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An *EUVE* observation of the globular cluster NGC 1851: The second EUV detection of a low mass X-ray binary?

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Abstract. We have detected EUV emission from the globular cluster NGC 1851, using the Deep Survey Photometer aboard the *Extreme Ultraviolet Explorer* (EUVE). The minimum EUV luminosity implied by our detection is $\sim 10^{35}$ – 10^{36} ergs s^{-1}, for a distance and reddening appropriate to NGC 1851. This is only the second detection of a globular cluster at EUV energies. If this flux is due to the cluster LMXB X0512-401, then the observed EUV luminosity is likely to be comparable to the 2–10 keV X-ray luminosity of the LMXB. With the detection of EUV emission from M15, these observations suggest that the EUV flux of LMXBs in general may represent a sizable fraction of their total bolometric luminosity. However, additional observations are needed to conclusively show that these cluster LMXBs (X0512-401 and AC211) indeed dominate the cluster EUV emission. Finally, we compare our NGC 1851 measurement with the EUVE detection of the X-ray transient XTE J1118+480 during outburst, and show that these objects appear to have comparable EUV luminosities.

Key words: stars: binaries: close – Galaxy: globular clusters: individual: NGC 1851 – stars: individual: X0512-401 – stars: individual: XTE J1118+480

1. Introduction

As discussed by Callanan et al. (1999), little is known of the EUV properties of Low Mass X-ray Binaries (LMXBs), primarily because most LMXBs are relatively distant (>1 kpc) and lie behind significant optical extinction (>0.5 magnitudes) that dramatically reduces any EUV flux.

The two LMXBs with the lowest reddening are those that reside in the globular clusters M15 (AC211) and NGC 1851 (X0512-401): these systems provide a unique opportunity to study the EUV characteristics of LMXBs in general. Indeed, Callanan et al. (1999) have found EUV emission from M15, which they argue is most likely due to AC211. This prompted us to search for EUV emission from NGC 1851.

X0512-401 is a moderately bright system (X-ray luminosity $\sim 10^{36}$ ergs s^{-1}), first discovered by Clark et al. (1975). Callanan et al. (1995) found evidence for only low amplitude variability in the 2-10 keV lightcurve. Deutsch et al. (1996) have found a UV-bright object (B$\sim$21, (U-B) = -0.9), only 2″ away from the X-ray position. No orbital period is known, although the faintness of the optical counterpart indicates a short period system: indeed, the only LMXBs in the compilation of van Paradijs & McClintock (1994) of comparable absolute magnitude have periods $\leq$ 1 hr.

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2. Observations and data reduction

NGC 1851 was acquired by the EUVE Deep Survey and Spectrometer (DSS) telescope on UT 1995 Dec 15.42, and was observed until 1995 Dec 16.73. This telescope, filter and detector combination has significant transmission between about 65 and 170 Å, peaking at approximately 90 Å (Bowyer et al. 1994). The total integration time was 33 ksec (see Callanan et al. 1999 for further details concerning the data reduction).

The EUV source was detected at a position of RA =05^h 14^m 08.4^s, Dec = -40° 02′ 58″ (J2000) with an uncertainty of approximately ±25 arcsececonds. This is in good agreement with the coordinates of the cluster itself (to within 1.2σ: e.g. Djorgovski & Meylan 1993). The average count rate in the DS was 0.0044±0.0006 count s^{-1}. The lightcurve is shown in Fig. 1: there is no evidence for any statistically significant variability.

3. Discussion

At a distance of 12.2 kpc (e.g. Webbink 1985), the EUV source in NGC 1851 lies 1.8± 1.5 pc from the centre of the cluster, which corresponds approximately to the half light radius. X0512-401 itself is some 12" away from the cluster core: unfortunately, EUVE has insufficient positional accuracy to allow us to distinguish between X0512-401 or objects withinin the cluster core as the origin of the EUV emission, on the basis of source location alone.

The reddening towards NGC 1851 has been measured by Walker (1992) to be $E_{B-V} = 0.02 \pm 0.02$: in a subsequent paper, (Walker 1998), a slightly higher value of 0.05±0.02 was derived, although systematic effects may have led to an artifically high

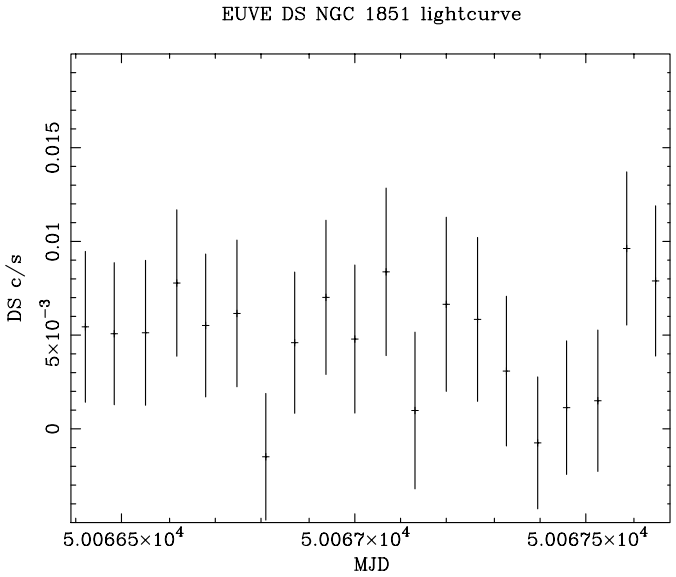

Fig. 1. The EUVE Deep Survey Photometer light curve of NGC 1851.

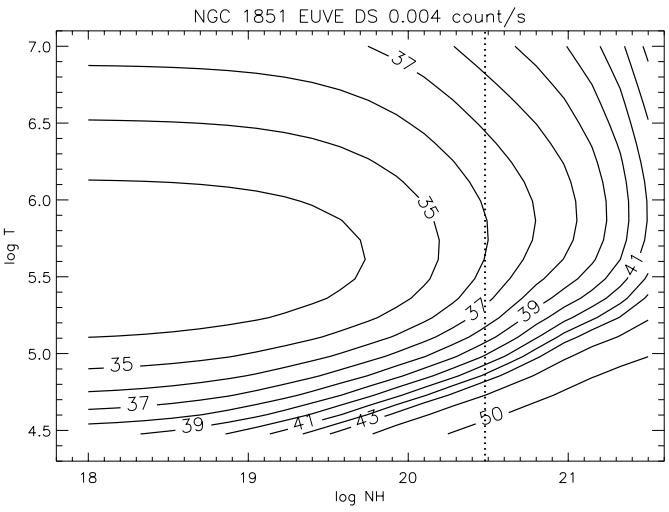

Fig. 2. A contour plot of the bolometric luminosity of the EUV component, as a function of the line-of-sight neutral hydrogen column density and effective temperature. The contours are logarithmically spaced, for a blackbody spectral shape. The luminosity is scaled to our DS countrate of 0.004 counts s^{-1}. The vertical line denotes a column of 3×10^{20} cm^{-2} towards the cluster.

value. Using the Savage & Mathis (1979) reddening curve, these correspond to $N_H = 10^{20}$ and 2.5×10^{20} cm^{-2} respectively. However, radio studies (Dickey & Lockman 1990) yield $N_H \sim 3.6\times10^{20}$ cm^{-2}, with relatively little scatter ($\sim$10% over an area of a few square degrees). For the discussion that follows, we will use a column of 1-4$\times10^{20}$ cm^{-2}. We note that the column of $\sim2\times10^{20}$ cm^{-2} measured by Verbunt et al. (1995) using the ROSAT PSPC lies in the middle of this range.

Following Callanan et al. (1999), we model the spectral shape of the source as a blackbody. In Fig. 2., we plot the intrinsic bolometric luminosity as a function of effective temperature and line of sight column, corresponding to our DS countrate: the data imply a bolometric luminosity of $\sim10^{35}$ – 10^{36} ergs s^{-1}, for the range of columns discussed above.

4. The origin of the EUV emission from NGC 1851

By analogy with the EUV emission of M15 (Callanan et al. 1999) we believe that the origin of the observed EUV emission is due to X0512-401 itself. As in the case of M15, our confidence would be bolstered by the detection of any variability in the EUV lightcurve: however, the low S/N of our data precludes any such measurement.

Our simple modelling indicates that the EUV luminosity is likely to be a sizable fraction of the X-ray luminosity of X0512-401, as found in the case of AC211 in M15: indeed because of absorbing column intrinsic to the binary, it could be substantially higher. However, the short period of X0512-401 (as inferred from its low absolute magnitude), coupled with the lack of any obvious X-ray modulation (Callanan et al. 1995) suggests that X0512-401 is a lower inclination system. We might therefore expect a lower line-of-sight absorbing column within the binary itself, compared to that of AC211. Hence the correction to the EUV luminosity due to the intrinsic column in the case of X0512-401 is likely to be less than that for AC211. An accurate determination of the NGC 1851 EUV luminosity will require a simultaneous measurement of both the EUV flux and X-ray column.

5. Comparison with XTE J1118+480

Recently, Mauche et al. (2000) have announced the detection of the X-ray transient XTE J1118+480 (while in outburst) with the EUVE DS photometer, with a countrate of $\sim$ 1 counts s^{-1}, providing additional evidence that LMXBs can indeed be substantial emitters in the EUV. Furthermore, as the reddening towards this system is comparable to that towards NGC 1851 (Garcia et al. 2000), our NGC 1851 DS detection predicts a countrate of $0.004\times12.2^2 = 0.6$ counts s^{-1} for XTE J1118+480 (assuming a distance to XTE J1118+480 of 1 kpc). This is in reasonable agreement with the measurements of Mauche et al., and indicates that these LMXBs have comparable EUV luminosities.

6. Conclusions

We have detected EUV emission from the globular cluster NGC 1851. The emission is likely due to the cluster LMXB, and if so represents the second detection at EUV energies of an LMXB, implying in this case a minimum EUV luminosity of $\sim10^{35}$–10^{36} ergs s^{-1}, and suggesting that the EUV flux of LMXBs in general may represent a sizable fraction of their total bolometric luminosity. However, additional observations are first needed to conclusively show that these cluster LMXBs indeed dominate the cluster EUV emission.

It is clear that further observations of this and other low column LMXBs (e.g. using Chandra) are now required to establish the ubiquity of Globular Cluster/LMXB EUV emission. Indeed, the recent EUVE detection of XTE J1118+480

suggests that significant EUV emission may be common amongst LMXBs.

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