ABRIXAS

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1. Introduction

All Sky Surveys are very useful for several reasons: Firstly, their unbiased view provides the potential for new discoveries. Secondly, they yield large unbiased samples of a variety of objects which can be used for statistical investigations. And thirdly, the unlimited field of view of telescopic sky surveys allows to study extended objects and large scale structures.

The first telescopic all sky survey in X-rays which was performed by ROSAT in the soft X-ray band (0.1-2.4 keV) has demonstrated all these advantages. The main objective of ABRIXAS (A BRoad Band Imaging X-ray All Sky Survey) will be to perform a telescopic sky survey at higher energies, between ~0.5 keV and ~12 keV (see Trümper, Hasinger & Staubert, 1998). Thus, compared with ROSAT, the energy range is shifted upwards by about a factor of five. By using a CCD detector ABRIXAS shall have a substantially better spectral resolution compared with the ROSAT PSPC, and a somewhat improved survey point-spread function (HEW < 1 arcmin).

2. Scientific Objectives

ABRIXAS will allow to detect several ten thousand X-ray sources among which should be at least 10.000 new sources, which are too absorbed to be detected in the ROSAT All Sky Survey. ABRIXAS will therefore have a role as pathfinder e.g. for the XMM and AXAF and ASTRO-E missions.

K. Koyama et al. (eds.), The Hot Universe, 83-86.

https://doi.org/10.1017/S0074180900114482 Published online by Cambridge University Press

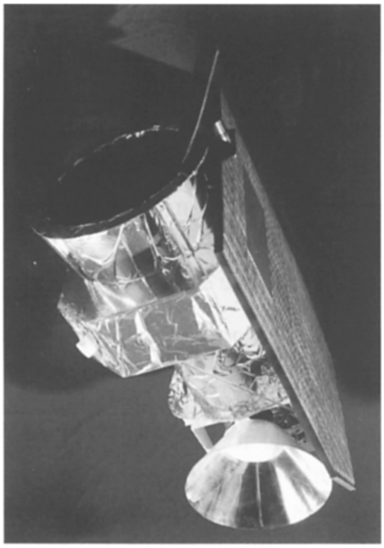

Figure 1. Artist's concept of ABRIXAS

ABRIXAS with its comparatively high spectral and angular resolution will also perform detailed spectroscopy of large-scale diffuse plasma sources like nearby supernova remnants, nearby clusters of galaxies or the diffuse emission region of the galactic ridge, which are too big to fit into the field of view of pointed X-ray telescopes.

Having identified the thermal galactic contributions through their line emission, ABRIXAS will obtain high-quality spectra and the angular distribution of the diffuse extragalactic background. It will be able to search for the redshifted iron line feature expected from the superposition of many active galactic nuclei as well as the fluctuations introduced by the large scale structure in the universe.

Finally, the regular pattern of the seven X-ray telescopes scanning the sky will produce information on the time variability of bright X-ray sources over time scales ranging from 10 seconds to 3 years.

Population synthesis models of the X-ray background (XRB), which are based on the unified AGN model, predict the XRB to be largely due to AGN with a wide distribution of intrinsic absorption column densities (Comastri et al., 1995). ABRIXAS will detect many of the nearby obscured AGN. The three year continuous X-ray survey of ABRIXAS will provide an unprecedented quality for the study of the X-ray background. Every piece of the sky will be covered many times by the surveys in seven different telescopes, thus allowing to correct for systematic errors. Therefore it will be possible to measure the energy spectrum of the X-ray background in a broad energy band with unprecedented quality, hopefully settling some of the systematic errors still hampering our current understanding. With the high statistical quality we will be able to search for the spectral feature around 2 keV, which is expected from the superposition of redshifted AGN iron lines (Matt and Fabian 1994).

The high spectral resolution will allow to discriminate the galactic thermal emission, which is thought to exist even at high galactic latitudes, from the isotropic extragalactic background. After removal of the galactic components we will be able to search for the XRB dipole due to the Compton-Getting effect. A multipole analysis of the residual background might be able to further constrain the power spectrum of cosmological density fluctuations. Finally, as soon as the future microwave background explorers (MAP and Planck Surveyor) will be operational, a crosscorrelation between the hard X-ray background and the high resolution microwave maps promises important cosmological results, e.g. on the integrated Sunyaev-Zeldovich effect and the X-ray/microwave source populations.

3. ABRIXAS Satellite and Payload

ABRIXAS is a scientific satellite project carried out by three institutes; the Astrophysical Institute Potsdam (AIP), the Institute of Astronomy and Astrophysics Tübingen (IAAT), and the Max Planck Institute for Extraterrestrial Physics (MPE). ABRIXAS will survey the whole sky in the way ROSAT did, by scanning it in great circles. The survey will take 3 years and provides full sky coverage in the energy band ~0.4 to 12 keV. The 3 years sensitivity will be comparable to that of the ROSAT all sky survey in the overlapping energy band, viz. at 1 keV. The angular resolution will be better than one arc min (see Döhring et al., 1998).

The optical system of ABRIXAS consists of seven Wolter type I mirror systems having 27 concentric shells each (see fig. 1). Their focal length is 160 cm. The optical axes of the seven telescopes are tilted with respect to each other by 7.25^o fig. 1a. The corresponding fields of views form a hexagonal pattern in the sky, c.f. fig. 1b (see Friedrich et al., 1996).

The 7 telescopes share one CCD chip of 6x6 cm2 as the imaging detector. The chip used for ABRIXAS as well as the whole detector including electronics is identical with the EPIC-Maxi detector developed by MPE for XMM. However, because of the low earth orbit of ABRIXAS the CCD chip will be operated at a somewhat higher temperature. Therefore, the lowest ABRIXAS energy will be 0.5 keV (possibly 0.3 keV) instead of 0.1 keV for XMM. Unique features of the pn-CCD are its large sensitivity at high energies (95 % at 10 keV), and its ~70 millisecond time resolution in the full frame mode achieved by a parallel readout. This is important for

TABLE 1. ABRIXAS Summary

Mirror Systems	7 Wolter, 27 electroformed Nickel shells per system
Detector	6×6 cm^2 XMM pn-CCD, Pixel size 150μ, shared FOV
Operating Temperature	-80 ^oC, ambient cooling
Spacecraft	3-axis angular momentum stabilized
Attitude Control	1 Momentum wheel, 3 magnetic torquers
Attitude Sensors	2 sun sensors, 3-axis magnetometer, 1 laser gyro
Attitude Determination	2 star trackers, GPS
Size	$2.5 \times 1.8 \times 1.2m^3$
Mass	$\sim$ 460 kg
Power	$\sim$ 200 W
Orbit Height	$\sim$ 580 km circular, Inclination 51^o
Launch	COSMOS rocket, Spring 1999 from Kapustyn Yar
Lifetime (goal)	3 years
Number of Surveys	6, Average exp. time 4.000 s

a scanning mission like ABRIXAS to avoid source blurring along the scan direction (70 ms correspond to a scan path of 17 arc sec).

ABRIXAS is a small (low cost) satellite with a mass of 460 kg to be launched by a Cosmos rocket purchased from Polyot. The satellite is developed and built by OHB Bremen with ZARM as the subcontractor for the attitude measurement and control system, c.f. Table 2. The X-ray mirrors are produced by Carl Zeiss and tested in MPE's Panter facility. The CCD camera is developed and built at the MPI/MPE Semiconductor Laboratory with parts of the readout electronics being provided by IAAT. The ground station will be operated by DLR/GSOC, while the overall project management will be done by DLR as the successor of DARA. The launch of ABRIXAS will take place in spring 1999 from Kapustyn Yar, the Russian equivalent of Huntsville, which is located east of Volgograd.

Acknowledgements

We are grateful for the enthusiastic support by the ABRIXAS teams in the funding agency, in industry and in the scientific institutes.

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https://doi.org/10.1017/S0074180900114482 Published online by Cambridge University Press