X ray spectroscopy of polar-scattered Seyfert 1 galaxies: The case of Fairall 51

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Abstract

We present a spectral re-analysis of Fairall 51, optically a Seyfert 1 galaxy, which, however, shows a very strong polarization. As this feature is not characteristic for Seyfert 1 objects, this galaxy may represent a borderline object between Seyfert 1 and Seyfert 2 galaxies and provide with valuable information about the structure of Active Galactic Nuclei. We present results from a study of two archival sets of observations performed in September 2005 and March 2006 by the European satellite XMM-Newton and four observations performed in September 2013 by the Japanese observatory Suzaku. It follows from the spectral analysis that there are at least two or three ionized absorbers in the studied AGN. Based on the spectral variability, we estimated the location of the variable absorber to be 3 to 60 light days from the central engine, which indicates its origin in the Broad Line Region.

Structure of an AGN

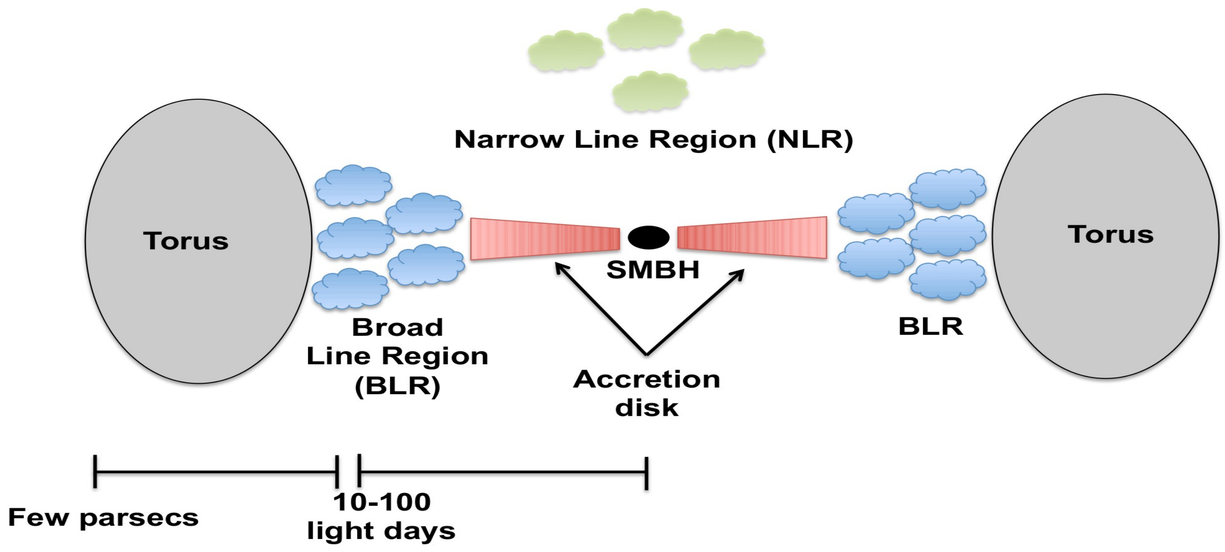

Fig. 1: A super-massive black hole (SMBH) is situated in the center, surrounded by a gaseous formation called an accretion disk, a structure of ionized clouds above the accretion disk forming the Broad Line Region (BLR), a structure of clouds extended beyond BLR forming the Narrow Line Region (NLR) and a gaseous-particle structure called torus surrounding the whole galactic nucelus (Antonucci (1993)).
Image credit: http://www.isdc.unige.ch/~ricci/Website/Active_Galactic_Nuclei.html

Classification and the Unification scenario

Several characteristics are used to distinguish between Seyfert 1 and 2 objects: type 1 galaxies posses both broad and narrow lines in their spectra and show very little polarization. On the other hand, type 2 objects present narrow lines only and show stronger polarization features, as they are observed through the torus. Regarding the Unification scenario for Active Galactic Nuclei, type 1 and type 2 galaxies are the same type of objects, observed from a different angle. Nevertheless, such a differentiation does not work for a special type of objects, the so-called polar-scattered Seyfert 1 galaxies. Since these objects display strong polarization due to polar-scatering, their polarization characteristics are similar to those of Seyfert 2 objects. Therefore, they are believed to be border-line objects between Seyfert 1 and Seyfert 2 galaxies. Smith et al. (2004) estimated polar-scattered Seyfert 1 galaxies represent 10 to 30 percent of the Seyfert 1 population.

Fairall 51 features & spectral analysis

Fairall 51 is a Seyfert 1 object with one of the highest optical polarization ever measured for a type 1 source. For its strong X-ray brightness, it has been a suitable target for X-ray spectroscopy study. We analyzed 2 datasets of Fairall 51 performed by the XMM-Newton satellite and 4 datasets by the Suzaku observatory. We fit the data using models from Svoboda et al. (2015) and Ricci et al. (2010). Each of the modeled datasets is well described by a power-law with the Photon Index varying from 1.82 to 2 absorbed by a low-, medium- and a highly-ionized absorbers and the additional soft X-ray component that can be modelled with an additional soft power-law component or by a hot plasma model (e.g. apec). The spectra and their residuals from the best fit model are shown in Figure 2. Fairall 51 is clearly an X-ray variable source. The most of the variability can be attributed to the least-ionised absorber. This variability was reported on the week time scale (Svoboda et al., 2015), from which it was possible to estimate the distance of the absorber. We extended their work by allowing more parameters to vary in the model and obtained the distance of 3-60 light days from the super-massive black hole (Mikusincova (2016), BSc. Thesis). RGS spectra from the 2005 observation were also analyzed. The data were fit by a powerlaw absorbed by three layers of partially covering ionized material. It is, however, distinct from the Fig. 3 the model does not fit the data successfully. Therefore, longer-exposure data would be desired.

Conclusions & future prospects

- Fairall 51 is an object of a very complex spectrum consisting of at least 2 – 3 ionized absorbers and either two powerlaw components or one powerlaw and an apec component for hot plasma
- The distance of the variable absorber was calculated to be approx. 3 – 60 light days, implying its location in the Broad Line Region
- For a more in-depth analysis of the spectrum below 2 keV, high resolution X-ray data, e.g. those achievable by the XMM-Newton RGS spectrographs with a sufficiently long exposure, would be needed
- Future X-ray polarimetry missions, such as planned IXPE and in-proposal XIPE and eXTP observatories would be essential in providing the data crucial for a more detailed study of polar-scattered Seyfert 1 galaxies

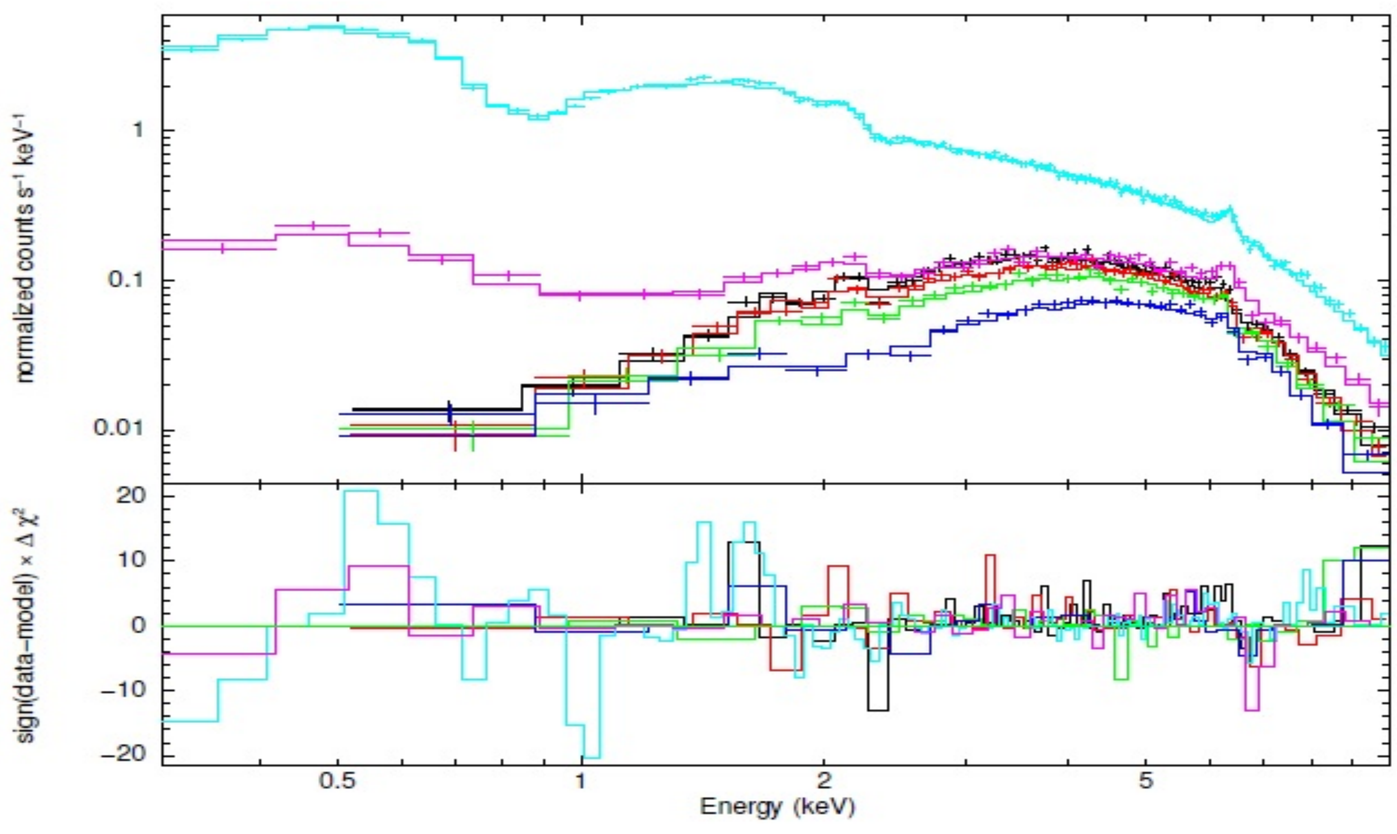

Fig. 2: Up: X-ray spectra of two XMM-Newton observations (2005 light blue, 2006 pink) and four Suzaku observations (1st black, 2nd red, 3rd green, 4th dark blue) fit by the model consisting of an apec and a power-law component absorbed by three layers of ionized material. Bottom: Data residuals from the best-fit model.

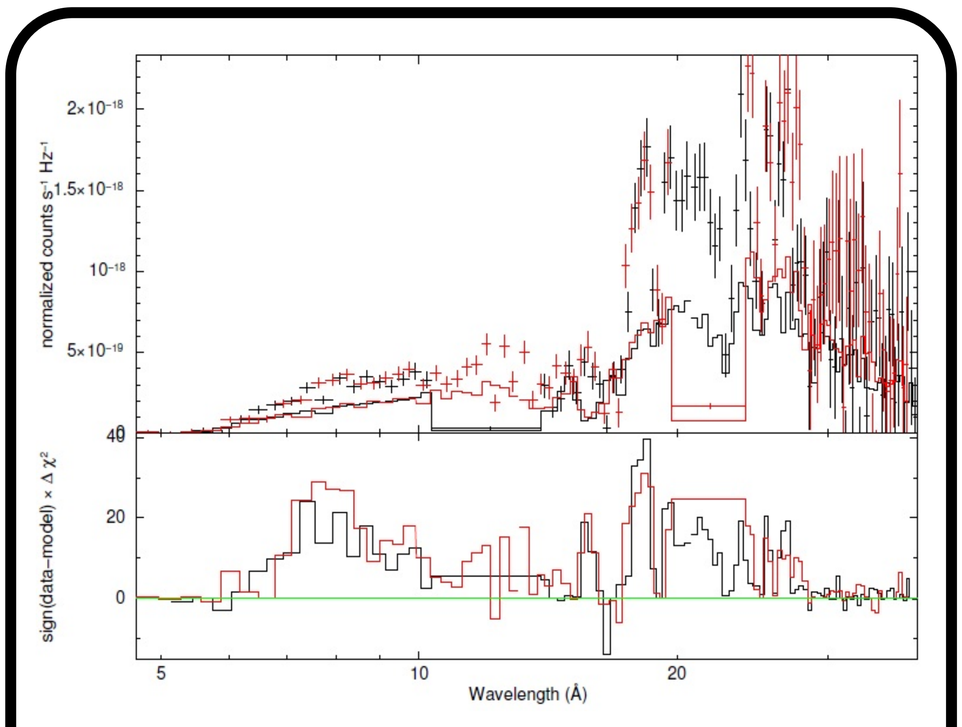

Fig. 3: RGS spectra of the 2005 XMM-Newton observations modeled with three warm absorbers. Clear residuals are present in the data, suggesting the presence of emission lines in the spectra.

References: R. Antonucci, 1993, ARA&A, 473, 31. • R. Mikusincova, 2016, Bachelor Thesis. • C. Ricci et al., 2010, A&A, 518, A47. • J. E. Smith et al., 2004, MNRAS, 140, 350. • J. Svoboda et al., 2015, A&A, 578, A96.