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Lobster Eye X-Ray Monitors: Recent Status

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The capabilities of the considered space mission LOBSTER for investigation of cataclysmic variables (CVs) are discussed.

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1. Introduction

The goal of this paper is to discuss the capabilities of the considered space mission LOBSTER for investigation of cataclysmic variables (CVs). LOBSTER, as a very wide-field soft X-ray monitor, will be able to provide a dense monitoring of the light changes of CVs in X-rays. It can be a promising satellite to provide a sensitive X-ray monitor which will enable to investigate a little studied long-term activity of various types of CVs (especially the magnetic ones) in the X-ray band.

2. X-ray Sky Surveys

Most of the past and recent X-ray telescopes used a narrow field of view (FOV) (less than 1 degree diameter). Past X-ray surveys were based mostly on the non-imaging experiments (without a use of optics), hence they were of a limited sensitivity. Monitors are typically sensitive to the radiation within energy 2 keV $< E <$10 keV, hence the soft X-ray emission components often remain unstudied. ASM/RXTE (All Sky Monitor onboard Rossi X-ray Timing Explorer) (Levine et al. 1996) was a non-imaging instrument, operating between 1996 and 2012. Several exposures of a given object per day are available in some cases (but in many cases only the daily means are meaningful). The sensitivity of RXTE ASM was good for X-ray binaries with the accreting neutron star or the black hole but only very few CVs (about 10) were detectable near the sensitivity limit. Obviously, a new-generation X-ray ASM monitor is needed for CVs.

3. Justification for X-ray sky monitoring

CVs represent the very active objects, with often violent long-term activity in both the optical and X-ray bands (dwarf nova (DN) outbursts, high/low state transitions in nova-likes, classical nova explosions), and often with the rapid transitions between the states of activity. A search for the relation of the optical and X-ray activity is very important, as monitoring of a large number of CVs is necessary to catch them in various states of activity. Most up to now X-ray observations of CVs are represented by snapshots catching selected CVs in a particular state of activity. In most cases, the transitions between the states are not mapped.

There is only poor statistics of phenomena and objects (deeper studies are available only for a few CVs). It is obvious that the progress in the future X-ray sky monitoring, as described briefly in this paper, can yield new valuable data to understand the physical processes in the unpredictable activity (e.g., state transitions) of CVs in more detail.

The X-ray monitors onboard a given satellite could operate only for a limited time segment. Moreover, the spectral regions differ for the individual monitors, hence it is difficult and sometimes unreliable to combine the data from various monitors. It is necessary to be cautious in assembling the long series of X-ray data from various X-ray telescopes. Most X-ray monitors are sensitive only to the hard or medium X-rays, very few monitors worked at energies $E <$1 keV. Many pieces of information are thus missing (especially supersoft X-ray sources (a special type of CVs) may not be detected at all in the hard X-ray band, although they can be very luminous).

4. Lobster-Eye (LE)

Lobster-Eye Telescopes represent the novel Wide Field X-ray Telescopes with FOV of about 100 sq. deg. (the classical X-ray optics has only 1 deg or less). They represent an analogy with lobster eyes and were designed for astronomy, but laboratory applications are also possible. The Lobster Eye (LE) X-ray optics was originally proposed by Schmidt (1975) and Angel (1979). Since then, numerous test specimens of Lobster Eye telescopes were designed and tested (e.g., Inneman et al. 1999; Hudec et al. 2000, 2003, 2004; Tichý et al. 2009, 2011). The LE X-ray telescope can be miniaturized for an application in picosatellites. The LE telescopes are based on a real analogy with the lobster eyes. The LE telescopes can typically serve in two basic operation modes as follows: (a) starrying (pointed) mode - only for the satellite with pointing; (b) scanning mode (no satellite pointing and/or stabilization are required).

The parameters of the LE optics are as follows. The energy range from the optical to the energy of 10 keV in 2D and from the optical to the energy of 30 keV in 1D mode, FOV typical 5×5 deg 1 module, more modules with have a larger FOV, angular resolution 1 to 10 arcmin typical, the gain 100-1000. The application areas are as follows: X-ray astronomy in scanning mode, sky monitoring for transients, X-ray astronomy in pointed mode, dense long term monitoring of selected sky area, XRF planetary science, X-ray imaging in the laboratory, X-ray laboratory collimators, X-ray imaging of laboratory plasma, X-ray security screeing and material research, X-ray imaging and low resolution spectroscopy of triggers in atmosphere (balloon experiments), X-ray imaging and low resolution spectroscopy of polar lights (balloon and rocket experiments).

5. Science objectives of X-ray monitoring

Wide field X-ray monitors of Lobster-Eye type were demonstrated to play an important role in modern astrophysics (e.g., Hudec et al. 2007; Švéda et al. 2004). The most important scientific cases for a monitor are the observations of activity of the sources in the direction towards the Galaxy center where these sources are accumulated. We plan to concentrate on the long-term (months) measurements of the light curves of bright persistent X-ray binaries and also the detection and measurement of the activity of bright transient events in X-ray binaries in the soft X-ray band.

6. Conclusions

LE based LOBSTER missions, if approved for space flight, will significantly contribute to the CVs science.

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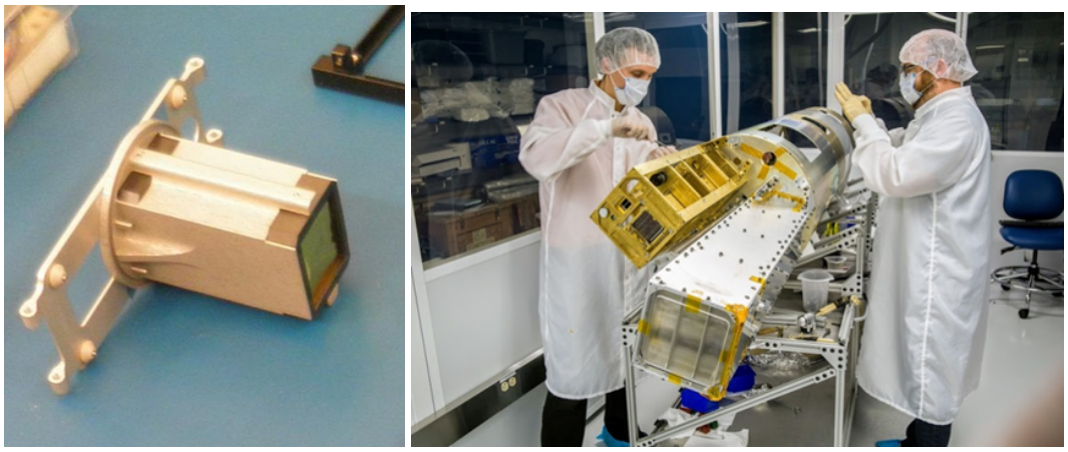

Figure 1: LE optical module for the VZLUSAT1 cubesatellite (left) and REX LE telescope assembled with the sounding rocket (right).

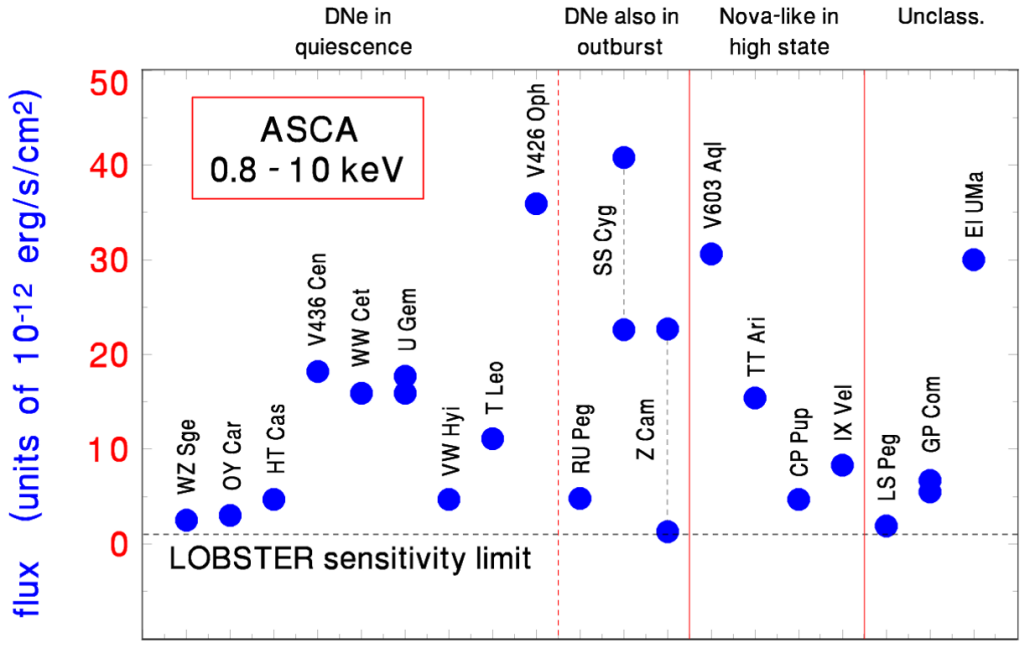

Figure 2: Possibilities of the detection of various types of CVs with LE. The observations by ASCA (Baskill et al. 2005) were used as the examples.

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