# X-RAY RADIATIONS OF INTERACTING BINARY 44i BOOTIS

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## ABSTRACT

In order to study the X-ray radiations from solar type strong interacting binary stars, we have collected X-ray data of 44i Bootis (P=0.2678 days, SP=G2+G2) from the EXOSAT data archive. Preliminarly analysis of a part of these data has been already reported by Vilhu & Heise (1986). In this paper, however, we present a more complete light curve in LE region than the previous work, and some unpublished X-ray light curves and spectrums. Using these new materials a new attempt to find the physical explanation about some observational characteristic figures in the X-ray light curves and spectrums has been made.

*Key Words :* Stellar Astronomy - Binary Systems - 44i Boo

## I. INTRODUCTION

X-rays from W UMa type systems are important as an evidence of the high coronal activity from the contact binaries. After the first detection of X-ray emission from a contact binary by HEAO 1 satellite (Carrol et. al. 1980), many observations of contact binaries have been carried out by numourous X-ray satellites as EINSTEIN, EXOSAT, ROSAT etc. and it is now recognized that W UMa type star were suitable to study the X-ray emission in the corona of the late type stars. Phase dependent studies of contact binaries with the EINSTEIN satellite (Cruddace & Duppree 1984) reveals complex coronal structures. They suggested that X-rays of W UMa systems come from the chromosphere and corona of the cooler companion. Vilhu & Heise (1986) reported results from EXOSAT observation of contact binaries. In their paper, it has been found that another X-ray emission region exists besides coronal X-ray emission region.

44i Boo is one of the W UMa systems which provide some interesting information about the coronal structure of the compact binaries in the X-ray region, and therefore have been observed by several X-ray satellites. The purpose of this paper is to reanalyze the X-rays from the 44i Boo for the better understanding of X-ray plasma in W UMa systems. The previous work (Vilhu and Heise 1986) contains only a part of the EXOSAT X-ray data available these days. We could present more complet light curves and a new ME X-ray light curves of 44i Boo. Some physical parameters of the X-ray plasma have been also determined by fitting the X-ray spectrum with serveral models.

## II. DATA AND REDUCTION

EXOSAT has observed 44i Boo on 1985 Jan. 10, and the observational data can be retrieved from the High Energy Astrophysics Archive Research Center (HEASARC ) of NASA. Vilhu & Heise (1986) have published a preliminarly X-ray light curve with these EXOSAT data.

We collected EXOSAT X-ray data of 44iBoo available from HEASARC. For the reduction of the collected data, the X-ray data analysis programm packages, XRONOS and XSPEC, have been used. The XRONOS is a timing analysis package, and XSPEC is a programm for the command-driven, interactive, X-ray spectral-fitting. Because the collected X-ray data have already been substracted from the backgroun radiation, one can simple combine light curves in LE and ME region. In the LE region, the X-ray radiation of 44i Boo has been observed 3 different filters (3Lx, 4Lx and ALP). We have normalized the X-ray count rates observed by these filters to the ALP count rate. The normalization factors for such reduction have been adopted from Westergaard et al. (1985) and Vilhu & Heise (1986). We also constructed ME X-ray light curves in 2 energy region, 0.8 - 3.6 keV and 3.6 - 8.9 keV respectively. Although the constructed ME light curves do not cover the full orbital period, it seems to be very meaningful that one tries to find some characteristics in these light curves, because they have not been published yet. We have also fitted the X-ray spectrum by power law, black body, bremsstrahlung and gaussian model by using XSPEC, in order to obtain the possible values of X-ray plasma parameters.

## III. RESULTS

The resulting X-ray light curves are presented in Figure 1. The upper curve is the normalized LE light curve, and the other 2 curves are for the ME light curves in 0.8 - 3.6 keV and 3.6 - 8.9 keV respectively. Combined LE light curve covers the full orbital phase, and has more data points than that of the previous work (Vilhu & Heise 1986). The LE light curve shows three main features: X-ray maximum at phases around 0.2 and 0.8, broad X-ray maximum at phase around 0.5, and dips near 0.5 which are symboled by +.

The first feature can be explained by the corona model of Cruddace & Duppree (1984). In their model,

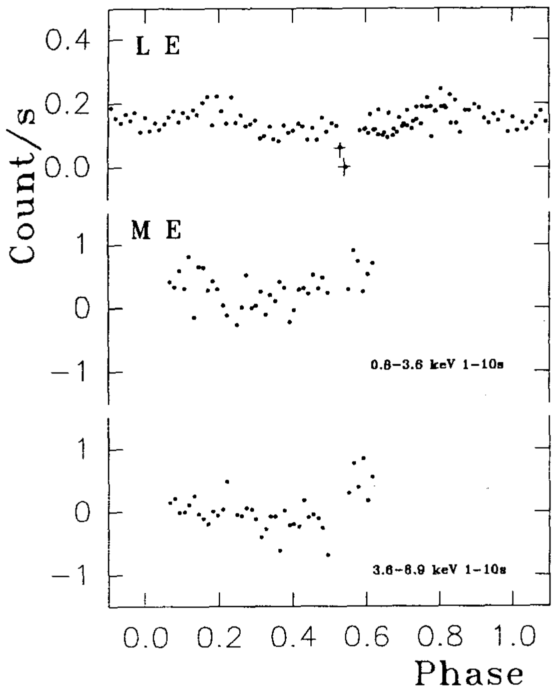


**Fig. 1.**— X-ray light curves of 44i Bootis. the upper curve is for LE, and the other 2 curves for ME region

the X-ray is expected to be radiated mainly from the vicinity (chromosphere and corona) of the cool star. At phase 0, the cooler star faces to the observer, so that the main X-ray region is observed near this phase. Therfore we conclude that the main X-ray maximum at phases around 0.2 and 0.8 comes from this corona model. For the second characteristic there is a suggestion by Vilhu & Heise (1986), that an extra X-ray source exists near the Lagrangian point(L1). During the partial eclipse of this extra X-ray source, we observe a gradual increase and decrease of X-ray radiation near the phase 0.5. However if this source is eclipsed totally by the atmosphere of the hotter star, one would observe a dips at this phase.

ME X-ray light curves do not cover the full orbital period. However because they have not been published yet, it is worth to note some characteristics in ME light curves as a preliminary result. There are more scatter in ME light curves than in LE light curve. More cruelly, there are some data points having the count rate under 0, which seem to be due to the wrong background substraction by HEASARC. For more detailed study, this substraction has to be redone by hand, instead of automatic substraction. But for the qualitative analysis, we use this light curves. It is clear from figure 1 that ME light curve is more modulated in lower energy region than in higher energy region. This phenomenon is similar to results for the case of cataclysmic variables (Kim & Beuermann 1995), which leads to a assumption that this modulation comes from X-ray photoabsorption in the line of sight.

The X-ray spectrum was fitted by power law, black body, bremsstrahlung and gaussian model. We found that no model gives the best fitted X-ray spectrum. We therefore conclude that our determination of physical parameters is erronous. Only marginally, a better fitted by the combination of power law and gaussian model has been found.

## IV. CONCLUDING REMARKS

We reinvestigated the X-rays from 44i Boo observed by EXOSAT. Our results confirm the coronal model suggested by Cruddace & Duppree (1984) and the existance of another X-ray emission region near L1. The unpublished energy dependent ME light curves can be considered more detail in further works in order to understand the X-rays of contact binaries in ME region. It is also in progress to collect the X-ray data from other X-ray satellites. Details of such study will be reported elsewhere.

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