THE ROLE OF ABSORPTION AND REFLECTION IN THE X-RAY SPECTRUM OF ACTIVE GALACTIC NUCLEI

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ABSTRACT

In the 2-10 keV range, the AGN continuum is generally well represented by a single power law but at lower energies it displays an excess with respect to the extrapolation of this power law, called the "soft X-ray excess"; the nature of this component is still under discussion. Until now the soft X-ray excess was attributed either to the reflection of the hard X-rays on the accretion disk, or to the presence of an additional Comptonizing medium. This feature could also be due to the absorption of an intrinsically steep power law source (whose origin is not clear) by a medium with a very large dispersion velocity (as a relativistic wind). Understanding the nature of the soft X-ray excess is essential for our knowledge of the Warm Absorber, the primary spectrum, and the accretion flow process. We have therefore examined the pros and cons of the reflection and absorption models. The observed soft X-ray spectra may probably be modeled by an "hybrid" model: absorption and reflection.

Key words: galaxies: active, Seyfert; X-rays: general.

1. INTRODUCTION

Now more than 50% of well studied Seyfert 1 (Sy1) galaxies and many quasars are known to possess absorbers (e.g., Blustin et al. 2005). One main issue is to explain the apparent change of slope in the overall X-ray spectrum at $\sim$ 1 keV in Sy1s and QSOs. When fitting an observed X-ray spectrum with a power law plus absorption plus the Compton reflection component plus the iron line and narrow spectral features, the model usually underpredicts the observed spectrum in the soft X-ray range. An additional component – a soft X-ray excess – is needed (Wilkes & Elvis 1987). Apart from an usual additional continuum or a strongly ionized reflection, this component is well modeled by absorption of an originally rather soft power law intrinsic spectrum due to an absorber having a random or bulk velocity of several thousands of km s^{-1} (Gierliński & Done 2004). We consider the advantages and drawbacks of the reflection vs. absorption models (Chevallier et al. 2005), using our code TITAN (Dumont et al. 2003).

2. RESULTS

Gierliński & Done (2004) modeled the X-ray spectrum of the Narrow Line Sy1 PG 1211+143 by a steep power law continuum between 0.1 and 20 keV, absorbed by an ionized slab of constant density. Note that the observed spectrum is smeared by a large (Gaussian) velocity dispersion $v/c = 0.2$ in order to get a "quasi-continuum" without narrow features. This high velocity can be due to an accelerated outflow, or to a disk wind with Keplerian motion and produced very close to the black hole.

We have computed the absorption spectra (primary source of radiation complete covered) for a grid of constant density models. Any small variation of the column-density N, the ionization parameter $\xi = L/n_{\rm H}R^2$, or the slope α of the primary continuum, would induce a strong variation on the shape of the X-ray spectrum.

Such a variation is not observed from one object to the other. It is more appropriate to assume that the absorbing medium is in total – gas and radiation – pressure equilibrium owing to the short dynamical time scale needed to reach again an equilibrium (less than one day, for $R \sim 10\ R_{\rm G}$, where $R_{\rm G} = GM/c^2$, and $M \sim 10^7\ M_\odot$). The thickness of the slab cannot then exceed a maximum value for a given ξ, due to thermal instabilities. A consequence is the existence of a "maximum absorption trough", which cannot be exceeded.

Figure 1 shows as an exemple the comparison of the X-ray spectrum of PG 1307+085 (Piconcelli et al. 2005) with that obtained with an absorbing slab of constant total pressure. This spectrum is well fitted, considering that the narrow emission feature around 0.5 keV – the OVII complex – must be provided by another emitting region.

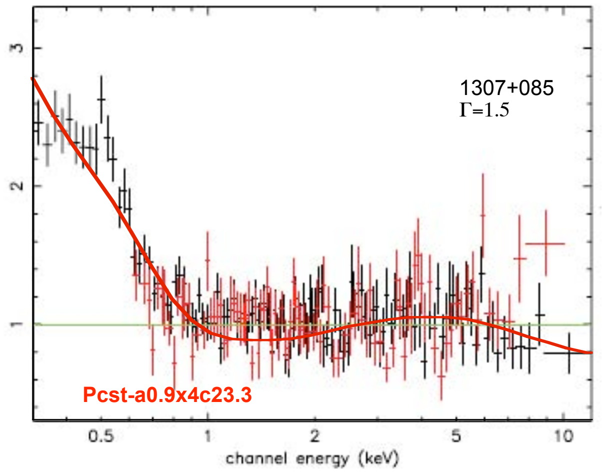

Figure 1. Comparison between the observed X-ray spectra for PG 1307+085 (Piconcelli et al. 2005, Fig. 2) and the computed spectrum (arbitrary units) of a power law primary continuum $\alpha = 0.9$ *absorbed by a constant total pressure slab (*$\xi = 10^4$*,* $N = 2\ 10^{23}$*,* $v/c = 0.2$*, CGS units). The observed and computed spectra have been both divided by the observed power law of photon index* $\Gamma = 1.5$ *over the 2–10 keV range.*

Absorption models are not very satisfactory from a physical point of view. Owing to its large column density ($\sim 10^{23}$ cm^{-2}), the wind implies too massive outflows (near the Eddington limit). Both the wind and the accretion models require an additional UV emission, which has to be provided by a geometrically thin accretion disk. The coexistence of a spherical accretion flow at about $25\ R_{\rm G}$ and a thin disk seems quite artificial. So we come back now to the "traditional" reflection models, including a "cold" accretion disk emitting the UV, surrounded by a hot corona emitting X-rays which are reflected by the disk (Haardt & Maraschi 1993). We notice that the soft X-ray excess almost disappears when the reflection spectrum is added to the primary continuum. Either ξ is small and the reflection spectrum displays a strong X-ray excess, but it is negligible as compared to the primary one; or ξ is large, and the reflection spectrum is comparable in flux to the primary one, but it has a small X-ray excess. A strong excess requires to hide the primary continuum (Fabian et al. 2002, Crummy et al. 2005).

Since both the absorption and the reflection models seem inadequate, we propose an "hybrid model", including the traditional reflection model, plus a high velocity absorbing medium with a modest thickness. The small soft X-ray excess is increased when it is absorbed by such a wind and becomes comparable to the observations. The mass outflow rate is thus 30 times smaller than in the previous absorption model.

3. CONCLUSION

Absorption models could account for some strong soft X-ray excesses, but require a kind of "fine tuning" in order to constrain the 1 keV trough, which otherwise could have any strength (e.g., constant density models). We have suggested a medium in total – gas and radiation – pressure equilibrium, which leads to a maximum intensity of the trough, as well as a "universal" shape of this maximum trough, due to the thermal instability mechanism. A complete grid of constant total pressure models, very demanding in computation time, is necessary to pursue this study. In the absorption model, either a thick accretion flow, or a relativistic wind is required. None of them seem realistic from a physical point of view, and moreover both require an additional source of UV emission, like a geometrically thin accretion disk. On the other hand, the "traditional" reflection models cannot account for the observations, unless the X-ray source is hidden from our view. Therefore we favor an "hybrid" model, where the primary UV-X source could be produced by a disk-corona system, and then absorbed by a modest relativistic wind.

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