Much of the emphasis in NASA's current Strategic Plans is on understanding the early universe and how it has evolved to its present state[1]. As astronomical observations are pushed to cosmological distances (z>3) the spectral energy distributions and important lines of X-ray objects, AGN for example, will be redshifted into the EUV waveband (~100-1000 Å/0.1-0.01 keV), including for example, the Fe L-shell complex (~60-6 Å/0.2-2.0 keV) and the O VII/VIII lines (~20 Å/0.5 keV). (An analogous situation exists for *JWST* relative to *HST*.) We illustrate this effect at a redshift (z) of 5 for the strong O VII and VIII lines in Figure 1, which shows the *Newton-XMM* RGS spectrum of the prototypical Seyfert galaxy NGC 1068 taken from Kinkhabwala et al[2]. A wealth of critical spectral diagnostics may be lost if future planned X-ray missions are optimized for traditional energies, i.e., > 0.3 keV (<41 Å).

This potential critical gap in performance is located at short EUV wavelengths, where the critical X-ray spectral transitions occur in high-z objects. Fortunately, normal-incidence multilayer-grating technology performs best precisely at such wavelengths, and we propose it as a solution to this problem. Multilayer gratings have a significant advantage in the achievement of both high resolving power (R=λ/Δλ) and high effective area in one instrument, but at the disadvantage of a limited bandwidth. However, the latter may be overcome by designing wavebands to match the location of spectral lines, and then building a suite of spectrometers. The top part of Figure 1 is the predicted performance for a SMEX concept design (optimized for galactic targets)[3], possible with present technology. Peak R and effective area lie in the ranges 8640–11400 and 15-60 cm^2, respectively. Where responses overlap, the effective area at the wavelengths of important spectral lines exceeds that of both *Chandra* and *EUVE* by an order of magnitude, and the resolving power is better by factors of 5 and 30, respectively. Most importantly, the multilayer designs can be tailored to locate the peak response of any spectrometer to any wavelength.

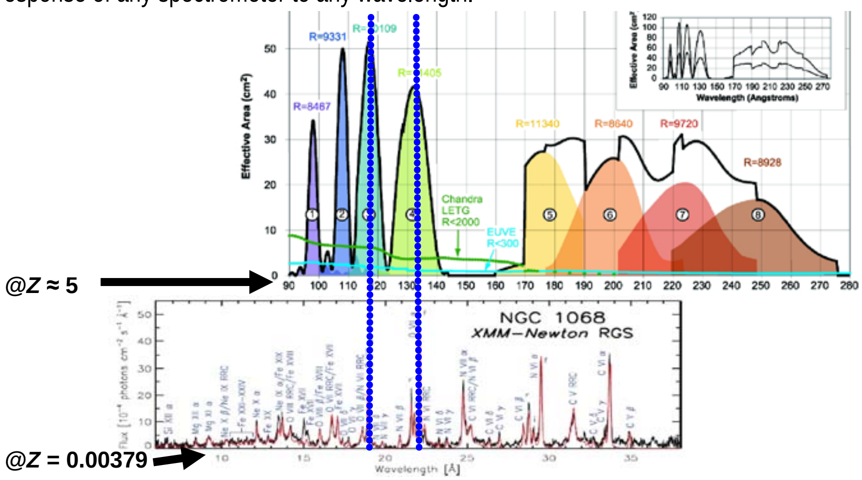

Figure 1. (bottom) XMM-Newton RGS X-ray spectrum[2] of prototypical Seyfert 2 galaxy NGC 1068 (z=0.00379). (top) Effective area and resolving power (R) for a SMEX concept design for a suite of 8 high-resolution multilayer-grating EUV spectrometers. The abscissae of the two figures have been offset to illustrate the scaling by a factor of (1+z), where the O VII lines fall at the peaks of two of these EUV spectrometers when the galaxy is shifted to z=5.

We have examined important issues for extragalactic observations including absorption by the galactic interstellar medium (ISM), the flux of distant X-ray objects, and practical instrument requirements (effective area, wavelength coverage, resolving power).[4] First, the patchy structure of the local ISM, e.g., 'Lockman hole' (~15 deg^2), allows extragalactic EUV observations. We find that there are 300 deg^2 of sky with n_H<1.0x10^{20} cm^{-2}, which is comparable to the *XMM-Newton* AGN X-ray survey[14] and 1300 deg^2 with column densities less than 1.6x10^{20} cm^{-2}; these limits allow practical observations at wavelengths up to 140 Å. For comparison, the *Chandra* and *HST* deep sky surveys are ~1 deg^2 and are located in regions of low neutral hydrogen column density. Thus we conclude that sufficient solid angle is available for extragalactic EUV observations of high-z AGN. Second, we find that observations of important spectral lines in high-z AGN are practical, assuming effective areas of order 10^6 cm in 10^6 sec and with resolving powers sufficient to disentangle source components from those caused by the galactic ISM and by intervening intergalactic gas.

While multilayer-grating technology is sufficiently mature for the purposes of galactic high-resolution EUV spectroscopy, the large collecting areas required to observe distant extragalactic sources profitably requires new developments. Fortunately, at least one candidate technology exists. Nanolaminate replication, a breakthrough technology that is derived from multilayer fabrication techniques, has made rapid progress, and high-quality meter-class mirrors have been fabricated.[5-9] We advocate extending this technology to the development of high-resolution gratings to provide the required collecting area economically.

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