, P., & Demers, S. 2004b, A&A, 418, 33
Battinelli, P., & Demers, S. 2005, A&A, 442, 159
Battinelli, P., & Demers, S. 2012, A&A, 544, A10
Bellazzini, M., Correnti, M., Ferraro, F. R. et al. 2006, A&A, 446, 1
Belokurov, V., Zucker, D. B., Evans, N. W., et al. 2007, ApJ, 654, 897
Bertin, E., & Arnouts, S. 1996, A&AS, 117, 393
Cioni, M.-R. L., Marquette, J.-B., Loup, C., et al. 2001, A&A, 377, 945
Demers, S., & Battinelli, P. 2007, A&A, 474, 35
Epchtein, N., de Batz, B., Capoani, L., et al. 1997, Messenger, 87, 27
Feast, M. W. 2009 in AGB Stars and Related Phenomena, eds. T. Ueta, N. Matsunaga, & Y. Ita, 48
Feast, M., & Whitelock, P. 2000, in The Evolution of the Milky Way: Stars versus Clusters, eds. F. Matteucci, & F. Giovannelli (Dordrecht: Kluwer), 229
Feast, M. W., Glass, I. S., Whitelock, P. A., & Catchpole, R. M. 1989, MNRAS, 241, 375
Feast, M. W., Whitelock, P. A., & Menzies, J. W. 2006, MNRAS, 369, 791
Frinchaboy, P. M., Majewski, S. R., Muñoz, R. R., et al. 2012, ApJ, 756, 74
Geha, M., William, B., Simon, J. D., et al. 2009, ApJ, 692, 1464
Giuffrida, G., Sbordone, L., Zaggia, S., et al. 2010, A&A, 513, A62
Habing, H. J., & Whitelock, P. A. 2004, in Asymptotic Giant Branch Stars, eds. H. J. Habing, & H. Olofsson (Springer), 8
Ibata, R. A., Gilmore, G., & Irwin, M. J. 1994, Nature, 370, 194
Iben, I., & Renzini, A. 1983, ARA&A, 21, 271
Ita, Y., & Matsunaga, N. 2011, MNRAS, 412, 2345
Kamath, D., Wood, P. R., Soszyński, I. et al. 2010, MNRAS, 408, 522
Kunder, A., & Chaboyer, B. 2009, AJ, 137, 4478
Lagadec, E., Zijlstra, A. A., Matsuura, M. et al. 2008, MNRAS, 383, 399
Lagadec, E., Zijlstra, A. A., Sloan, G. C. et al. 2009, MNRAS, 396, 598
Lorenz, D., Lebzelter, T., Nowotny, W. et al. 2011, A&A, 532, A78
Majewski, S. R., Skrutskie, M., Weinberg, M. D., & Ostheimer, J. C. 2003, ApJ, 599, 1082
Mateo, M., Olszewski, E. W., & Morrison, H. L. 1998, ApJ, 508, L55
Mateo, M., Olszewski, E. W., & Walker, M. G. 2008, ApJ, 675, 201
McDonald, I., White, J. R., Zijlstra, A. A., et al. 2012, MNRAS, 427, 2647
Menzies, J. W., Whitelock, P. A., Feast, N. W., & Matzunaga, N. 2010, MNRAS, 406, 86
Menzies, J. W., Feast, M. W., Whitelock, P. A., et al. 2011, MNRAS, 414, 3492
Nishida, S. Tanabé, T., Nakada, Y., et al. 2000, MNRAS, 313, 136
Saito, R., Hempel, M., Alonso-Garcia, J., et al. 2010, Msngr, 141, 24
Schlegel, D., Finkbeiner, D., & Davis, M. 1998, ApJ, 500, 525
Siegel, M. H., Majewski, S. R., Law, D. R., et al. 2011, ApJ, 743, 20
Simon, J. D., Geha, M., Minor, Q. E., et al. 2011, ApJ, 733, 46
Soszyński, I., Udalski, A., Szymański, M. K., et al. 2009, Acta Astrom., 59, 239
Stellingwerf, R. F. 1978, ApJ, 224, 953
van Loon, J. Th., Marshall, J. R., Matsuura, M., & Zijlstra, A. A. 2003, MNRAS, 341, 1205
Whitelock, P. A. 2012 AA&SS, 341, 123
Whitelock, P., Menzies, J., Irwin, M. J., & Feast, M. W. 1999, The Stellar Content of Local Group Galaxies, eds. P. Whitelock, & R. Cannon (San Francisco: ASP, CA.), IAU Symp. 192, 136
Whitelock, P. A., Feast, M. W., & van Leeuwen, F. 2008, MNRAS, 386, 313
Whitelock, P. A., Menzies, J. W., Feast, M. W., et al. 2009, MNRAS, 394, 795