On Seyfert spectra and variability

P. Magdziarz
Jagiellonian University, Astronomical Observatory, Cracow, Poland

Received December, 1997; Accepted April, 1998

Abstract

We discuss the observational phenomenology of Seyferts from the point of view of the disk model, and argue that the spectral variability may be related to geometrical changes of the cold matter which provides a source of seed photons for Comptonization in a hot central disk. One possible configuration is a model with quasi-spherical accretion in the central part of the disk, with variability determined by the dynamics of the transition zone between the cold and hot disk. The soft excess component appears as a driver of spectral variability and contributes significantly to the source energetics.

1 Introduction

The physical interpretation of the broad-band spectra of Seyfert nuclei is still an open question, despite the fact that the actual radiation processes responsible are well understood (e.g., Zdziarski et al. 1997). One of the main current problems to solve is a mapping of the observed, three component continuum emission, namely the big blue bump, the soft excess, and the hard continuum, onto a physical picture of matter accreting onto a black hole. Distinguishing between various geometries of AGN (e.g., Haardt 1997) is still an observational question on interpretation of the broad-band spectrum and variability.

2 Variability

It has been suggested that the complexity of AGN light curves is generally related to the basic nonlinearity of the underlying physics (e.g., Vio et al. 1992). Nonlinear variability has been clearly detected in high quality optical observations of some bright objects (e.g., Vio et al. 1991, 3C 345; Longo et al. 1996, NGC 4151), however, searches for nonlinear signatures have failed in most of the available X-ray data (e.g., Czerny and Letho 1997). This has been explained by the strong dependence of the analysis methods on signal degradation due to observational noise (Leighly 1997). In fact, nonlinearity has been recently detected in some X-ray observations with high signal to noise ratio on day-to-month time scales relevant to energy reprocessing (Leighly and O’Brien 1997, 3C 390.9; Boller et al. 1997, IRAS 13224-3809).

The overall character of variability detected in active objects is consistent with self-organized criticality models (SOC models; Mineshige, Ouchi and Nishimori 1994). This has been interpreted as a strong effect of triggering a number of energy reservoirs by an instability in the disk. This instability leads to an avalanche of accretion and in effect to flares with substantial nonlinearity (i.e., internal correlation between parameters of the flares). The light curve then consists of a weakly variable and relatively faint period before the triggering event, and a bright strongly variable period with some kind of decay after the triggering event. Recently, Leighly and O’Brien (1997; their Figure 1) separated such a characteristic shape of the X-ray light curve in the case of 3C 390.9. Some evidence for a similar pattern has also been detected in optical observations of NGC 4151 and NGC 5548 (Cid Fernandes et al. 1997).

3 Reprocessing and the source structure

Turner et al. (1997) have suggested recently that the broad iron line in Seyferts has a universal profile independent of type, leading to trouble for unification schemes, and putting into question the relation between the iron line and reflection component. Some Seyfert 2s show spectrum dominated by reflection component which is, generally, explained by hiding the nucleus by a large scale torus (e.g., Matt 1997). However, in the case of the reflection dominated spectrum of MCG -6-30-15 (type 1 Seyfert) both the iron line and the reflection component are probably concentrated inside about 10 Schwarzschild radii (Maiolino-Niedźwiecki et al. 1998). This, together with the universal shape of the iron line, argues for a quasi-spherical accretion in the central part of the disk. The structure of the central disk may be related to the cloudlets model (e.g., Kuncic et al. 1997). If the standard cold disk exists on scales larger than 10rg, the disk should sample different solutions at different radii (e.g., Chen et al. 1995). Then one might expect that the inner, radiation dominated edge of the cold external disk puffs up at large accretion rates, hiding at some epochs at least a part of the central region and leading to separation of the external disk from the central hot source. This may explain a delay of X-ray variations with respect to the soft excess suggested by observations of some sources (e.g., Kaastra and Barr 1989, NGC 5548). The inner region of the cold disk is dominated by scattering, thus may be responsible for a variable soft excess continuum (Magdziarz et al. 1998).

There is strong evidence that the reprocessing of X-rays is non-local, at least in the best-observed Seyfert NGC 5548, since UV and optical emission vary nearly precisely in phase (Krolik et al. 1991; Clavel et al. 1992). This strongly argues against stationary models of the disk–patchy corona and a correlation between active regions has to be postulated by, e.g., a much shorter time scale of energy transfer to the active regions than the triggering time scale (Haardt et al. 1994). Alternatively, models with a central coherent X/γ source can naturally explain the global variability behavior. Recently, Magdziarz et al. (1997) have detected in NGC 5548 a correlation between the total brightness in
3. Haardt, F., Proc. Second Italian Workshop on Active Galactic Nuclei (astro-ph/9612082) (1997).
4. Haardt, F., Maraschi, L. and Ghisellini, G., ApJ, 432, L95 (1994).
5. Igumenshchev, I. V., Abramowicz, M. A. and Novikov, I., MNRAS, in press (1997).
6. Iwasawa, K., et al., MNRAS, 282, 1038 (1996).
7. Kaastra, J. S. and Barr, P., AA, 226, 59 (1989).
8. Kuncic, Z., Celotti, A. and Rees, M. J., MNRAS, 284, 717 (1997).
9. Leighly, K. M., Proc. of IAU Symp. 188, Kyoto, Japan, in press (1997).
10. Leighly, K. M., et al., ApJ, 483, 767 (1997).
11. Leighly, K. M. and O’Brien, P. T., ApJ, 481, L15 (1997).
12. Maciolek-Niedźwiecki, A., et al., in preparation (1998).
13. Magdziarz, P., et al., in preparation (1998).
14. Magdziarz, P., et al., Proc. 4th Compton Symposium, in press [astro-ph/9707202] (1997).
15. Magdziarz, P. and Blaes, O., Proc. of IAU Symp. 188, Kyoto, Japan, in press [astro-ph/9710183] (1997).
16. Matt, G., Proc. Second Italian Workshop on Active Galactic Nuclei (1997).
17. Mineshige, S., Ouchi, B. and Nishimori, H., PASJ, 46, 97 (1994).
18. Nandra, K., et al., MNRAS, 273, 85 (1991).
19. Papadakis, I. E. and Lawrence, A., MNRAS, 272, 161 (1995).
20. Papadakis, I. E. and Lawrence, A., Nature, 361, 233 (1993).
21. Turner, T. J., George, I. M., Nandra, K. and Mushotzky, R. F., ApJ, in press (1997).
22. Yaqoob, T. and Warwick, R. S., MNRAS, 248, 773 (1991).
23. Zdziarski, A. A., et al., Proc. of the 2nd INTEGRAL Workshop, ESA SP-382 (1997).