Contact Binary Variables as X-ray Sources

Kaushar Sanchawala [a], Wen-Ping Chen [a,b] and Mu-Zhen Chiou [b]
[a] Graduate Institute of Astronomy, National Central University, Chung-Li, Taiwan
[b] Physics Department, National Central University, Chung-Li, Taiwan
email: kaushar@ouflows.astro.ncu.edu.tw

Abstract

We present cross-identification of archived x-ray point sources with optical variable stars found in All Sky Automated Survey (ASAS). In a surveyed sky area of 300 square degrees, 36 objects were identified as possible W Ursae Majoris type. We compute the distances to the W Ursae Majoris systems and present their x-ray luminosities.

The ASAS Project

- The All-Sky Automated Survey first ran with a prototype ASAS-1 and ASAS-2 equipped with 768X512 Kodak CCD and 135/f1.8 telephoto lens to monitor stars brighter than 14 magnitudes in the I band at the Las Campanas Observatory in Chile (4),(5).
- From April 7, 1997 to June 6, 2000, more than 140,000 stars had been observed in the selected fields covering ~ 300 square degree for nearly 50 million photometric measurements.
- More than 3500 variable stars have been found (ASAS-2) , of which nearly 90 $\%$ are new identifications. Among these 380 are periodic variables.
- The ASAS-3 system installed in August 2000, has discovered over 1000 eclipsing binaries, almost 1000 periodic pulsating variables, and over 1000 irregular stars among the 1,300,000 stars in the 0h-6h quarter of the southern hemisphere till date (6).

The W Ursae Majoris Variables

- W Ursae Majoris (also called EW) variables are contact eclipsing binaries, with periods p=0.2-1.4 days.
- Their light curves show two nearly equal minima with virtually no plateau.

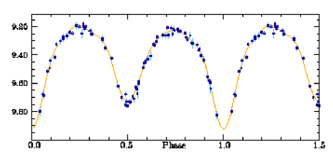

Fig. 1 HIP 59683 (HD 106400, AH Vir) is a W UMa type system with a period of 0.407528 days (http://astro.estec.esa.nl/Hipparcos/education_lcA.html)

- W UMa systems are known x-ray emitters. Stępień et. al (1) examined a sample of 102 such systems and found 54 of them to be x-ray sources.
- The x-ray emission mechanism of these systems is not clearly known but is thought to be related to stellar magnetic activity.
- A large sample of W UMa systems with x-ray emission is an important first step to shed light on their x-ray nature.

W UMa stars - Absolute Magnitude

- We made use of the ASAS-2 database of the variable stars and among the 380 periodic variables, identified 36 possible candidates of the W Ursae Majoris type.
- We searched the x-ray counterparts for these W UMa stars in the ROSAT database and found that 10 of the W UMa stars had x-ray counterpart (Angular separation $< 30''$).
- In some cases, the cross-identification was relatively straightforward, either because the nominal positions of the x-ray and optical source coincided (Fig. 2) or because no other obvious star was near the x-ray position (Fig. 3). The fig. 4 shows the light curves of a few W UMa stars for which we found the x-ray counterpart in the ROSAT database.

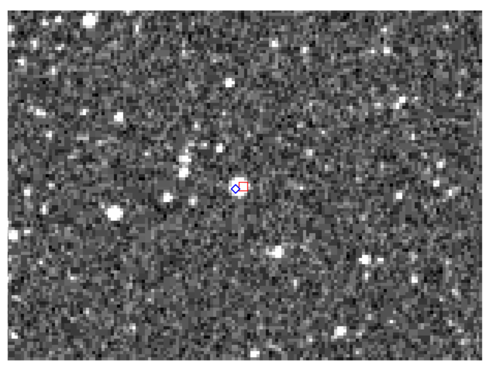

Fig.2 ASAS053959-6828.7

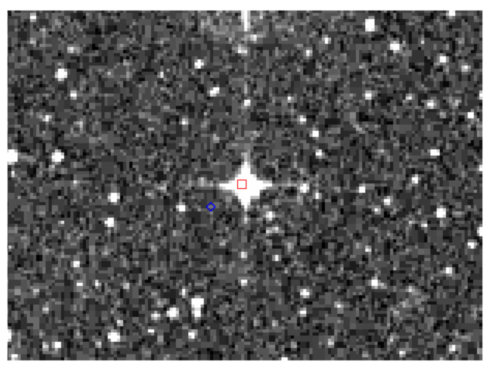

Fig. 3 ASAS184139-0044.7

DSS images : Red box indicates the positon of ASAS objects whereas the blue box shows the position of their x-ray counterpart.

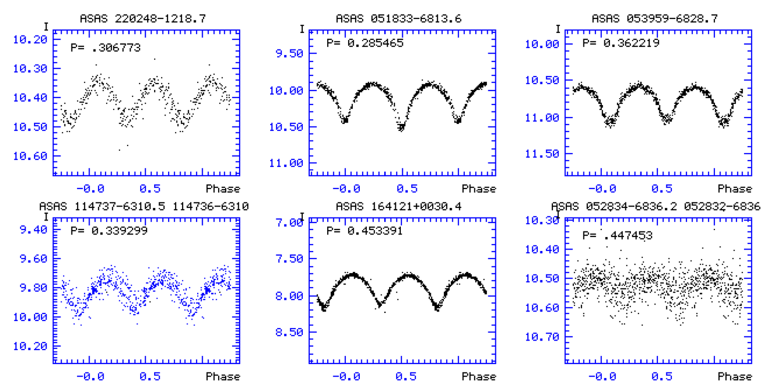

Fig. 4 Light curves of a few ASAS variables with x-ray counterparts in ROSAT.

- For 8 of the W UMa stars, the angular separation was less than 30" whereas for the remaining 2 it exceeded this limit. We used S. Rucinski's absolute magnitude calibration method (2), (3) to compute the absolute magnitudes of the stars and hence their distances.

The exact calibration used is as given below.

$$M_I = b_{P(VI)} log\ P + b_{VI}(V-I)_0 + b_{0(VI)}$$

where $b_{P(VI)} = -4.4^{+1.3}_{-1.6}$, $b_{VI} = +2.3^{+0.9}_{-0.6}$ and $b_{0(VI)} = -0.2^{+0.2}_{-0.3}$,

which is valid over the following ranges in period and color,

$0.27 < P < 0.63$; $0.38 < (V-I)_0 < 1.21$ & $1.8 < M_I < 5.0$.

- Two of the W UMa stars with x-ray counterparts, have the periods or colors outside the range of the calibration. Hence, we computed the absolute magnitudes of 8 W UMa stars in I band and their distances.

W UMa stars - X-ray luminosity

We computed the x-ray luminosities for the W UMa stars from their x-ray counts. The flux was obtained by multiplying the energy conversion factor with the count rates (1).

$ECF = (5.3HR + 8.7)10^{-12} erg cm^{-2} cts^{-1}$.

where the hardness ratio $HR = (H-S)/(H+S)$, for which H and S denote the source counts in the hard (0.5-2.0 keV) and soft (0.1-0.4 keV) passbands of ROSAT, respectively.

Table 1 lists the W UMa stars with their computed distances and their X-ray luminosities.

Table 1

RA	DEC	P	V − I	d	L_x
05:18:33	-68:13.6	0.2854	1.044	117	7.24 $\times 10^{29}$
05:39:59	-68:28.7	0.3622	0.746	274	4.76 $\times 10^{29}$
05:28:34	-68:36.2	0.4474	0.789	285	5.16 $\times 10^{29}$
16:41:21	00:30.4	0.4533	0.654	97	1.87 $\times 10^{30}$
18:41:39	-00:44.7	0.2875	0.923	205	1.26 $\times 10^{30}$
22:02:48	-12:18.7	0.3067	0.873	173	1.02 $\times 10^{30}$
*11:47:37	-63:10.5	0.3392	1.131	111	5.17 $\times 10^{30}$
*20:48:59	00:27.4	0.5134	0.664	493	2.90 $\times 10^{30}$

d is the mean distance in parsec and L_x is the mean x-ray luminosity in erg.sec^{-1}.
*Angular separation of the counterpart is $> 30''$.

X-ray luminosity vs. rotation

To study the interplay between stellar rotation and magnetic activity, we see that for single stars (Fig. 5) the x-ray luminosity increases with rotation, until $P \leq 1$ d, for which saturation occurs. The W UMa stars are tidally locked and all have periods below 0.63 d. As fast rotators, W UMa stars offer a good tool to investigate such relationship in contacting binary environment. Fig. 6 plots L_x versus period for W UMa stars, with data from (1) and (8) and our work. It appears that the faster an W UMa star rotates, the weaker its x-ray emission is, which may also be hinted in the single star data. The actual reason of this 'anti-correlation' is unknown, and we plan to study an enlarged W UMa sample (e.g., ASAS-3) for their x-ray emission to shed light on this issue.

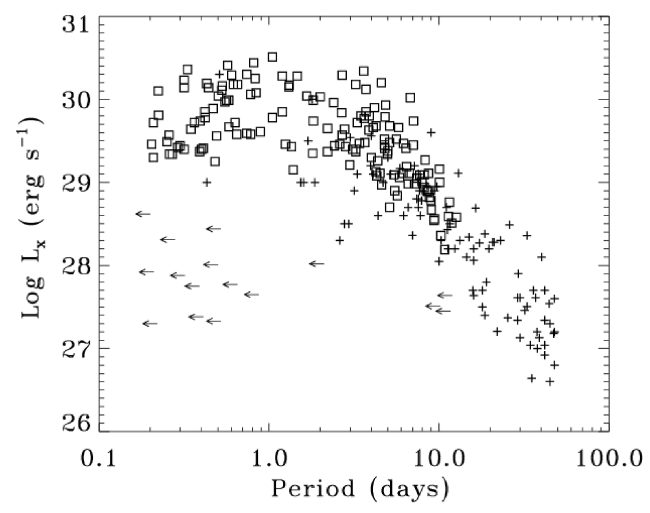

Fig. 5 X-ray luminosity vs. rotation of field dwarfs (crosses) and cluster stars (squares). Leftward arrows indicate field stars with periods derived from $v\ sini$ data, taken from (7).

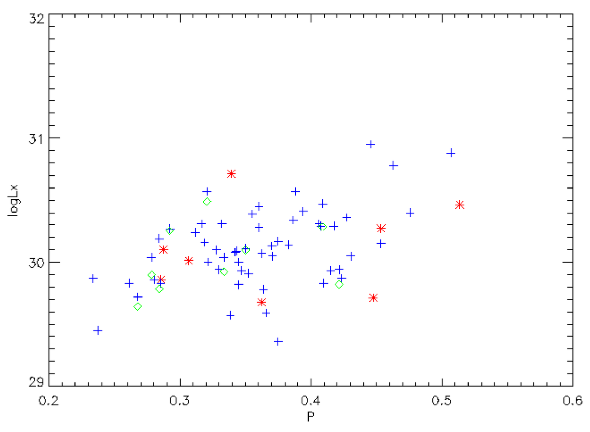

Fig. 6 The points in blue color are the values taken from (1), and in green color are the values taken from (8). The points in red color are the ones we obtained for the W UMa stars from ASAS-2.

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