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EUVITA - an Extreme UV Imaging Telescope Array with Spectral Capability

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Abstract. *EUVITA is a set of 8 extreme UV and soft X-ray normal incidence imaging telescopes, each of them sensitive in a narrow band ($\lambda/\Delta\lambda = 15$ to 80), centered at wavelengths between 50 and 175 Å. Each telescope has an effective area of a few cm², a field of view of 1.2° and an angular resolution of 10 arcseconds. EUVITA will be flown on the Russian mission SPECTRUM X-G. This satellite will be launched in a highly eccentric orbit with a period of 4 days, allowing long, uninterrupted observations (e.g. 10⁵ seconds). The present paper includes an overview of EUVITA's scientific capabilities and a short description of the instrument. Simulations of various types of sources show EUVITA's capability to detect galactic and extragalactic EUV sources. EUVITA's narrow spectral bands allow the measurement of source parameters such as temperature or power law index as well as interstellar absorption, and will resolve groups of strong lines emitted by optically thin hot plasmas.*

1 Introduction

Observations in the extreme UV (EUV) and soft X-ray bands are limited by interstellar absorption and blocking by the earth's atmosphere. However, the interstellar medium is not uniformly distributed. K. Jahoda et al. (1990) show that the column density of neutral hydrogen can be as low as 4.4×10^{19} cm⁻² in small areas of the sky. Elvis et al. (1989) estimate that roughly 1 % of the sky has a total galactic hydrogen column density less than 9×10^{19} cm⁻². Galactic and extragalactic observations are possible in these windows as has been shown by missions on sounding rockets and satellites. The history of EUV astronomy spans little more than two decades. In 1976 the Apollo-Soyuz mission (S. Bowyer, 1991) showed that it was possible to detect sources at these wavelengths. Later, from 1983 to 1986, the European X-ray Observatory EXOSAT provided the first detailed look at astronomical

objects between 6 and 400 Å, i.e. 0.03-2 keV (for a review see N. White, 1991). The ROSAT Wide Field Camera (WFC) is sensitive in the EUV from 0.02-0.2 keV (60-600 Å) and has carried out an all-sky survey yielding 384 relatively bright EUV sources (K. Pounds et al. 1992). More recently, the Extreme Ultraviolet Explorer (EUVE) mission launched in June 1992, is designed to make both spectroscopic and wide-band observations over the entire EUV region from 70 to 700 Å (i.e. 0.018-0.17 keV) (Bowyer and Malina, 1991). Finally, among planned EUV/soft X-ray missions, the ALEXIS experiment consists of an array of narrow band, wide field-of-view telescopes, with multilayer mirrors sensitive at 66, 72 or 93 keV (188, 172 and 133 Å) (W. Friedhorsky, 1991).

The EUVITA (Extreme UV Imaging Telescope Array) experiment will be flown on the Russian Spectrum-X-G satellite along with several other experiments such as SODART (covering the range 0.2 to 20 keV, i.e. 0.6-60 Å), JET-X (0.3-10 keV, or 1.2-40 Å), MART-LIME (4-100 keV, 0.12-3 Å) and TAVUEX (0.004-0.008 keV, 1500-3000 Å). EUVITA is sensitive from 0.06 to 0.26 keV (i.e. 45-200 Å), with an angular resolution of 10 arcseconds FWHM, and a spectral resolution of $\lambda/\Delta\lambda = 15$ to 80, and is thus complementary to the other experiments aboard. The 8 EUVITA imaging telescopes¹ will be placed along the principal axis of Spectrum-X-G, co-aligned with the instruments mentioned above. Such a combination allows a very wide spectral coverage of the objects to be observed. This coverage is essential for understanding the emission mechanisms of the various sources and for deconvolving the emitted spectrum from interstellar effects. The EUVITA bandpasses are at energies corresponding to the maximum of spectral energy distributions of black bodies with temperatures $T = 3 \times 10^5$ to 10^6 K. All EUVITA telescopes will be operated simultaneously so that the variability of the spectral properties of sources will be monitored continuously. This is more difficult with instruments in which wavelengths are successively selected by filter wheels (as with EXOSAT or ROSAT).

Table 1 gives a comparison of EUVITA with some of the other EUV/soft X-ray experiments mentioned above. Of all these, EUVITA is the only imaging experiment with narrow band spectral capability. Its good angular resolution competes with the best imaging X-ray telescopes. The maximal effective area of each EUVITA telescope is comparable to the effective areas of the spectroscopic instruments listed in Table 1. The 4 day orbit and the excellent pointing capability of the Spectrum-X-G satellite will allow uninterrupted observation times of up to 10⁵ seconds, considerably longer than the standard observations on ROSAT or EUVE.

There is a wide range of astrophysical objects for which EUVITA observations can bring data essential for the understanding of their nature. These include objects in the solar system, single stars, single or interacting compact stars, interstellar medium, galaxies, active galactic nuclei and clusters of galaxies.

¹The number of telescopes is still in discussion.

Figure 1: Schematic view of a EUVITA telescope with its multilayer mirror and detector box.

experiment description	EUVITA array of eight imaging telescopes	EXOSAT LE imaging mode	TGS mode	ROSAT WFC filters S1 & S2	EUVES DS/S short wave spectrometer	deep survey
mirror	grazing incidence					
	normal incidence					
	multilayer coated					
field of view [°]	1.2	2		5	2.1	
angular resolution, FWHM [arcsec]	10.0	24		60 - 180	18	
bandpass [Å]	45 - 200	6 - 250		60 - 200	70-190	40 - 385
max. effect. area [cm ²]	1-10.0	≤ 12.0		≤ 15	≤ 2.15	32 & 11.6
spectral resolution λ/Δλ	see Table2					
	15-80	-	25-60	-	160-280	≤ 0.76

Table 1: Comparison of EUV experiments: EUVITA, EXOSAT LEIT telescope with CMA detector (N. White, 1991), ROSAT WFC (K., Pounds et al, 1992) and EUVES DS/S telescope with SW spectrometer or Deep Survey instrument (EUVES Handbook, 1992).

telescope number	1	2	3	4	5	6	7	8
field of view (FOV) [°]	1.2							
angular resolution [arcsec]	≈ 10							
mirror	normal incidence multilayer mirror							
useful mirror area [cm ²]	221							
central wavelength λ_0 [Å]	175	149	132	102	83	70	59	49
resolution $\lambda_0/\Delta\lambda$	15	20	30	50	60	60	60	80
max. refl. [%]	30	45	40	10	10	10	10	10
filter	Al/C	Lex/Be	Lex/Be	Lex/Ti/B	Lex/Sn	Lex/Sn	Lex/Sn	Lex/Sn
grid transmissivity	0.64							
	maximum effective areas [cm ²] with different photocathodes:							
MgF ₂	4.3	4	5	0.8	1	1.6	1.2	0.7
CsI	4.6	5.3	8.4	1.3	0.8	1	0.9	1
KBr	3.9	4.1	5.8	1.5	1.9	3	2.4	1.9
NaBr	7.5	7.7	10.4	1.8	2.1	3.2	2.8	2.5
	grasp (I) [Å] with different photocathodes:							
MgF ₂	2.8 10 ⁻¹	2.0 10 ⁻¹	1.5 10 ⁻¹	1.7 10 ⁻²	9.1 10 ⁻³	1.2 10 ⁻²	8.5 10 ⁻³	3.2 10 ⁻³
CsI	3.0 10 ⁻¹	2.8 10 ⁻¹	2.5 10 ⁻¹	2.7 10 ⁻²	7.5 10 ⁻³	7.5 10 ⁻³	6.4 10 ⁻³	4.4 10 ⁻³
KBr	2.7 10 ⁻¹	2.1 10 ⁻¹	1.8 10 ⁻¹	2.8 10 ⁻²	1.8 10 ⁻²	2.3 10 ⁻²	1.7 10 ⁻²	9.0 10 ⁻³
NaBr	4.9 10 ⁻¹	3.9 10 ⁻¹	3.2 10 ⁻¹	3.7 10 ⁻²	1.9 10 ⁻²	2.5 10 ⁻²	2.0 10 ⁻²	1.1 10 ⁻²

Table 2: Parameters describing the EUVITA bandpasses: the central wavelength of the peak, bandwidth of the peaks with $\Delta\lambda = \text{FWHM}$, the peak reflectivities, and the filters used for each telescope. The maximum effective areas and the "grasp" I (see section 4) are given for different filters.

Figure 2: Dots: mirror reflectivity (unitless), long dashes: filter transmission (unitless) and dash-dots: quantum efficiency (unitless) of the NaBr photocathode, and their contribution to the effective area in cm^2 (full line) of telescope 5 centered at 83 Å.

Figure 3: The curve shows the flux of the hot white dwarf HZ43. The triangles mark the minimal detectable fluxes of the EUVITA telescopes for a NaBr photocathode and an observation time of 10^5 seconds. The sensitivity of the EUVE instruments (Bowyer and Malina, 1991a) is given for comparison.

Figure 4: Effective areas for the EUVITA telescopes with photocathodes of MgF_2 (full line), CsI (dots), KBr (dashes) and NaBr (dash-dots)

2 Instrument characteristics

This section briefly describes the EUVITA instruments. More detailed technical information will be given by Zehnder et al. (in preparation). Figure 1 gives a schematic view of one EUVITA telescope. Each telescope has a normal incidence multilayer coated parabolic mirror. The diameter of the mirrors is 20 cm with a focal length of 140 cm. The relative thickness of the individual layers of mirror coating defines the reflectivity as a function of the wavelength (see figure 2). It is possible to produce multilayers for the EUV with peak reflectivities of 10 to 45 % and a bandwidth smaller than 10 % FWHM.

The EUVITA-detector will be mounted on-axis at the prime focus of the mirror in the detector electronic box supported by a spider arrangement. Note that in such a configuration the detector does not point towards open space. The detector box will also contain the front-end detector electronics. It consists of a microchannel plate stack (MCP) in zigzag configuration and a wedge and strip position sensitive readout anode (Siegmond et al., 1986). The ion grid prevents positive ions from reaching the detector. A broad band metallic filter is mounted close to the front of the MCP stack so as to block off photons with energies lower than the bandpass peaks of the mirrors, in particular in the far UV region where the mirror reflectivity increases.

In order to enhance the quantum efficiency a photocathode layer is deposited directly onto the top MCP. Further quantum efficiency enhancement is obtained by applying a negative bias to the filter mesh mounted in front of the MCP. In this way electrons emitted from the MCP surface are forced back into the MCP channels without any loss of spatial resolution. The front-end electronics are mounted directly behind the detector. This design ensures low noise levels.

The useful geometric mirror area is 221 cm² on-axis, taking into account the shadow of the detector and support. The field of view is 1.2 degrees (diameter). The angular resolution of the telescope is given by the aberration of the mirror, the spatial resolution of the detector and the jitter of the telescope and is roughly 10 arcseconds.

The designs of the individual telescopes are identical. The telescopes differ only in the multilayer coatings of the mirrors, in the filters and in the photocathode materials. These three elements define the bandpass of each telescope and are chosen in such a way as to optimise the overall sensitivities.

3 Effective areas

The EUVITA bandpasses are described in table 2. The various components listed in this table are not yet definitively optimised, but should serve as a guide for the scientific discussion below.

Figure 2 shows how the mirror reflectivity, the filter transmission and photocathode quantum efficiency contribute to the effective area of telescope 5, centered at 83 Å. Globally, the mirror reflectivities follow Lorentzian profiles with an increase in the UV determined by the reflectivity of the mirror substrate (Silicium). The reflectivities used in this paper are based on both measurements and calculations performed in the EUV by the Nizhny Novgorod group.

The effective area for each telescope is plotted as a function of wavelength in figure 4. Beyond 1000 Å, the effective areas of the detectors have dropped well over 6 orders of magnitude below peak areas. For the present simulations, MgF₂, CsI, KBr and NaBr photocathodes have been considered in turn, and a global transmissivity of 0.64 has been used for the filter mesh and the ion repelling grid.

4 Minimum detectable fluxes

The signal to noise ratio $\frac{S}{N}$ is given by :

$$\frac{S}{N} = \frac{S}{\sqrt{S + (1 + \frac{1}{k})N_{bgd}}} \quad (1)$$

where S is the number of counts per detection area (see below), N_{bgd} the background counts per detection area, and k is the number of detection areas from which the average sky and detector noise background are measured. In the present case k is large enough so that $(1 + \frac{1}{k}) \sim 1$. By inverting (1) one obtains the minimal number of counts per detection area necessary to achieve the desired $\frac{S}{N}$ ratio:

$$S_{min} = \frac{1}{2} \times \left(\frac{S}{N}\right)^2 \times \left[1 + \sqrt{1 + 4 \times \frac{N_{bgd}}{(\frac{S}{N})^2}}\right] \quad (2)$$

The minimum detectable flux $F_{min} \left[\frac{\text{photons}}{\text{cm}^2 \times \text{sec} \times \text{Å}} \right]$ for a pointlike source is then:

$$F_{min} = \frac{S_{min}}{\text{Surface} \times P \times t \times I} \quad (3)$$

where P is the percentage of all the detected counts falling in one detection area, t is the observation time, and $Surface$ is the effective area of the mirror. I is the integral over all wavelengths of the product of the mirror reflectivity, the filter and mesh transmissivity and the photocathode quantum efficiency. I is also called the “grasp”, and is given in table 2 for each telescope and for different filters.

In order to determine the minimal detectable fluxes we consider a circular detection area of radius $40 \mu\text{m}$ on the MCP surface. For a Gaussian point spread function with a $50\mu\text{m}$ FWHM (corresponding to ~ 7 arcsec) 83% of the total counts will be collected within this detection area ($P = 0.83$). The total background in orbit is expected to be of the order of 10 counts/sec over the 7.55 cm^2 surface of the MCPs. Therefore a value of $S_{\min} = 13.5$ counts per detection area is necessary to detect a source with a signal to noise ratio $\frac{S}{N} = 3$ in $t = 10^5$ sec. The corresponding minimal fluxes $F_{\min}$ for the individual telescopes are listed in table 3. In figure 3 these numbers are compared with the EUV flux of the hot white dwarf HZ43. The following calculations show that the point source observations are limited by photon noise, while the extended sources are limited by the background flux.

The contribution of geocoronal emission to the total background in orbit has been evaluated with the “worst case” airglow model used for EUVE (EUVE Guest Observer Handbook, op. cit.). The geocoronal count rate for EUVITA is calculated by multiplying the intensity of a given geocoronal line (in photons per square centimeter, per second and per steradian) by the field of view of our instrument and by the effective area at this wavelength. The HeI (256 Å), HeII (304 Å), HeI (584 Å) and H I Lyman α (1216 Å) lines are potentially the most important contributors to EUVITA’s red leak. However the filters maintain this background contamination at a low level with count rates under 0.03, 3, 1.2 and 0.032 counts per second, per telescope, respectively. In addition, the satellite SPECTRUM X-G will spend much time near apogee, above the geocorona, at an altitude of about 200’000 km.

telescope number	1	2	3	4	5	6	7	8
Min. det. flux	1.5	1.9	2.3	20	39	29	37	65

Table 3. Minimal detectable fluxes $F_{\min}$ [10^{-6} photons/ $\text{cm}^2 \text{ sec } \text{\AA}$] for a NaBr photocathode and an observation time of 10^5 seconds.

5 Scientific capability

A series of model spectra has been calculated for different galactic and extragalactic EUV sources, known or potential. For several of these sources the exact shape of the EUV to soft X-ray spectral energy distribution is still unknown, and has been modelled by blackbody or power law spectra. These spectra were folded with the interstellar extinction (given by the appropriate hydrogen column density in the line of sight and the photoelectric cross sections of Morrison and McCammon, 1983) and with the effective areas of the different EUVITA telescopes. Simple integration of the resulting spectra over the wavelength range (in the present case our calculations go from 1 to 1000 Å) then yields the expected count rates. Our results are valid for NaBr photocathodes and are summarised in table 4. In the following discussion we assume a typical observation duration of 10^5 seconds and require a $\frac{S}{N}$ ratio equal to or greater than 3 for a successful source detection.

Late-type stars are the main population in the solar neighborhood. EINSTEIN and EXOSAT observations have shown that almost all late-type cool dwarf stars are soft X-ray emitters (Pallavicini, 1989). It is generally accepted that these soft X-rays originate in the thermal line and continuum emission from the optically thin (usually multi-temperature) plasma composing the hot coronae surrounding the stars. Flare activity of late-type stars is also known to emit considerable flux. EUV observations of plasmas with temperatures up to several 10^6 K are necessary in constraining theoretical models for the processes heating the coronal plasma (i.e. the conversion of magnetic energy into thermal energy). The spectral resolution of EUVITA will not allow the observation of individual lines. Yet measuring the flux from groups of strong lines will be possible and should lead to a better knowledge of coronal temperature structure.

The stellar densities given by Allen (1973) lead to a total of ~ 400 F, G, K and M stars within a radius of 10 pc. The ROSAT Wide Field Camera identified 181 late-type stars of spectral class F to M during its all-sky survey (Pounds et al., 1992). When accounting for incompleteness of their survey, this number agrees well with numbers predicted from the scaling of EINSTEIN late-type star luminosity functions, except that the number of observed M stars is lower than predicted.

A model spectrum for a typical stellar corona has been calculated by summing up the emission from an optically thin plasma (Mewe et al., 1985) with three separate temperature components: $T = 4 \times 10^5$ K, $T = 10^6$ K and $T = 3 \times 10^6$ K, with the following emission measures ($EM = \int n_e^2 dV$, where n_e is the electron density) $EM = 3 \times 10^{50} \text{ cm}^{-3}$, $EM = 2 \times 10^{51} \text{ cm}^{-3}$ and $EM = 10^{52} \text{ cm}^{-3}$ respectively. This model, based on observed values, corresponds to the one used by Vedder et al. (1991) for evaluating the number of sources observable with EUVE. At a distance of 10 pc and assuming a high value of hydrogen column density ($5 \times 10^{18} \text{ cm}^{-2}$), the model source

is detected by all EUVITA telescopes. The contribution from the lines dominates in the wavebands at lower energies and leads to relatively high count rates (from over 0.1 counts/sec in telescope no. 1, to a minimum of 7×10^{-4} in telescope 8). If the model source is placed at 25 pc, and assuming the same absorbing column density as before ($5 \times 10^{18} \text{ cm}^{-2}$ corresponding to a volume density $n_H = 0.07 \text{ cm}^{-3}$ at a distance of 25 pc), only the low energy wavebands (telescopes no. 1 to 4, and 6) will measure significant count rates.

Hot O-B stars emit most of their radiation in the FUV and EUV but are not abundant in the solar neighborhood. The ROSAT Wide Field Camera all-sky survey contains only 8 possible identifications. It is believed that the coronae of early-type stars are heated by shocks in the stellar wind (unlike the coronae of late-type stars), however the heating mechanism is not fully understood. In order to simulate EUVITA count rates we have calculated a model for an isothermal outer corona, based on EINSTEIN data for the B1 star α Vir (Kudritzki et al. 1991). We have used the emission from an optically thin plasma (Mewe et al., 1985) at $\log(T) = 6.3$ K, the emission measure of the source is 10^{53} cm^{-3} . α Vir is at a distance of 86 pc, and the absorbing column density is between 3×10^{18} and 10^{19} cm^{-2} . This hot star will be observed by EUVITA telescopes 1 to 3, 6 and 7, with 2×10^{-3} to 2×10^{-4} counts/sec.

Single compact stellar objects also can be EUV emitters. The hydrogen-dominated atmospheres of isolated hot ($T_{\text{eff}} \geq 2 \times 10^4 \text{ K}$) white dwarfs are transparent to soft X-ray radiation originating from thermal emission in their photospheres. The effective temperature and gravity of white dwarfs can be obtained by comparing observations at all wavelengths with spectra obtained from model atmospheres. The EUV and soft X-ray observation of white dwarfs is necessary for understanding the evolutionary link between the final stages of low mass stars and the beginning of the WD phase. Moreover, white dwarfs are numerous: EXOSAT was able to observe about 20 in its low energy range, and the ROSAT Wide Field Camera all-sky survey identified 119 white dwarfs (Pounds et al., 1992). The effective temperature of hot white dwarfs is lower than the temperature range in which EUVITA is the most sensitive ($T = 3 \times 10^5$ to 10^6 K), however we expect nearby sources to be well detected in the lower energy wavebands. EUVITA's spectral capacity can be used to discriminate between models of white dwarf atmospheres. Different models predict significantly different fluxes across several ionisation edges (due to O and Ne).

One very strong galactic EUV source is the hot white dwarf HZ 43. Heise et al. (1988) give a description of the complete electromagnetic spectrum of HZ 43 based on fluxes measured in the optical to soft X-ray bands. We calculated an empirical model spectrum from this data. The temperature of HZ 43 is $T_{\text{eff}} = 45,000 - 54,000 \text{ K}$. This source will be detected by all telescopes with count rates from 5 counts/sec (telescope 1) down to about 2×10^{-3} counts/sec (telescope 8), assuming interstellar absorption $N_H = 2 \times 10^{18} \text{ cm}^{-2}$.

Another type of source is thermal emission from the hot surface of *single neutron stars*. Surface temperatures of cooling neutron stars are expected to be in the range $10^5 \leq T \leq 10^{8.5}$ for ages between 10^3 to 10^6 years (Ögelman, 1991). The X-ray luminosities (including thermal and non-thermal energy sources) range from 10^{28} to 10^{36} erg/sec (Seward and Wang 1988). Therefore sufficiently nearby and unabsorbed neutron stars could be observed in soft X-rays. The EINSTEIN Observatory clearly detected X-ray emission from 10 radio pulsars, which EXOSAT was also able to observe, and ROSAT is expected to double this number. Such observations are important for understanding the internal structure of neutron stars, and to test theories of neutron star re-heating processes. However there are difficulties in distinguishing the thermal emission from magnetospheric or nebular emission (Ögelman, 1991). The measurement of the temperature of a neutron star is subject to precise knowledge of the interstellar absorption. Furthermore, pulsar distance measurements are to be considered very critically (Frail and Weisberg, 1990). PSR 0833-45 is the central pulsar identified with the Vela supernova remnant, and is among the brighter pulsars observed by EINSTEIN (Seward and Wang, 1988). A blackbody model of this source with a temperature of 10^6 K , a distance of 500 pc, a radius of 12 km and an absorbing column density of $N_H = 2 \times 10^{20} \text{ cm}^{-2}$ gives count rates between 3.5×10^{-4} counts/sec and 10^{-3} counts/sec for telescopes 6, 7 and 8. This source will not be observed by the lower energy telescopes, partly because their bandpasses are more affected by absorption, and then because the blackbody continuum peaks towards the higher energies.

Accretion driven stellar sources are among the brightest soft X-ray sources. Cataclysmic variables (CVs) are a large group of interacting binary systems containing a white dwarf accreting matter from a normal stellar companion by way of an accretion disk. The surface temperature of the compact star is higher than if it were an isolated star. Furthermore, the accretion disk and the boundary layer of this disk are predicted to emit substantially in the EUV and soft X-rays. The space density of CVs in the solar neighbourhood has been estimated at a few times 10^{-6} pc^{-3} (Wade and Ward, 1985). The ROSAT WFC observed 17 CVs and 5 AM Her-type magnetic CVs.

Observations of CVs with EUVITA were simulated by using the boundary layer models of Wade (1991) for a white dwarf with mass $M = 1.3 M_{\odot}$ at a distance of 125 pc (appropriate for the SS Cyg system). Wade's models depend on the fraction f of the surface area of the WD from which the boundary layer radiates. Simulations using models for $f = 1$ and $f = 0.01$, and with absorbing column densities up to $N_H = 3.5 \times 10^{19} \text{ cm}^{-2}$ yield high count rates (0.3 to 23 counts/sec at $N_H = 3.5 \times 10^{19} \text{ cm}^{-2}$). However the non-observation of the CV VWHy1 by Voyager may suggest that boundary layers are less luminous than expected (R. Polidan et al., 1990). Therefore, another CV model was computed using ROSAT results for VWHy1 (T. Belloni et al., 1991). The ROSAT spectrum was well fitted with optically thin thermal emission at

a temperature of 2.17 keV , with a flux at earth of $1.2 \pm 0.2 \times 10^{-11} \text{ erg cm}^{-2}$ between 0.08 and 2.4 keV . This CV has extremely low interstellar absorption ($N_H < 9.0 \times 10^{17} \text{ cm}^{-2}$), and its distance is estimated at 65 pc . Our model of VWHy1 is based on the ROSAT parameters. We consider optically thin plasma emission (calculated by Mewe et al. 1985) with an emission measure $EM = 6.1 \times 10^{23} \text{ cm}^{-3}$. This EM corresponds to the flux measured by ROSAT. According to this model EUVITA will detect VWHy1 in all telescopes (2×10^{-4} to 1×10^{-2} counts/sec, with $N_H = 10^{18} \text{ cm}^{-2}$). The contribution from a few strong lines is large for telescopes 1 to 4 (15 to 70 % with $N_H = 0$).

Among extragalactic X-ray sources let us consider *clusters of galaxies*. X-ray imaging and observations with spectrometers have shown that the main X-ray emission process in clusters of galaxies is bremsstrahlung and line emission from the intra-cluster medium (ICM) (Forman and Jones 1990). The ICM has temperatures of typically $10^7 - 10^8 \text{ K}$ and densities of $10^{-4} - 10^{-2} \text{ cm}^{-3}$. In many of the observed clusters there exist dense cores where inflowing gas cools down to temperatures far below 10^7 K (Fabian, Nulsen and Canizares 1991). The combination of several imaging telescopes like those of EUVITA could be a powerful instrument to derive the temperature and density profile of the ICM. Recently Sarazin, O'Connell and McNamara (1992) presented ROSAT X-ray images of the center of the cooling flow cluster A2029 which show highly structured X-ray emission (filaments) in the central region. With its good angular resolution (10 arcseconds) and its maximal sensitivity for emission from plasmas with $T \sim 10^6 \text{ K}$, EUVITA could be able to map the innermost regions of the clusters and provide information about the structure of the cooling flow regions. We simulated among others the cluster A2199 which has a low column density of $7 \times 10^{19} \text{ cm}^{-2}$ and a red-shift of $z=0.0309$. To derive the total emissivity of the intra-cluster gas and its spatial distribution, it was split into several concentric shells. For each shell a constant temperature and density was assumed, which defined the emitted plasma spectrum. The code of Mewe et al. (1985) was used to calculate the spectra for solar abundances. The temperature and density profiles were taken from K.A. Arnaud (1988). The resulting count rates are low compared to the background count rates expected from the large area covered by the image of the cluster. In the case of A2199 the simulated EUVITA image has a radius of 3 mm on the MCP (7.2 arcmin). The feasibility of observations of such diffuse sources will therefore crucially depend on the background rate observed in orbit. Furthermore the model we used does not take into account any more condensed filamentary structures. Clusters with lower N_H values are being investigated.

Active Galactic Nuclei (AGN) are still another class of extragalactic EUV sources. Observation of EUV and soft X-ray emission from AGN is essential in constraining theoretical models of AGN accretion disks (Courvoisier and Clavel, 1991). In particular, the EUVITA wavebands will detect radiation from the poorly known, high energy end of the UV continuum excess (or 'blue bump') characteristic for quasars

and Seyfert galaxies, where this excess component is expected to decrease and join the high energy power law spectrum. The blue bump has often been associated with thermal emission from the surface of an accretion disk. Furthermore, the spectral survey of AGN performed by EXOSAT indicates that approximately 50 % of all unobserved sources show evidence for an EUV excess (or 'soft excess') above their X-ray power law spectrum (Turner and Pounds, 1989).

Recent observations of the quasar 3C273 with the ROSAT proportional counter in the $0.1-2.4 \text{ keV}$ energy range (Staubert et al., 1991) establish a clear soft excess component varying in time independently from the hard X-ray flux. The exact shape of the EUV spectrum below 0.1 keV is unknown (see Courvoisier et al. 1987, for a discussion of the overall energy distribution). A minimal EUV/soft X-ray emission model of quasar 3C273 ($z = 0.158$) is given by a power law with an energy index $\alpha = 1.8$, and normalised to $32 \mu\text{Jy}$ at 10^{17} Hz in the observer's frame. This model yields detectable count rates (1.5×10^{-4} to 1.7×10^{-3} counts/sec) in telescopes 5 to 8, assuming $N_H = 2.5 \times 10^{20} \text{ cm}^{-2}$. The fluxes in the remaining bandpasses are absorbed and are below the 3 sigma detection limit given above.

A source with a more powerful soft excess, Seyfert 1 galaxy PG1211+143, is well fitted by a double power law (Bechtold et al. 1987, Comastri et al., 1992). The power law in the soft X-ray region has an energy index $\alpha = 3.3$, the power law break is at 0.67 keV in the object rest frame. At this energy the observed flux is normalised at $3.92 \mu\text{Jy}$ ($z = 0.085$). Assuming a galactic hydrogen column density $N_H = 2.8 \times 10^{20} \text{ cm}^{-2}$, this model of PG1211+143 is detected by telescopes 5 to 8 (with count rates from 2.3×10^{-4} to 2.4×10^{-3} counts/sec).

source: distance: $N_H \text{ cm}^{-2} \rightarrow$ telescope ↓	cool star 10 pc $5 \cdot 10^{18}$	hot star 86 pc 10^{19}	HZ43 62 pc $2 \cdot 10^{18}$	neutron star 500 pc $2 \cdot 10^{20}$	CV 65 pc 10^{18}	3C273 $z=0.158$ $2.5 \cdot 10^{20}$	1211+143 $z=0.085$ $2.8 \cdot 10^{20}$
1	$1.1 \cdot 10^{-1}$	$2.4 \cdot 10^{-3}$	5.1	$1.9 \cdot 10^{-5}$	$5.6 \cdot 10^{-3}$	$2.8 \cdot 10^{-5}$	$2.7 \cdot 10^{-5}$
2	$1.1 \cdot 10^{-2}$	$1.9 \cdot 10^{-3}$	3.5	$3.7 \cdot 10^{-5}$	$4.4 \cdot 10^{-3}$	$5.5 \cdot 10^{-5}$	$5.8 \cdot 10^{-5}$
3	$7.2 \cdot 10^{-3}$	$5.1 \cdot 10^{-4}$	2.4	$3.4 \cdot 10^{-6}$	$1.2 \cdot 10^{-2}$	$5.8 \cdot 10^{-6}$	$7.1 \cdot 10^{-6}$
4	$1.3 \cdot 10^{-3}$	$8.1 \cdot 10^{-5}$	1.8	$1.0 \cdot 10^{-5}$	$5.2 \cdot 10^{-4}$	$2.1 \cdot 10^{-5}$	$3.1 \cdot 10^{-5}$
5	$1.0 \cdot 10^{-3}$	$4.2 \cdot 10^{-5}$	3.9	$6.8 \cdot 10^{-5}$	$3.9 \cdot 10^{-4}$	$1.5 \cdot 10^{-4}$	$2.3 \cdot 10^{-4}$
6	$1.5 \cdot 10^{-3}$	$1.9 \cdot 10^{-4}$	2.4	$3.5 \cdot 10^{-4}$	$4.6 \cdot 10^{-4}$	$7.9 \cdot 10^{-4}$	$1.3 \cdot 10^{-3}$
7	$7.5 \cdot 10^{-4}$	$2.3 \cdot 10^{-4}$	7.0	$8.8 \cdot 10^{-4}$	$4.0 \cdot 10^{-4}$	$1.7 \cdot 10^{-3}$	$2.4 \cdot 10^{-3}$
8	$6.6 \cdot 10^{-4}$	$1.1 \cdot 10^{-4}$	1.9	$1.0 \cdot 10^{-3}$	$2.4 \cdot 10^{-4}$	$1.7 \cdot 10^{-3}$	$2.0 \cdot 10^{-3}$

Table 4: Simulated count rates in counts per second for the different model spectra mentioned in the text and with a NaBr photocathode.

6 Synthetic photometry

The aim here is to investigate how EUVITA observations can be used to measure the astrophysical properties of a given source. Calculations were made with different emission models applicable to astrophysical sources (black body, power law and optically thin plasma models). For each model we compute flux ratios between EUVITA bandpasses for different source parameters. These ratios prove to be good indicators of both the source parameters and the amount of absorbing galactic hydrogen.

R. Mewe et al. (1985, 1986) have computed continuum emission and line power output for an optically thin thermal plasma in ionisation equilibrium for several electron temperatures T_e . This type of plasma is found in stellar coronae, supernovae remnants and clusters of galaxies. In the case of AGN, the soft excess emission process is unknown, significant contribution might however be expected from a hot corona surrounding the accretion disc. In the following simulations a red-shift $z=0$ was taken and line profiles were not taken into account, since natural broadening and thermal Doppler broadening for temperatures below 10^8 K are small: $\Delta\lambda \sim 10^{-4}$ [Å] and $\Delta\lambda/\lambda \leq 10^{-3}$. However macroscopic velocity fields greater than 3000 [km/s] would produce Doppler broadenings of $\Delta\lambda/\lambda \geq 10^{-2}$; this is no longer negligible, especially for the narrower bandpasses. Flux ratios between pairs of EUVITA telescopes were calculated for 13 electron temperatures between $\log(T) = 5.6$ and 6.8. For temperatures between $\log(T) = 5.6$ and 6, and no absorption, the lines contribute more than 80% of the total observed flux in all EUVITA telescopes. Exact knowledge of the bandpass profiles is crucial since these flux ratios are sensitive to the location of the bandpass peak. Figure 5 shows which lines contribute to the EUVITA bandpasses. It also illustrates how the bandpasses have been distributed in energy so as to measure different groups of strong emission lines. Figure 6 illustrates the ratio between line and continuum flux for each telescope in the case of unabsorbed emission. Figure 7 shows the contours of equal flux ratios for two pairs of EUVITA telescopes: $\text{flux}(1)/\text{flux}(3)$ and $\text{flux}(7)/\text{flux}(8)$. These ratios have been calculated for an optically thin plasma source. Figure 7 also shows how these ratios depend on the absorbing column density and on the temperature of the plasma. These graphs, together with the sensitivity to groups of lines, demonstrate that EUVITA will not only be able to measure temperatures, but will give other information about sources, like the ionisation mechanism and the abundance of heavy elements.

Figure 5: The spectrum of an optically thin thermal plasma at $\log T = 5.6$ and 6 (see R. Mewe et al. 1985, 1986). The continuum flux units are photons per second per Å and per cubic centimeter of source plasma [photons $\cdot \text{cm}^{-3} \cdot \text{Å}^{-1}$], assuming an electron density $n_e = 10^{10} \text{ cm}^{-3}$, whereas the line flux should be read in [photons $\cdot \text{cm}^{-3} \cdot \text{Å}^{-1}$], in absolute value above the continuum. Only the stronger lines have a label. The EUVITA wavebands are also plotted in normalised, logarithmic scale, for comparison.

Figure 5: continued

Figure 6: Ratio between line and continuum flux for each telescope in the case $N_H = 0$.

Figure 7: *Optically thin plasma: contour plot of logarithmic flux ratios for two pairs of EUVITA telescopes. Full lines: $\text{flux}(1)/\text{flux}(3)$. Thin lines: $\text{flux}(7)/\text{flux}(8)$.*

7 Conclusion

EUVITA has a good angular resolution (10 arcsec) over a field of view of 1.2° , with an effective area comparable to that of presently flown instruments. The novel feature of EUVITA is that it combines these 'standard' properties with a spectral resolution of a few Å. This should allow to resolve prominent groups of emission lines.

We have demonstrated that EUVITA will be able to detect several classes of galactic, and in favorable cases extragalactic sources, at signal-to-noise levels which are sufficient to allow a measurement of the source parameters in the EUV. For known sources, the bandpass combination allows to measure independently the source characteristics and the intervening column density.

The EUV and soft X-ray domain is still largely unexplored. In addition to the determination of astrophysical quantities in a new spectral region for known sources, we expect that instruments of the class of EUVITA will also produce a number of unexpected results. It is indeed true that each time that a new spectral window has been opened to astronomical investigations, new and exciting physical phenomena have been unveiled.

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