Photometric Variability of Be/X-ray-Pulsar Binaries in the SMC

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We have studied the photometric variability of ten SMC Be/X-ray pulsars using MACHO and OGLE-II data. For some of these systems we have found periodic behavior, including orbital outbursts and/or nonradial pulsations (NRP) of the Be star. For others we were unable to identify any clear photometric periodicity, although their long-term light curves show significant structure. We present periodograms, phase dispersion minimization (PDM) variances, and folded light curves for the systems which exhibit periodic photometric variability.

Subject headings: X-rays: binaries – stars: Be – (stars:) pulsars – stars: variable – stars: individual: XMMU J005152.2−731033 RX J0051.8−7231 RX J0052.1−7319 CXOU J005323.8−722715 XMMU J005605.2−722200 XMMU J005920.8−722316 CXOU J010102.7−720658 SAX J0103.2−7209 RX J0103.6−7201 RX J0105.1−7211
1. Introduction

The Be/neutron-star systems are an important subclass of high-mass X-ray binaries. These systems are particularly numerous in the Small Magellanic Cloud where about four dozen are known (Coe et al. 2005). Many are transient X-ray sources, and a large fraction have been shown to be X-ray pulsars (e.g. Coe et al. 2005, Liu et al. 2005, Haberl & Pietsch 2004, and references therein).

The optical identifications for these sources depend on accurate X-ray positions which have been greatly improved with data from Chandra and XMM-Newton. Two valuable sources of optical data for Magellanic Cloud systems are the MACHO and OGLE-II surveys (e.g. Alcock et al. 1999, Udalski et al. 1997, Zebrun et al. 2001, Szymanski 2005) that provide regular photometric data in V, R (MACHO) and I (OGLE-II) over many years. For SMC sources the identification with Be stars is more secure if they are also included in the catalogue of Hα emission-line stars of Meyssonnier & Azzopardi (1993; hereafter designated as [MA93]).

In previous papers we have studied the photometric properties of a sample of Magellanic Cloud X-ray binaries (e.g. Schmidtke et al. 2004, Schmidtke & Cowley 2005a). In this paper we present results for ten more Be/X-ray pulsars in the SMC. The sources studied were selected both on the basis of availability of longterm photometry and because they lack previous optical studies.

2. Analysis of Optical Data from the MACHO and OGLE-II Projects

As in our earlier work, we have relied on photometric data from the MACHO and OGLE-II surveys. We have transformed the ‘blue’ and ‘red’ instrumental MACHO magnitudes into standard V and R colors (see Alcock et al. 1999). Each data set, or portion
thereof, was flattened (prewhitened) to remove longterm changes in the mean brightness level by fitting a low order polynomial to the data. In sources which show large longterm variations (ones we call “swoopers”) the light curve can only be flattened in segments, and there are often parts that can’t be flattened at all because the slope of variation is too steep or irregular. The resulting light curve segments are then analyzed using the method of Horne & Baliunas (1986). Often these systems show periodic “outbursts”, thought to be caused by interaction between the neutron star and the Be star’s disk near periastron passage. In such cases the Horne & Baliunas method may not be the best way to search for periods, since it assumes sinusoidal variations. Thus, for some systems we also used the phase dispersion minimization (PDM) technique described by Stellingwerf (1978). This method can identify periods in a light curve whose shape is not sinusoidal, but instead is characterized by recurring outbursts.

Table 1 lists the X-ray sources studied and includes the MACHO coordinates of the optical counterpart, the MACHO and OGLE-II identification numbers, and other information about the systems. In the text the sources we studied are listed in order of right ascension for ease in locating the discussion about them. Coe et al. (2005) have introduced a useful identification number for Small Magellanic Cloud pulsars which avoids the confusion of multiple X-ray names. They use SXP followed by the pulse period in seconds (e.g. SXP15.3 or SXP202), and they give a convenient cross listing of names (their Table 1). For all the systems studied here we have included the SXP number. In addition, Coe presents finding charts for most of the SMC pulsars on his web site\(^1\). For the systems we have studied, we have confirmed his identifications are the same as ours.

In an earlier paper on SMC pulsars (Schmidtke & Cowley 2005a), we showed that some Be/pulsars exhibit nonradial pulsations (NRP) with periods typically less than a day.

\(^{1}\)http://www.astro.soton.ac.uk/~mjc/smc
Therefore, in all cases we have not only searched for orbital periods, but also for pulsation periods. Our searches covered the period range from 0.2 to 1000 days using a variety of techniques and subsamples of the data.

Table 2 lists the periods found for some of the Be/pulsar systems. For a few systems possible periods are only given in the text, but not included in the table, because we think they need further verification. There are other sources for which we found no clear photometric periods in spite of detailed searches of the entire data set or subsections of it. In the section below we give details about the analysis of each source.

3. Individual Be/X-ray Pulsar Systems

3.1. XMMU J005152.2−731033 = RX J0051.9−7311 = SXP172

This X-ray source was identified with a Be star in the SMC by Cowley et al. (1997; their “Star 1”; also [MA93]504). Yokogawa et al. (2000) later found this source (then named AX J0051.6−7311) to show 172.4 s X-ray pulsations. Haberl & Pietsch (2004) also detected the pulsar and gave its pulse period as 172.21±0.13 s.

The longterm OGLE-II light curve (Fig. 1) shows the source undergoes slow dips and rises. The MACHO data have several problems. The west-pier \( V \) data have many ‘dropouts’ and hence are not usable. \( R \) data are only available when the telescope was east of the pier. Hence, the longterm MACHO light curves are not continuous, making periods difficult to identify. When only east-pier data were studied, no clear periods were found in either \( V \) or \( R \), and additionally none were found in any subset of the MACHO data.

However, OGLE-II \( I \) data reveal a period of 69.9±0.6 days (Schmidtke & Cowley 2005b). We assume this is the orbital period, although one might have expected a somewhat longer orbital period based on Corbet’s (1984) \( P_{\text{pulse}}/P_{\text{orb}} \) relation. Fig. 1 shows the
PDM and periodogram, which are similar to those seen in some other Be/X-ray systems. Although the strongest peaks in the periodogram are at 1/2 and 1/3 the true period, the PDM variance is minimized at 69.9 days. The 69.9-day folded light curve (Fig. 1) shows "outbursts" lasting a few tenths of the period, with an average amplitude of $\sim 0.02$ mag. However, at some epochs the outbursts are more prominent. In Fig. 1 we have superimposed observations from the strongest outburst on the mean folded light curve to show how much the amplitude varies. We have also searched for short periods (i.e. less than 2 days), but we found nothing significant.

Laycock et al. (2005) report a period of $P_X=67\pm5$ days based on several X-ray outbursts. This 67-day period is in acceptable agreement with our optical period, considering their analysis is based on weekly monitoring. We note that their Table 6 lists a value of $P(\text{orb})=147\pm24$ days, rather than the 67-day value given in their text.

### 3.2. RX J0051.8−7231 = SXP8.88

This variable X-ray source, also known as 1E0050.1−7247, was found to be a pulsar by Israel et al. (1997). Although there is some uncertainty about its exact position, the optical counterpart is thought to be the Be star [MA93]506 (which is also Star #2 of Stevens et al. 1999). Fig. 2 shows its longterm optical light curve from both MACHO and OGLE-II data. Its irregular "swooping" behavior continued during OGLE-III observations, as shown by Coe et al. (2005). They suggest that this source may be the same as SXP16.6, since neither source has a well-defined position. However, Laycock et al. (2005) argue against this interpretation.

From MACHO $R$ data, Coe et al. (2005) derived $P_{\text{orb}}=185\pm4$ days. However, since the calibration of east- and west-pier data is not always the same, this can introduce a half-year
pseudo-period. Hence, we have processed data from the two pier configurations separately and merged the data sets after prewhitening. Using this technique, we did not find the 185-day period. We suspect that it is an artifact of slightly different calibrations for the east- and west-pier data.

We have also subdivided both OGLE-II and MACHO photometry into time segments. In the segment near the start of OGLE-II observations (MJD 50600-50800) there is a weak periodicity at $P=33.4\pm1.0$ days. This appears to be caused by several small outbursts (perhaps near periastron passage, with amplitudes varying from orbit to orbit). These outbursts are marked on the inset of Fig. 2. Although these high points are from several different orbital cycles, there is no evidence of this period in any of the MACHO data. New data would be needed to confirm this possible periodicity. Corbet et al. (2004) analyzed X-ray outbursts from this source and found $P_X=28.0\pm0.3$ days, which is in general agreement with the possible 33-day optical period.

3.3. RX J0052.1−7319 = SXP15.3

This transient source was found to be a pulsar by Finger et al. (2001). It was optically identified with a Be star by Covino et al. (2001; their “Star A” which is also [MA93]552). The longterm MACHO and OGLE-II light curves for this star are shown in Fig. 2. In spite of a detailed investigation of these data and various subsets of it, we were unable to find any significant periods in $V$, $R$, or $I$.

3.4. CXOU J005323.8−722715 = SXP138

Using Chandra data, Edge et al. (2004) found this source to be a 138-s pulsar. From the accurate X-ray position they identified the optical counterpart as the Be star
Edge et al. derived a photometric (orbital) period of $P_{\text{orb}} = 125 \pm 1.5$ days from MACHO data, although details of their analysis are not given.

The longterm $R$ light curve for this star is plotted in Fig. 2. There is a slow downward trend with occasional small “outbursts” (e.g. near MJD 50400 and 50620), but these are not periodic. We have re-examined both the $V$ and $R$ data, studying the east-pier and west-pier data separately. We find that there is a significant seasonal effect in which the mean brightness from each pier differs. Hence, it was necessary to prewhiten the data from each pier configuration before combining them.

We have searched for periods in both MACHO colors and in a variety of data subsets. Although the first half of the west-$R$ data shows a weak periodicity near 122-123 days (perhaps the same period as reported by Edge et al.), other time segments show different possible periods in the range of 220-260 days. It appears that each of these periods is related either to the length of the seasonal data train in a pier configuration or gaps between these data sets. No single long period is consistent with all of the photometry. Each of these “periods” produced a low-amplitude sinusoidal light curve, rather than the outburst behavior usually displayed in orbital periods.

The periodograms for this source also show some power near $\sim 1$ day, but in each case these are aliases of the long “periods” discussed above. We conclude that none of the peaks in the periodograms represents a true orbital period, but rather they are artifacts of the data.

3.5. XMMU J005605.2$-$722200 $= 2E0054.4$–$7237 = SXP140

This 140-s pulsar was discovered by Sasaki, Pietsch, & Haberl (2003) using XMM – Newton data. They note that it may be the same source as 2E 0054.4–7237.
Its position is coincident with the Be star [MA93]904 whose longterm MACHO light curve is shown in Fig. 3. The source is clearly a “swooper”. Unfortunately it lies outside of the OGLE-II fields, so I photometry is not available. Coe et al. (2005) note a blending problem in the crowded field of this source (see image at: http://www.astro.soton.ac.uk/~mjc/smc/Finders/sxp140.jpg).

The MACHO data were analyzed mainly in Seg A (MJD 49650-50500), since this is the only part of the longterm light curve that could be prewhitened reasonably well. A period near 197±5 days is present in both R and V photometry. The folded light curve shows a typical orbital outburst, with a rapid rise (∼0.04 mag) and a more gradual decline. In other time segments of the longterm light curve, where it was impossible to flatten the data, we examined the region where outbursts were expected. In most cases there was evidence for a brightening at the predicted times. The 197-day period is in reasonable agreement with Corbet’s (1984) $P_{\text{pul}}/P_{\text{orb}}$ relationship. We conclude that this is probably the orbital period since in similar systems the amplitude of outbursts varies or may be absent.

3.6. XMMU J005920.8−722316 = SXP202

This X-ray source was discovered to be a 202-s pulsar by Majid et al. (2004) using archival XMM – Newton data. Its X-ray position is coincident with both an OGLE-II and a MACHO star. The longterm light curve for this system (Fig. 4) shows it to be another “swooper”.

We have searched the I, R, and V data for possible periods. The photometric behavior is similar to SXP138, with various subsets of the data showing weak power at periods related to the length of the data train and its aliases. In I there is some power at ∼203 days and its alias at ∼0.99 days, but light curves folded at these periods merely bunch
the observations into a few clumps and do not appear to be reasonable. We conclude that there are no clear periodities in the photometric data. Coe et al. (2005) came to the same conclusion.

3.7. **CXOU J010102.7−720658 = RX J0101.0−7206 = SXP304**

Macomb et al. (2003) discovered this 304.5-s pulsar in *Chandra* observations of the SMC. Its position clearly identifies it with the Be star [MA93]1240, which is the same star Edge & Coe (2003) found to have strong Hα emission.

Although no OGLE-II data are available, this star is included in the MACHO data set. The longterm MACHO V light curve is shown in Fig. 5. The mean magnitude is relatively flat over a long stretch of time (MJD 49000-51000) allowing it to be prewhitened quite easily. The periodogram shows very prominent power at P=0.26 days, which we associate with nonradial pulsations of the Be star. When the data are subdivided into four time segments, there is evidence that the period changes slightly between segments A-B and C-D (as shown in Fig. 5). The folded Seg C data show that the amplitude is greatest in V and least in I.

We have also searched for longer periods which might arise from orbital interactions between the pulsar and the Be star’s disk. Using the same data in which the NRP were found, there is moderate power at P~520 days. To further investigate this long period, we subtracted a sinusoid with the period and amplitude of the NRP. Analysis of the residuals still reveals a periodicity at 520±12 days. The light curve folded on this period shows a steep rise and slower decline, typical of orbital outbursts. However, the significance of this period is low, and further data are needed to confirm this possible orbital period.
3.8. **SAX J0103.2−7209 = 2E 0101.5−7225 = SXP348**

Israel et al. (2000) showed this X-ray source to be a 348-s pulsar. Its position identifies SXP348 with the Be star [MA93]904. The MACHO data have a significant number of ‘dropouts’ and other problems, probably related to its proximity to a much brighter star. Although unlisted in OGLE-II’s Difference Image Analysis, photometry for the star is available in the complete OGLE-II data set. The $I$ light curve is shown in Fig. 4.

Analysis of the $I$ photometry shows a weak period at 93.9 days. The folded light curve shows a steep rise and slower decline, but additional data would be needed to confirm this as the orbital period. A system with a 348-s pulse period would be expected to have an orbital period considerably longer than 94 days.

3.9. **RX J0103.6−7201 = SXP1323**

Using *XMM−Newton* data Haberl & Pietsch (2005) discovered 1323-s X-ray pulsations from this source, making it the slowest known SMC pulsar. Its optical counterpart is the Be star [MA93]1393. Only OGLE-II data are available for this star, but this photometry reveals a wealth of information about the source’s variability.

The periodogram shows extremely significant power at $P=26$ days as well as at other periods (see Fig. 6 and Schmidtke & Cowley 2006). When the data are folded on the 26-day period, the variation is approximately sinusoidal with a full amplitude of $\sim0.04$ mag. From the known relation between pulse period and orbital period (Corbet 1984), one would expect the orbital period to be much longer than 26 days. In addition, orbital light curves usually show outbursts rather than sinusoidal variations. Hence, we conclude that the alias period at $P=0.96$ days (the second strongest peak in the periodogram) is likely to be the true primary period, with the variation due to nonradial pulsations of the Be star.
The periodogram also shows many other peaks, some resulting from other pulsational periods and others being aliases of the true periods. The next strongest peak is at P=0.88 days, which we identify as a second pulsational mode of the Be star. A third pulsational period is present at 0.42 days, as can be seen in Fig. 6.

We further analyzed these periods using a variety of techniques. Although all three of the NRP periods given above can be seen in the original periodogram, we experimented with the data by subtracting the 0.96-d period and examining the periodogram of the residuals. This showed the 0.88-day period to be highly significant. The 0.96-day light curve must be a nearly perfect sine curve since no evidence of it was found in the residuals. We then subtracted the 0.88-day period, and examined the new residuals. This showed periods at both 0.42 and 0.28 days (aliases of each other), with the 0.42-day period being slightly more significant. Finally, we note that when all three NRPs (0.96, 0.88, and 0.42 days) are subtracted from the data, the resulting residuals show another weak peak at 1.05 days, suggesting that a fourth NRP period may be present. Thus, this source has many pulsational modes, all present at the same time. We also looked for changes in these periods by subdividing the longterm light curve into 4 time segments. No significant changes in any of the periods were found.

3.10. RX J0105.1−7211 = AX J0105−722 = SXP3.34

This 3.34-s pulsar was identified by Coe et al. (2005) with the Be star [MA93]1506. The longterm MACHO light (Fig. 7) shows a fairly steady mean light level with considerable scatter. Coe et al. found an optical period of 11.09 days from these data, but he pointed out that the strength of Hα emission (EW=−54Å) was not consistent with the P_{orb}/EW relationship of Reig, Fabrigat, & Coe (1997). We have searched to higher frequencies and find that the fundamental period is at 1.099 days, with the 11-day period being an
alias of that period (Schmidtke & Cowley 2005c). The power at the 1.009-day period is exceptionally strong (Fig. 7). This period is extremely stable in both frequency and amplitude. The folded V, B, and I light curves show the greatest amplitude in I and the smallest in V, although the differences are small. This short period clearly is another example of prominent nonradial pulsations from the Be star.

When the 1.099-day variation is subtracted from the data, analysis of the residuals shows a periodogram with a second significant peak at P=0.980 days. The folded light curve reveals a very low-amplitude sinusoid in each color (Fig. 7). When the data are divided into 4 time segments, we find that the amplitude is weakest in the last segment (starting about MJD 50950).

4. Summary

We have looked for general conclusions regarding the Be/X-ray pulsars systems based on their photometric behavior. We have considered not only the sources in this paper, but also results from previous studies (e.g. Coe et al. 2005, Schmidtke & Cowley 2005a, Schmidtke et al. 2004). We see no correlation between the length of the X-ray pulse period and whether or not orbital periods are seen in the photometric data. Sources with short pulse periods (e.g. 7.8 s for SMC X-3), long pulse periods (e.g. SXP755 with P_{orb}=394 days), and many intermediate values may or may not show orbital outbursts. The presence of such outbursts must depend on the orbital eccentricity and the extent of the Be star’s disk at the time of periastron passage. Perhaps the systems which do not show outbursts have nearly circular orbits.

We also see that NRP are found in sources with a wide range of X-ray pulse periods (from 3.34 s to 1323 s). However, we note that sources with “swooping” light curves
generally do not show NRP, even in the flattest portions of their light curves (e.g. SXP8.88). The only possible exception to date is SXP82.4 whose OGLE-III light curve (Coe et al. 2005) fades considerably, suggesting it may be a “moderate swooper”. Its 1.33-day NRP were found only in the early part of the longterm light curve when its the mean brightness was almost level (see Fig. 4 in Schmidtke & Cowley 2005a).

In summary, we have analyzed the longterm optical light curves of ten SMC Be/X-ray pulsars. We determined orbital periods for four sources and a possible orbital period for another system. Overall, the orbital periods found in this study fit reasonably well with the Corbet relation between orbital and X-ray pulse period. We have identified strong nonradial pulsations for three sources, and two of these sources show multiple NRP.

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The OGLE-II database, as described by Udalski et al. (1997), Zebrun et al. (2001), and Szymanski (2005), was also extensively used for this project.
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Fig. 1.— (top) Longterm $I$ light curve of XMMU J005152.2–731033 (SXP172). (middle) Variance calculated by the PDM method (upper, with scale on right) and periodogram (lower) of $I^*$ data from Seg A. The 99% confidence level is also shown. (bottom) $I^*$ data folded on the 69.9-day period and binned (filled squares), with the individual points from the outburst near MJD 50790 superimposed (open circles).

Fig. 2.— (top) Longterm $V$ (upper) and $I$ (lower) light curves of RX J0051.8–7231 (SXP8.88). The inset shows an enlargement of the region between MJD 50600 and 50800, with four outbursts marked. (middle) Longterm $R$ (upper) and $I$ (lower) light curves of RX J0052.1–7319 (SXP15.3). (bottom) Longterm $R$ light curve of CXOU J005323.8–722715 (SXP138).

Fig. 3.— (top) Longterm $R$ light curve XMMU J005605.2–722200 (SXP140). (middle) Periodogram of $R^*$ data from Seg A showing the orbital period of 197 days. (bottom) $R^*$ light curve folded on 197 days and averaged in 20 phase bins.

Fig. 4.— (top) Longterm $R$ (upper) and $I$ (lower) light curves of XMMU J005920.8–722316 (SXP202). (bottom) Longterm $I$ light curve of SAX J0103.2–7209 (SXP348).

Fig. 5.— (top) Longterm $V$ (upper) and $I$ (lower) light curves of CXOU J010102.7–720658 (SXP304). (middle) Periodograms of $V^*$ data from 4 time segments (A – D) showing the variation in period and power. (bottom) Folded light curve of $V^*$, $R^*$, and $I^*$ data from Seg C showing strong nonradial pulsations at $P=0.26$ days. The amplitude appears to be greatest in $V^*$. 
Fig. 6.— (top) Longterm $I$ light curve of RX J0103.6$-$7201 (SXP1323). (second) Periodogram of $I^*$ data showing several significant periods and their aliases (see text). (third) $I^*$ data, folded on $P=0.96$ days, after signals from $P=0.88$ and $P=0.41$ days have been subtracted. (fourth) $I^*$ data, folded on $P=0.88$ days after the variation of the other two NRP have been subtracted. (bottom) Similar to the above two plots, but the $I^*$ data have been folded on $P=0.41$ days after subtraction of the variation due to the two other short periods.

Fig. 7.— (top) Longterm $R$ (upper) and $I$ (lower) light curves of RX J0105.1$-$7211 (SXP3.34). (second) Periodogram of $R^*$ data showing the exceptionally strong peak at $P=1.099$ days. (third) Folded and binned light curves in $V^*$, $R^*$, and $I^*$ at $P=1.099$ days. The amplitude is largest in $I^*$. (fourth) Periodogram of $R^*$ data after the 1.099-day variation has been subtracted. The strongest remaining power is at $P=0.980$ days. (bottom) $V^*$, $R^*$, and $I^*$ light curves, folded on $P=0.980$ days, after removal of the 1.099-day signal. See text for further discussion of this source.
Table 1. Small Magellanic Cloud Be/Neutron-Star Systems Studied

| System Name       | R.A.(2000)\(^a\) | Dec.(2000)\(^a\) | SXP #   |
|-------------------|------------------|-----------------|---------|
|                   | OGLE-II #        | MACHO #         | [MA93] \(^b\) # |
| XMMU J005152.2−731033 | 00:51:51.86  | −73:10:33.4     | SXP172  |
|                   | 005152.02−731033.7 | 212.16077.13   | 504     |
| RX J0051.8−7231    | 00:51:53.00  | −72:31:48.1     | SXP8.88 |
|                   | 005153.12−723148.3 | 208.16087.9   | 506     |
| RX J0052.1−7319    | 00:52:13.98  | −73:19:18.1     | SXP15.3 |
|                   | 005213.99−731918.3 | 212.16075.13   | 552     |
| CXOU J005323.8−722715 | 00:53:23.86  | −72:27:15.1     | SXP138  |
|                   | - - - - - -   | 207.16202.50    | 667     |
| XMMU J005605.2−722200 | 00:56:05.62  | −72:22:00.2     | SXP140  |
|                   | - - - - - -   | 207.16374.21    | 904     |
| XMMU J005920.8−722316 | 00:59:20.94  | −72:23:17.4     | SXP202  |
|                   | 005921.03−722317.1 | 207.16545.12   | —       |
| CXOU J010102.7−720658 | 01:01:02.56  | −72:06:56.5     | SXP304  |
|                   | 010102.87−720658.7 | 206.16663.16   | 1240    |
| SAX J0103.2−7209   | 01:03:13.93  | −72:09:13.8     | SXP348  |
|                   | 010313.89−720914.0 | 206.16776.17   | 904     |
| RX J0103.6−7201    | 01:03:37.50  | −72:01:32.9     | SXP1323 |
|                   | 010337.50−720132.9 | - - - - - -     | 1393    |
| RX J0105.1−7211    | 01:05:02.40  | −72:10:55.9     | SXP3.34 |
|                   | 010502.51−721055.9 | 206.16890.17   | 1506    |

\(^a\)Coordinates are the MACHO position of the optical star, except for RX J0103.6−7201.

\(^b\)From catalogue of SMC Hα emission-line stars by Meyssonnier & Azzopardi (1993).
Table 2. Photometric Periods for SMC Be/Neutron-Star Systems

| System Names               | $P_{\text{orb}}$ | NRP\(^a\) | References   |
|----------------------------|------------------|------------|--------------|
| XMMU J005152.2−731033 (SXP172)\(^b\) | 69.9±0.6         | —          | Laycock et al.\(^c\) |
| RX J0051.8−7231 (SXP8.88)   | 33.4±1.0         | —          | Corbet et al.\(^d\)  |
| XMMU J005605.2−722200 (SXP140) | 197±5            | —          |              |
| CXOU J010102.7−720658 (SXP304) | 520±12           | 0.26       | Schmidtke & Cowley\(^e\) |
| RX J0103.6−7201 (SXP1323)   | —                | 0.98; 0.88; 0.41 |             |
| RX J0105.1−7211 (SXP3.34)   | —                | 1.099; 0.980 | Coe et al.\(^f\)  |

\(^a\)NRP = nonradial pulsations of the Be star.

\(^b\)Optical counterpart is Star 1 in field of SMC 25 (Cowley et al. 1997).

\(^c\)Laycock et al. (2005) find $P_{\text{orb}}$=67±5 days from X-ray outbursts.

\(^d\)Corbet et al. (2004) give $P_{\text{orb}}$=28.0±0.3 days from X-ray outbursts.

\(^e\)Schmidtke & Cowley (2006) give further information about this source.

\(^f\)Coe et al. (2005) give $P_{\text{orb}}$=11.09 days, which is an alias of the strong NRP at 1.099 days (Schmidtke & Cowley 2005c).
