How complex is the obscuration in AGN? New clues from the *Suzaku* monitoring of the X-ray absorbers in NGC 7582

Stefano Bianchi[1], Enrico Piconcelli[2], Marco Chiaberge[3,4], Elena Jimenez Bailón[5,6], Giorgio Matt[1] and Fabrizio Fiore[2]

[1] Dipartimento di Fisica, Università degli Studi Roma Tre, via della Vasca Navale 84, 00146 Roma, Italy
[2] Osservatorio Astronomico di Roma (INAF), Via Frascati 33, I-00040 Monte Porzio Catone, Italy
[3] Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218
[4] INAF - IRA, Via P. Gobetti 101, I-40129 Bologna, Italy
[5] Instituto de Astronomía, Universidad Nacional Autónoma de México, Apartado Postal 70-264, 04510 Mexico DF, Mexico
[6] LAEFF Apd. 78 Villanueva de la Cañada - 28691-Madrid, Spain
E-mail(SB): bianchi@fis.uniroma3.it

Abstract

We present the results of a *Suzaku* monitoring campaign of the Seyfert 2 galaxy, NGC 7582. The source is characterized by very rapid (on timescales even lower than a day) changes of the column density of an inner absorber, together with the presence of constant components arising as reprocessing from a Compton-thick material. The best fitting scenario implies important modifications to the zeroth order view of Unified Models. While the existence of a pc-scale torus is needed in order to produce a constant Compton reflection component and an iron Kα emission line, in this Seyfert 2 galaxy this is not viewed along the line of sight. On the other hand, the absorption of the primary continuum is due to another material, much closer to the BH, roughly at the distance of the BLR, which can produce the observed rapid spectral variability. On top of that, the constant presence of a 10^{22} cm^{-2} column density can be ascribed to the presence of a dust lane, extended on a galactic scale, as previously confirmed by *Chandra*. There is now mounting evidence that complexity in the obscuration of AGN may be the rule rather than the exception. We therefore propose to modify the Unification Model, adding to the torus the presence of two further absorbers/emitters. Their combination along the line of sight can reproduce all the observed phenomenology.

Key words: galaxies: active — galaxies: Seyfert — X-rays: individual: NGC7582

1. The monitoring campaign

During the second *Suzaku* Announcement of Opportunity (AO2), we proposed a strategy to observe NGC 7582 at different timescales, from 1 week to about 6 months, allowing us to probe distances as close as the BLR and almost as far as the traditional torus. Moreover, this campaign complemented the scales of the order of years already tested with XMM-*Newton*. Therefore, NGC 7582 was observed four times by *Suzaku* in 2007 (PI: M. Chiaberge): on May 1st and 28th, and November 9th and 16th. XMM-*Newton* observed NGC 7582 in two targeted exposures on 2001 May 25th and 2005 April 29th. Both observations were discussed in Piconcelli (2007). Moreover, the source is within the EPIC field of view of another target, observed on 2007 April 30th, accidentally just a day before the first *Suzaku* one. We refer the reader to Bianchi et al. (2009) for details on all the observations discussed in this paper.

2. NGC 7582: the big picture

The fourth and latest *Suzaku* observation caught the source at the lowest state, but this indeed allowed us to have a clearer view of the reprocessing components of its spectrum, which apparently are those of a typical Seyfert 2. The resulting scenario applies well to all other X-ray observations of NGC 7582, the different states being due only to the variability of the column density of the inner absorber (see Bianchi et al. 2009 for a detailed spectral analysis). In this section, we will discuss in detail the implications on the complex geometry of the absorbers required in this source.

The intrinsic nuclear emission appears obscured by a very large column density (just below the 'canonical' Compton-thick limit). The spectrum below 10 keV is

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therefore dominated by a Compton reflection component and the relative iron line. Both the flux of the reflection component and of the iron line are consistent with being constant during the *Suzaku* monitoring campaign and with the values found in XMM-*Newton* observations, the older dating back to 2001. The material that produces both components is far away from the nuclear X-ray emitting source, possibly in the classic pc-scale 'torus' invoked in Unification Models (Antonucci 1993).

These reprocessing components appears to be obscured by a second absorber, which must be located farther away. Its column density is not well constrained in the *Suzaku* spectra, but is consistent with the one measured by XMM-*Newton*, around $4-5\times10^{22}$ cm^{-2}. It can be identified with a large scale obscuration, as the dust lanes commonly observed in galaxies. Indeed, the combined analysis of *HST* and *Chandra* images clearly detected such a dust lane also in the X-rays, with a column density consistent with the one required by the spectral fits (Bianchi et al. 2007).

The soft X-ray emission, as reported by Piconcelli (2007) thanks to the well-exposed XMM-*Newton* Reflection Grating Spectrometer (RGS) high resolution spectra, appears dominated by emission lines of highly ionized species. This is a general characteristic of Seyfert 2 galaxies, as found by Guainazzi & Bianchi (2007). The lack of any variability of the soft X-ray emission is in agreement with the scenario, where these emission lines are produced in a large scale material, spatially coincident with the Narrow Line Emission (NLR) and likely dominated by photoionization from the AGN (see e.g. Bianchi et al. 2006).

However, our monitoring campaign discovered a striking feature that characterizes NGC 7582: the presence of an absorber, whose rapid variability imposes a location far closer to the BH than the torus. While significant variability is also observed on larger timescales between the *Suzaku* observations, the most rapid variation occurs between the last XMM-*Newton* observation and the first *Suzaku* one, allowing us to estimate the distance of the absorber within or immediately outside the BLR (see Bianchi et al. 2009 for details).

3. A new Unification Model?

We have presented a *Suzaku* monitoring campaign of the Seyfert 2 galaxy, NGC 7582. The dramatic spectral variability observed during the 4 observations is best explained by changes of the absorbing column density of a material close to the X-ray primary source. Given the significant variation between a new XMM-*Newton* observation and the first *Suzaku* one, separated by only 20 hours, its distance can be estimated to be a few $\times10^{15}$ cm, i.e. roughly consistent with the BLR.

Together with this material, the presence of a Compton-thick material on larger scale, likely the 'torus' envisaged in the Unification models, is required in order to account for the Compton reflection component and the neutral iron Kα emission line, whose fluxes appear constant in years. On the top of that, a third, Compton-thin material intercepts the line of sight and can be associated to the dust lane observed in optical and *Chandra* X-ray images.

Table 1. A new Unification Model, based on three absorbers, located at different distances from the BH. Their presence along the line of sight (highlighted by a $\surd$) determines the classification of the object. As for the torus, it is required in all cases, because of the ubiquity of not-variable reprocessed components from Compton-thick material, even if only Compton-thick sources intercepts it along the line of sight. See text for details.

Classification	**Dust lane** (>> pc)	**Torus** (pc)	**Clouds** (< pc)
Seyfert 1			
'Ch-look' Seyfert 1			$\surd$
C-thin Seyfert 2	$\surd$		
'Ch-look' Seyfert 2	$\surd$		$\surd$
C-thick Seyfert 2	?	$\surd$	?

In the last years, a number of sources have shown a geometry for the absorbers which is necessarily more complex than what generally assumed in simple Unification Models. NGC 7582 is a clear-cut example, where three neutral absorber/emitter regions must be present on very different scales. We propose that the scenario adopted for this source may be the rule rather than the exception. The Unification Model should therefore be modified in order to account for all the observational evidence collected so far.

The new scenario (see Tab. 1) is based on the model presented by Matt (2000): to the ubiquitous pc-scale torus, an extended, Compton-thin material, likely associated to galactic dust lanes, has to be added. Moreover, we suggest the presence of another material, made of Compton-thick and/or Compton-thin clouds, located roughly at the BLR, whose presence can be unveiled only when the torus does not intercept the line of sight and the material is patchy, leading to observable absorption variability on short timescales.

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