STATUS & PROSPECTS OF THE X-RAY ASTRONOMY SATELLITE ASTRO-H

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The ASTRO-H satellite is an X-ray astronomy satellite currently planned to be launched in 2015. It is a successor of the series of Japan's X-ray astronomy satellites, and is being developed under an international collaboration with the US, some European countries, and Canada. The satellite carries four scientific payloads: SXS (soft X-ray spectrometer), SXI (soft X-ray imager), HXI (hard X-ray imager), and SGD (soft gamma-ray detector), providing a non-dispersive high-resolution spectroscopic capability with SXS and a wide energy coverage with the four instruments. We present the status of the development and some of the scientific prospects related to the interest of the session, which includes high-resolution X-ray spectroscopy of neutron stars.

Keywords: X-ray; instrument; neutron stars.

1. ASTRO-H Satellite

ASTRO-H[1] is an X-ray astronomy satellite. It is sixth in the series of Japan's X-ray observatories, and is currently being designed and built based on the experience of our continuous 35 years of the X-ray observatory programs, as well as a wide international collaboration of many space agencies and universities both in the European and North American regions.

It is planned to be launched in 2015 with an HII-A rocket from the Tanegashima space station into a near-earth orbit with an altitude of ∼550 km and an inclination angle of ∼31 degrees. It has a length of 14 meters when extended and a weight of 2.7 metric tons, making it the heaviest scientific satellite ever launched from Japan. We anticipate the mission life of at least 3 years.

ASTRO-H is equipped with a suite of scientific tools. There are a total of four X-ray telescopes, two of them are dedicated for soft X-ray optics below 10 keV, and the other two are for hard X-rays above 10 keV. At the focus of the two soft X-ray telescopes, there is the Soft X-ray Imager (SXI), which is the X-ray CCD detector and the Soft X-ray Spectrometer (SXS), which is the X-ray micro-calorimeter detector. At the focus of the two hard X-ray telescopes, there are two units of the Hard X-ray Imager (HXI). In addition, we have non-imaging soft gamma-ray detector (SGD). All these instruments work simultaneously and cover different energy ranges from 0.5 to 500 keV for three decades, giving the observatory a wide energy range capability.

SXS,[2] the soft X-ray spectrometer, is an X-ray micro-calorimeter spectrometer placed at the focus of a soft X-ray telescope.[3] The X-ray micro-calorimeter is basically a thermometer, which measures the temperature rise caused by photoelectric absorption of X-ray photons. With this technique, we can achieve a high energy resolution of 7 eV at 6 keV non-dispersively.[4] Unlike the dispersive high-resolution spectrometers onboard the Chandra and XMM-Newton observatories, the energy resolution is almost flat across the band pass.

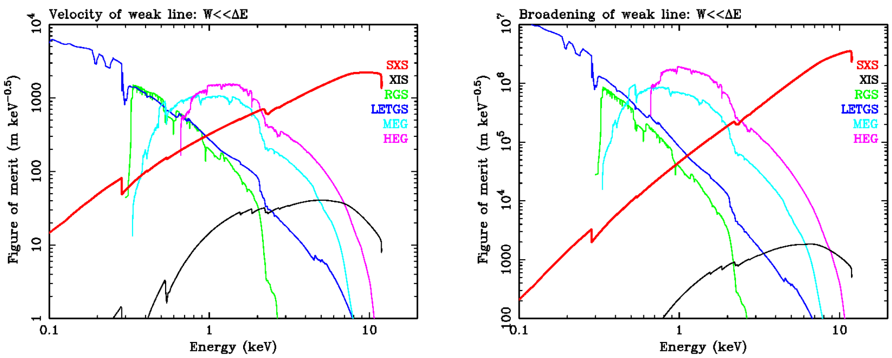

Fig. 1. Figure of merit for the line shift (*left*) and broadening (*right*) measurement of weak lines of the SXS in comparison to other X-ray spectrometers (courtesy: J. Kaastra at SRON).

Figure 2 shows a figure of merit for the sensitivity to determine the line shift and broadening of a weak emission line. The non-dependence of the energy resolution upon the energy gives the SXS a large merit particularly above 2 keV. Above 2 keV, the SXS also has a larger effective area than all the high-resolution spectrometers. The field of view of the SXS is small with a $3{\times}3$ arcmin^2 and the telescope half-power diameter is 1.3 arcmin. Therefore, the SXS only has a limited imaging capability.

An interesting feature is the modulated X-ray source (MXS) provided by SRON.[5] It is basically an X-ray generator that can be switched on and off in the order of a millisecond. It generates the bremsstrahlung continuum emission and some characteristic X-ray lines of the target material and will be used to correct for the gain in the orbit, which can be unstable due to the change of the thermal environment. We can illuminate the sensor with the MXS intermittently during observations, thus we can do X-ray "iodine cell" high-resolution spectroscopy.

2. Application to Neutron Stars

The unique capability of the SXS can be applied to a wide range of topics in the astrophysics. Constraining the equation of state of the dense matter in the neutron stars (NS) is one of them. By using the Fe absorption features during X-ray bursts, we can measure the gravitational redshift, which is directly related to M/R of the NS. Such features were claimed in some previous studies,[6] but none has been firmly established. With the advantage of the SXS (fig. 2), we have a chance of making this measurement.

As a pilot study, we retrieved an X-ray burst source list by in't Zand et al. and prioritized the possible targets considering its rotation and burst frequency. The slower rotation is better, as the absorption line is less broadened. Some simulation spectra were produced (an example is shown in figure **??**), in which we found that SXS has a sensitivity to derive the redshift with a 1 ks exposure, and it has an advantage over the currently used spectrometers in the 2–10 keV range.

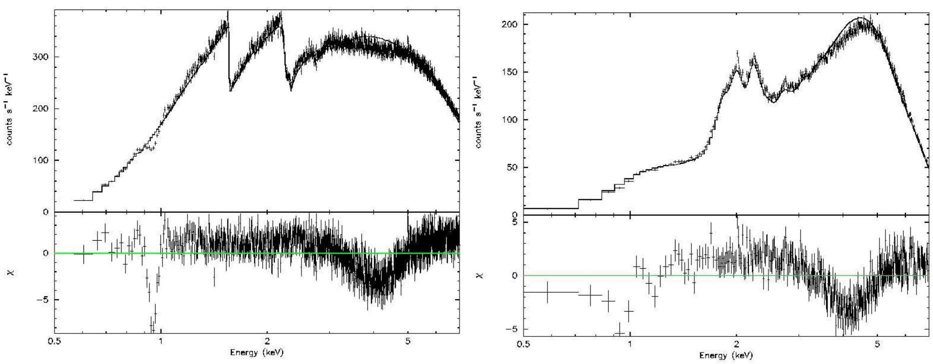

Fig. 2. Simulated spectra of the SXS (left) and HETGS (right). Observed spectral parameters of EXO 0748–676[7] plus two absorption lines at 0.95 and 4.1 keV were added for a 1 ks exposure.

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