We present Suzaku observations of five hard X-ray-selected nearby Seyfert 2 galaxies. All the sources were clearly detected with the PIN Hard X-ray Detector up to several tens of keV, allowing for a fairly good characterization of the broadband X-ray continuum. We find that a unique model, even including multiple components, fails to represent the spectra of all the sources. Heavy obscuration manifests itself in different ways. For two sources, there is evidence for a reflection-dominated continuum; among the other three, one is “mildly” Compton thick (CT; $N_H \sim 10^{24}$ cm$^{-2}$), while the remaining two are heavily obscured ($N_H \sim 10^{23.5}$ cm$^{-2}$) but Compton thin. Strong, narrow, iron K\alpha lines (EW $\sim$ 1–2 keV) due to neutral or mildly ionized gas are detected in CT active galactic nuclei (AGNs). In all of them, the K\alpha line is accompanied by the K\beta. The intensity and shape of the soft X-ray spectrum are different from object to object. Soft X-rays may originate from a nuclear component scattered off, or leaking through, the X-ray absorber plus thermal X-rays from the host galaxy. Emission from circumnuclear gas photoionized by the active nucleus, parameterized with a power law plus individual narrow Gaussian lines, also provides an acceptable description of the soft X-ray spectra. The limited Suzaku XIS CCD energy resolution does not allow us to draw firm conclusions about the origin of the soft X-ray emission. We briefly discuss our findings in the light of the AGN unified model and the geometry of the obscuring gas.

**Key words:** galaxies: Seyfert – X-rays: individual (NGC 5728, NGC 4992, ESO 263-G13, ESO 137-G34, ESO 323-G32)

1. INTRODUCTION

A number as high as 50% of Seyfert 2 galaxies in the nearby universe are obscured in the X-ray band by column densities on the order of or larger than the inverse of the Thomson cross section ($N_H \geq \sigma_T^{-1} \sim 1.5 \times 10^{24}$ cm$^{-2}$), hence dubbed Compton thick (CT). If the optical depth ($\tau = N_H \sigma_T$) for Compton scattering does not exceed values on the order of “a few,” X-ray photons with energies higher than 10–15 keV are able to penetrate the obscuring material and reach the observer. For higher values of $\tau$, the entire X-ray spectrum is depressed by Compton down scattering and the X-ray photons are effectively trapped by the obscuring matter irrespective of their energy. The former class of sources (mildly CT) can be efficiently detected by X-ray instruments sensitive above 10 keV, while for the latter (heavily CT) their nature may be inferred through indirect arguments, such as the presence of a strong iron K\alpha line over a flat reflected continuum. The search for and the characterization of the physical properties of CT AGNs are relevant for understanding the evolution of accreting supermassive black holes (SMBHs). In particular, mildly CT AGNs are the most promising candidates to explain the so far largely unresolved spectrum of the X-ray background around its 30 keV peak (Worsley et al. 2005; Treister & Urry 2005; Gilli et al. 2007). According to the Gilli et al. (2007) X-ray background (XRB) synthesis model, their integral contribution to the hard X-ray background is on the order of 25%–30%. This fraction has been estimated under simplified hypotheses. In particular, the same luminosity function and cosmological evolution of unobscured and Compton thin AGNs is assumed; moreover, the number density of “heavily” CT AGNs is the same as “mildly” CT. While these assumptions are not inconsistent with the present observational framework (Risaliti et al. 1999; Guainazzi et al. 2005), it should be noted that absorption column densities in excess of $10^{24}$ cm$^{-2}$ were measured or inferred for about a few tens of nearby AGNs (Comastri 2004; Della Ceca et al. 2008), and only a handful of them are known beyond the local universe (Norman et al. 2002; Iwasawa et al. 2005). CT AGNs may represent a significant fraction of the accretion power in the universe and indeed a correction for the CT contribution to the estimates of the SMBH local mass density has to be included in the calculations (Marconi et al. 2004).

An unbiased census of extremely obscured AGNs would require one to survey the hard X-ray sky above 10 keV with good sensitivity. Such an argument is one of the key scientific drivers of the NuSTAR (Harrison et al. 2010) and Astro-H (Takahashi et al. 2010) missions, which will be launched in the next few years, and of the NuHxM mission study (Pareschi et al. 2010).

For the time being, one has to rely on the observations obtained by the high-energy detectors on board BeppoSAX, Integral, Swift, and, more recently, Suzaku. All-sky surveys were performed using both the IBIS coded-mask telescope on board Integral and the BAT detector on board Swift. Though limited to bright and thus low-redshift sources, they have proven to be quite successful. More than one hundred AGNs are reported in both the Integral (Beckmann et al. 2009) and Swift catalogs (Tueller et al. 2010; Cusumano et al. 2010).

Hard X-ray selection is less biased against absorption and thus provides a useful benchmark for studying the column density distribution of obscured AGNs and the fraction of CT sources in the local universe. The large majority of Integral and Swift sources were observed by XMM-Newton and Chandra and their broadband X-ray spectra were discussed by Winter et al. (2008). While the already known nearby CT AGNs were recovered by Swift and Integral surveys, the fraction of “newly” discovered CT AGNs is surprisingly low and apparently
inconsistent, by about a factor of 2, with that predicted by Gilli et al. (2007) in the local universe. On the basis of these findings, it has been proposed (Treister et al. 2009) that the contribution of CT AGNs to the hard X-ray background may be significantly lower (by a factor of 2 to 3) than previously thought, with important implications for the evolution of the accretion power.

Since absorption column densities are often measured on relatively poor-quality X-ray spectra taken from non-simultaneous observations, above and below about 10 keV, and combining different instruments, the CT fraction and, more in general, the absorption distribution in the local universe may still be subject to several uncertainties. Good quality simultaneous spectra extending over the 0.5–100 keV energy range are needed for a robust measurement of absorption column densities, especially in the CT regime. Moreover, nearby obscured AGNs always show excess emission above the extrapolation of the obscured nuclear spectrum (e.g., Turner et al. 1997). Soft X-ray spectroscopy is a powerful tool for studying the origin of this component which is plausibly related to warm gas photoionized by the nuclear continuum (Guainazzi & Bianchi 2007). The X-ray detectors on board the Japanese satellite Suzaku are well suited to this purpose, at least as far as “local” AGNs are concerned. We have conceived a program with Suzaku to observe nearby, relatively X-ray bright (> 10^{-11} erg cm^{-2} s^{-1}) AGNs selected by requiring (1) a significant detection above 10 keV by either Swift or Integral and (2) evidence for significant X-ray absorption at lower energies from archival observations. The immediate science objective is the characterization of the broadband X-ray spectra of hard X-ray-selected, heavily obscured AGNs and a first step toward a better census of CT absorption in the nearby universe.

2. SAMPLE SELECTION

Five sources (NGC 4992, NGC 5728, ESO 137–G34, ESO 263–G13, and ESO 323–G32), spectroscopically classified as Seyfert 1.9–2.0 galaxies, were originally selected from the Integral/IBIS (Beckmann et al. 2006) and Swift/BAT (Markwardt et al. 2005) catalogs. The column densities, as inferred from archival (Chandra and XMM-Newton) observations, are on the order of 10^{23}–10^{24} cm^{-2}, though affected by large errors. By construction, the sample is biased toward obscured AGNs.

The extremely bright flux of NGC 4992 in the Integral observation, coupled with the lack of a detection in the RASS (Voges et al. 1999), is consistent with an absorbed spectrum, as confirmed by a snapshot Chandra observation (Sazonov et al. 2005).

Chandra revealed a heavily obscured nucleus in NGC 5728 (Zheng et al. 2006). Although the column density is not well constrained due to the limited response at high energies, the presence of a strong iron line (EW ~ 1 keV) suggests that the source might be obscured by CT gas.

ESO 137–G34 was detected by Integral and subsequently observed with XMM-Newton (Malizia et al. 2009). The combined XMM-Newton and Integral spectra can be well fitted by both a transmission and a reflection model as well as by a more complex absorption distribution. In all cases, there is evidence for CT absorption.

ESO 323–G32 and ESO 263–G13 were selected on the basis of a significant (> 5σ) Integral/IBIS detection, unambiguous optical classification as Seyfert 2 galaxies, and the lack of archival observations in the 2–10 keV energy range. Both are detected by ROSAT with a soft X-ray spectrum. The

![Table 1](http://www.astro.isas.ac.jp/suzaku/process/caveats)

| Name     | z | Exposure Time (ks) | XIS* | PIN |
|----------|---|-------------------|-----|-----|
| NGC 4992 | 0.025 | 31.5             | 3.30 ± 0.06 | 6.4 ± 0.5 |
| NGC 5728 | 0.009 | 37.1             | 3.10 ± 0.06 | 7.9 ± 0.4 |
| ESO 263-G13 | 0.033 | 37.4             | 6.30 ± 0.09 | 4.0 ± 0.4 |
| ESO 137-G34 | 0.009 | 78.0             | 1.80 ± 0.04 | 1.3 ± 0.2 |
| ESO 323-G32 | 0.016 | 80.5             | 1.00 ± 0.04 | 0.7 ± 0.2 |

Notes. Background subtracted count rates in units of 10^{-2} counts s^{-1}.

4. SPECTRAL ANALYSIS

For the sake of clarity and to ease comparison with some of the previous Suzaku results on heavily obscured AGNs (Ueda et al. 2007; Eguchi et al. 2009), we consider two baseline spectral models for the broadband Suzaku spectra, namely a transmission dominated (TD) model: $w_{\text{abs}}(\text{apec + pexrav + zpea}f\text{bs}(\text{cutoffpl+2zgauss}))$ in XSPEC notation and a reflection dominated (RD) model: $w_{\text{abs}}(\text{apec + pow + pexrav + 2zgauss})$. The spectral components of the TD model are: a power law with an exponential cutoff fixed

http://www.astro.isas.ac.jp/suzaku/process/caveats

ftp://legacy.gsfc.nasa.gov/suzaku/doc/xrt/suzakumemo-2008-06.pdf
The additional zgauss component accounts for Kα and Kβ lines. Given that the XIS CCD energy resolution is not appropriate to fit a photoionization code model (Iwasawa et al. 2003), the expected soft X-ray spectrum of a photoionized plasma is modeled with a power law with photon index free to vary (Table 3), plus intrinsically narrow (setting \( \sigma = 0 \) in the zgauss XSPEC model) Gaussian lines at the energy expected (Table 4) for the strongest features observed in high-resolution RGS spectra of obscured AGNs (see Guainazzi & Bianchi 2007). The presence of the line is evaluated on the basis of a visual inspection of the residuals obtained by fitting a single power law. The best-fit energies, fluxes, and associated 1σ errors of the various lines for each source are reported in Table 4.

The best-fit spectral parameters of the continuum along with observed X-ray fluxes and 2–10 keV intrinsic luminosities are summarized in Table 2 for the fits with a partial covering and a thermal spectrum for the soft X-rays, and in Tables 3 and 4 when the soft X-rays are modeled with a power law plus Gaussian lines. The shape of the hard X-ray continuum is rather independent of the model adopted for the soft X-ray spectrum. Therefore, fluxes and luminosities are reported only in Table 2. Galactic absorption using Morrison & McCammon (1983) cross sections (model wa_Gal in XSPEC) is fixed at the values measured by Dickey & Lockman (1990).

The detailed results of spectral fits for each source are summarized in the following.

### 4.1. NGC 4992

The TD model provides an acceptable fit to the observed spectrum of NGC 4992, while the RD model is ruled out at an extremely high confidence level (\( \Delta \chi^2 > 600 \)). The primary continuum is obscured by cold gas, with a column density of \( N_H \approx 5.5 \times 10^{23} \text{ cm}^{-2} \) almost fully covering the central source. The iron line intensity (EW \( \sim 340 \text{ eV} \)) is consistent with being originated by transmission through the obscuring gas. The constraints on the scattering fraction (\( f_{\text{scatt}} < 0.3\% \)) and reflection intensity (\( R \approx 0.2–0.5 \)) are rather stringent. The soft X-ray emission is extremely weak, and both a thermal spectrum (\( kT \sim 0.3 \text{ keV} \)) and a steep power law plus three emission lines at the energies corresponding to the transitions reported in Table 4 provide an acceptable fit. We note that in the latter case no continuum is formally required, and the entire soft X-ray flux may be explained as emission from multiple lines.

### 4.2. NGC 5728

The TD model provides the best fit to the broadband spectrum of NGC 5728. An RD model can be safely discarded on a statistical basis (\( \Delta \chi^2 > 130 \)). The source is mildly CT (\( N_H \approx 1.4 \times 10^{24} \text{ cm}^{-2} \)) and thus hard X-rays (\( > 10 \text{ keV} \)) are piercing through the obscuring gas. The reflection component is rather weak (\( R \approx 0.1–0.3 \)). A strong (EW \( \sim 1 \text{ keV} \)) iron Kα line is detected along with a line at \( \sim 7 \text{ keV} \). The best-fit energy of the ~7 keV feature, its intensity (EW \( \sim 70–90 \text{ eV} \)), and the observed intensity ratio with respect to Kα, favor an interpretation in terms of Kβ emission. The soft X-ray spectrum below a few keV is fitted by a combination of a scattered power law, with \( f_{\text{scatt}} \approx 0.4\%–1.2\% \), and thermal plasma emission (\( kT \sim 0.3 \text{ keV} \)). The residuals below a few keV suggest the presence of line emission. A fit with a steep power law plus several emission lines (Table 4) also provides a statistically acceptable solution (Table 3) and smooth residuals in the soft X-ray band.
Figure 2. *Suzaku* broadband spectra and data to model ratio for the five Seyfert galaxies of the sample. In the left column we plot the sources best fitted with a TD model, and in the right column the two RD X-ray spectra. The spectral parameters of the broadband fits shown in the figures are reported in Table 2.

4.3. ESO 263–G13

The *Suzaku* spectrum of ESO 263–G13 is best fitted by a TD model. An RD model fails to fit the data over the entire energy range ($\Delta \chi^2 > 700$). The absorption column density is the lowest in the present sample ($\sim 3 \times 10^{23}$ cm$^{-2}$); the scattering fraction and the reflection component intensity are poorly constrained ($f_{\text{scatt}} < 0.8\%$ and $R \sim 0.1\text{--}1.2$, respectively). The equivalent width (EW) of the iron K$\alpha$ line ($\sim 80$ eV) is consistent with that expected by transmission through the observed column density. The soft X-ray spectrum is characterized by low counting statistics. Both a power law plus thermal X-rays ($kT \sim 0.5$ keV) and a power law plus two emission lines provide an acceptable fit. The latter fit is slightly better in terms of $\chi^2$, though the improvement is not statistically significant.

4.4. ESO 137–G34

Both an RD model ($\chi^2$/dof $\simeq 169/139$, see Table 3) and a TD model ($\chi^2$/dof $\simeq 160/138$) provide an acceptable fit to the broadband spectrum of ESO 137–G34. In the TD fit, the primary hard X-ray continuum ($\Gamma \simeq 1.8$) is obscured by a column density of $\sim 1.2 \times 10^{24}$ cm$^{-2}$. The intensity of the scattering fraction ($f_{\text{scatt}} \simeq 5\%$) is higher than that measured in the sources best fitted with a TD model, while the reflection component is relatively weak ($R \sim 0.3$). Even though neither of the two models can be preferred on the basis of purely statistical arguments, the individual parameters of the TD model are highly degenerate and cannot be reliably constrained. As a consequence, an RD model is preferred. It is worth noting that the source would be classified as Compton thick in both cases. The strong K$\alpha$ line (EW $\sim 1.5$ keV) is accompanied by a line at $\sim 7$ keV. The best-fit line intensity ratio ($\sim 0.2$) is slightly higher, but not inconsistent within the errors, than that expected by a K$\beta$ line origin for the $\sim 7$ keV feature. The soft X-ray spectrum can be fitted with a thermal plasma ($kT \sim 0.8$ keV) and a power-law slope which is significantly steeper than that of the hard X-ray continuum. Some residual line like emission, around 1 keV and 1.8 keV, is still present, suggesting a more complex spectrum. A fit with a power law plus several Gaussian
lines (Table 4) provides an acceptable solution in terms of \( \chi^2 \) statistics and smooth residuals (see Figure 3).

4.5. ESO 323–G32

Both an RD model (\( \chi^2 / \text{dof} \approx 79 / 89 \), see Table 3) and a TD model (\( \chi^2 / \text{dof} \approx 83 / 88 \)) provide an acceptable fit to the broadband spectrum. In the TD fit, the primary hard X-ray continuum \( \Gamma \approx 2.0 \) is obscured by a column density of the order of \( \sim 1 - 2 \times 10^{24} \text{ cm}^{-2} \). The relative intensity of the transmitted component is about a factor of 2 lower than that of the reflection component. Similarly to ESO 137–G34, the best-fit spectral parameters, in particular the column density \( N_H \) and the scattering fraction, cannot be constrained. An RD model is thus preferred as the best fit to ESO 323–G32, the faintest source of the sample. The iron K\( \alpha \) line is very strong (EW \sim 2 \text{ keV}), and the best-fit energy and intensity of the \( \sim 7 \text{ keV} \) feature are consistent with a K\( \beta \) origin. The weak soft X-ray emission can be adequately modeled with either a power law plus a thermal spectrum or a power law plus two Gaussian lines. Both fits are statistically acceptable and comparable.

4.6. Summary of Fitting Results

4.6.1. Hard X-ray Spectra

All the targets are obscured by column densities larger than \( \sim 3 \times 10^{23} \text{ cm}^{-2} \). Two of them are highly absorbed but
Compton thin \((N_H \sim 3-5 \times 10^{23} \text{ cm}^{-2})\), while the other three are Compton thick. In NGC 5728, the primary hard X-ray continuum is transmitted through a column density \(N_H \sim 10^{24} \text{ cm}^{-2}\). In ESO 137–G34 and ESO 323–G32, both a TD and an RD model provide an acceptable description of the broadband spectra. An interpretation in terms of an RD continuum is preferred and considered more reasonable (see Sections 4.4 and 4.5). The photon indices are in the range 1.4–1.9 and thus typical of or possibly slightly flatter than the average values of Seyfert 1 galaxies. This suggests that the intrinsic continuum, when visible, is reasonably well constrained and highlights the importance of the hard X-ray band in the study of heavily obscured AGNs. The absorption-corrected luminosities of the sources best fitted by the TD model are in the Seyfert range \((L_{2–10 \text{ keV}} \sim 10^{41} \text{ erg s}^{-1})\). The observed hard X-ray luminosities of the RD AGNs are of the order of \(10^{41} \text{ erg s}^{-1}\). The intrinsic luminosity can be approximated by \(L_{\text{int}} \sim L_{\text{obs}}/(C \times A_{2–10})\) where \(C = \Delta \Omega/4\pi\) and \(\Delta \Omega\) is the solid angle illuminated by the central source reflecting X-rays, and \(A_{2–10}\) is the albedo of Compton reflection in the 2–10 keV energy range. The albedo is a weak function of the slope of the primary spectrum and, for the range of slopes of the sources in our sample, is of the order of 7%, assuming reflection from a slab covering a solid angle of \(2\pi\) at the source. We note that the albedo due to torus reflection is likely to be lower than the quoted value (Murphy & Yaqoob 2009). The intrinsic luminosities for the two RD Seyferts are 1.4–3.2 \(\times 10^{42} \text{ C}^{-1} \text{ erg s}^{-1}\), consistent with the X-ray luminosities of Seyfert galaxies. The ratio between observed and intrinsic luminosity in the Circinus galaxy (Matt et al. 1999) is about a factor of 2 lower than that estimated for the objects in our sample. Given that \(C < 1\) and considering the uncertainties associated with the Compton reflection albedo from distant matter, the agreement is rather good. The reflection component intensity, for those sources best fitted with a TD model, is poorly constrained; however, it seems to be relatively weak. The EWs of the iron K\(\alpha\) line in Compton thin sources are consistent with a transmission origin through the observed column densities. In the RD sources, the large EWs further support the presence of an RD continuum in these objects. An emission line feature at \(\approx 7 \text{ keV}\) (rest frame) is detected in the most obscured AGNs. The best-fit line energy and measured intensity are consistent, in all cases, with iron K\(\beta\) emission.

### 4.6.2. Soft X-ray Spectra

Soft X-ray emission is ubiquitous in the sources of our sample, although the intensity and shape of the soft X-ray spectrum vary significantly from object to object (Figure 1). The fraction of scattered flux, in the three objects whose hard X-ray continuum is best fitted with a TD model, is relatively low and below about 1%. These sources would be dubbed “hidden” AGNs by Winter et al. (2008). In all sources, including the two RD objects for which the scattering fraction cannot be derived, a soft thermal component with temperatures in the range 0.3–0.8 keV is also required. The 0.2–2 keV X-ray luminosity associated with the thermal component is in the range 1–7 \(\times 10^{40} \text{ erg s}^{-1}\), consistent with the values observed in “normal” galaxies (i.e., Norman et al. 2004). While the physical origin of the thermal component could be associated with diffuse hot plasma in the host galaxy, it is important to note that the best-fit temperatures are derived by fitting the iron L-shell emission at 0.7–1 keV. We also note that line-like features below \(\approx 2\) keV are present in the residuals, with respect to a fit with a thermal component and a power law (Figure 3). Prompted by these considerations, we explored a different possibility for the origin of soft X-ray emission. A photoionized plasma is found to be an excellent description of the soft X-ray spectra for a large sample of obscured Seyfert 2 observed with the high-resolution RGS gratings on board XMM-Newton (Guainazzi & Bianchi 2007). The spectrum of photoionized gas is usually modeled with specific codes (i.e., XSTAR). However, the available counting statistics and the limited CCD energy resolution of the present data are not such to adequately constrain the physical properties of the emitting plasma. We adopted a simplified approach fitting the observed spectra with a power law plus individual narrow emission lines. The best-fit line energy and intensities are reported in Table 4. In two sources of our sample, NGC 5728 and ESO 137-G34 (both CT), the parameterization described above provides a formally better description of the soft X-ray spectra, though not statistically significant, than a power law plus thermal emission. A comparison of the best-fit Suzaku spectra of three objects in the sample is shown in Figure 3. From the analysis of the

### Table 4

| Parameters | NGC 4992 | NGC 5728 | ESO 263-G13 | ESO 137-G34 | ESO 323-G32 | Line ID^a |
|------------|---------|---------|------------|------------|------------|------------|
| \(E_1\) (keV) | \(0.70^{+0.06}_{-0.05}\) | \(0.65 \pm 0.02\) | \(0.69 \pm 0.03\) | ... | ... | O\textsc{vii} (0.65)-Fe xvii (0.72) |
| Fluxx1 | \(0.9 \pm 0.5\) | \(3.7 \pm 1.0\) | ... | ... | ... | Ne \textsc{x} (1.02) |
| \(E_2\) (keV) | \(0.84 \pm 0.02\) | \(0.88 \pm 0.01\) | \(0.87 \pm 0.02\) | ... | ... | Si xvii (1.84) |
| Fluxx2 | ... | \(1.0 \pm 0.2\) | ... | ... | ... | S xv (2.44) |
| \(E_3\) (keV) | ... | \(0.98 \pm 0.02\) | ... | ... | ... | Si xvii (1.84) |
| Fluxx3 | ... | \(0.8 \pm 0.1\) | ... | ... | ... | S xv (2.44) |
| \(E_4\) (keV) | \(1.69^{+0.06}_{-0.05}\) | \(1.76 \pm 0.02\) | ... | ... | ... | Si xvii (1.84) |
| Fluxx4 | ... | \(2.35 \pm 0.03\) | ... | ... | ... | S xv (2.44) |
| \(E_5\) (keV) | ... | \(0.11 \pm 0.04\) | ... | ... | ... | Si xvii (1.84) |
| Fluxx5 | ... | \(0.15 \pm 0.06\) | ... | ... | ... | Si xvii (1.84) |
| \(E_6\) (keV) | ... | \(3.13 \pm 0.04\) | ... | ... | ... | Si xvii (1.84) |
| Fluxx6 | ... | \(0.11 \pm 0.05\) | ... | ... | ... | Si xvii (1.84) |

Notes. Emission-line fluxes in units of \(10^{-3} \text{ photons cm}^{-2} \text{ s}^{-1}\). Errors in both line energy and flux are at 1\(\sigma\).

^a Suggested line identification and corresponding energies in keV (from Guainazzi & Bianchi 2007 and House 1969). The approximate energy interval for the Ne \textsc{x} triplet is reported.
residuals, it is clear that line-like emission below 2 keV is not properly accounted for by a thermal plasma fit.

5. DISCUSSION AND CONCLUSIONS

Thanks to the broadband energy range and sensitivity of the X-ray detectors on board Suzaku it has been possible to study, with good accuracy, the spectral properties of a sample of five hard-X-ray-selected type-2 AGNs. The presence of cold obscuring gas has been unambiguously established in all the sources. Although this result was expected, given the sample selection criteria, the X-ray spectra show a high degree of spectral complexity. In particular, the absorption column density and the relative intensity of the various spectral components differ from object to object.

The primary emission is seen, in three out of five sources, through column densities in the range $10^{23.5-24}$ cm$^{-2}$. The fraction of the intrinsic flux scattered into the line of sight and parameterized by $f_{\text{scatt}}$ in the partial covering fits is relatively low and the reflection component intensity weak. On the basis of Suzaku observations of six Swift-selected AGNs, thus an almost identical selection criterion, Eguchi et al. (2009) found that sources with a low scattering fraction ($f_{\text{scatt}} < 0.5\%$) also have a relatively strong reflection component ($R \gtrsim 1$). They dubbed these objects as “new”-type AGNs (see also Ueda et al. 2007) and proposed that they may represent the tip of the iceberg of a hitherto uncovered population of AGNs obscured by a geometrically and optically thick torus (Levenson et al. 2002).

The analysis of the present data does not support the “new”-type AGN interpretation. A possible explanation may be due to the strong degeneracy in the fit parameters. For example, if the reflection component is also absorbed (like in the Eguchi et al. 2009), a solution in terms of a stronger reflection intensity and lower normalization of the scattered component is found, and results similar to Eguchi et al. (2009) are also recovered.
in our sample (Comastri et al. 2009). However, we believe that the quality of our data does not allow us to constrain absorption on the reflection component; moreover, our best-fit solution has the advantage of having a lower number of free parameters. It is also worth pointing out that the intensity of the reflection spectrum from CT gas strongly depends on the geometry of the system. The reflection fraction, obtained from fitting disk-reflection models to CT AGNs, cannot be directly associated with a solid angle (Murphy & Yaqoob 2009). A better understanding of the nature of “new”-type AGNs and whether there are two distinct classes of Seyfert 2, possibly related to the geometry of the obscuring medium or a continuous distribution of spectral parameters, requires a larger sample of objects with a good counting statistic to allow for a detailed spectral analysis.

The observational evidence of obscured AGNs with a low scattering fraction is at variance with the average values adopted for the above parameters in the Gilli et al. (2007) XRB synthesis models. We have tested the impact of different normalizations for the scattering component in absorbed ($N_{H} > 10^{22}$ cm$^{-2}$) AGNs. The fit to the XRB spectrum and source counts are basically unaffected, unless $f_{\text{scatt}}$ exceeds values of the order of 10%. High $f_{\text{scatt}}$ values appear to be the exception, rather than the rule, and are definitely ruled out among highly obscured Swift-selected AGNs.

The possibility that photoionized gas is responsible for the soft X-ray emission in obscured AGNs is consistent with the present observations. It is interesting to note that the residuals in the soft X-ray band of the NGC 5728 Chandra spectrum (Zheng et al. 2006) and ESO 137–G34 XMM-Newton spectrum (Malizia et al. 2009), both fitted with thermal emission, suggest the presence of unaccounted-for emission lines at energies close to those reported here. Unfortunately, the physical status of the ionized gas cannot be constrained by the present observations. Only a limited number of emission lines are individually detected above the 3σ level. It is, however, reassuring that the best-fit energies reported in Table 4 are consistent with those expected by ionized metals observed with the XMM-Newton and Chandra gratings observations of much brighter Seyfert 2 galaxies (Brinkman et al. 2002; Kinkhabwala et al. 2002; Guainazzi & Bianchi 2007). The ~0.9 keV feature identified with Ne ix appears to be ubiquitous, possibly with the exception of NGC 4992 which is, however, the faintest soft X-ray source in the sample.

It is worth noting that the three brightest soft X-ray sources in the sample, all of them CT (Figure 1), show strong [O iii] ionization cones in optical images (e.g., Wilson et al. 1993). Moreover, extended soft X-ray emission almost spatially coincident with [O iii] cones is detected by Chandra imaging observations of NGC 5728 (Zheng et al. 2006). Furthermore, ESO 137–G34 and ESO 323–G32 are hosted by S0 galaxies which are expected to have neither intense star formation activity nor thermal X-ray emission from hot gas.

Although it may be premature to discard a thermal origin for the soft X-ray emission on the basis of the present X-ray observations, we stress that the above described arguments would support the presence of photoionized plasma, which is also favored by high-resolution αCs observations of bright obscured AGNs (Guainazzi & Bianchi 2007).

Long-look observations of selected samples of obscured AGNs are clearly needed to elucidate the nature of the soft X-ray emission in these objects, though firm conclusions can be drawn only by high-resolution X-ray observations (with either gratings or calorimeters).

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