Bare AGN: The Innermost Accretion Geometry

M. Fink, T. Dauser, T. Beuchert, S. Jeffreson, J. Tawabutr, J. Wilms, J. García, D. J. Walton Dr.

Karl-Remeis-Observatory Bamberg & ECAP

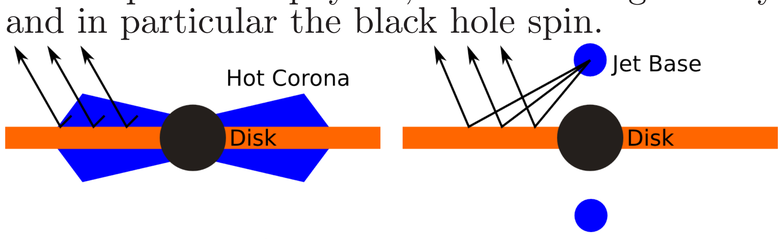
Email: marco.fink@fau.de

Abstract

We re-analyze the sample of bare AGN spectra introduced by Walton et al. (2013) by making use of more recent data including high signal-to-noise spectra from the *XMM-Newton* and *NuSTAR* archives. We model features of blurred reflection off an ionized accretion disk with different flavors of the relativistic ray-tracing code `relxill`. We show that the more physically motivated and self-consistent lamp-post geometry is largely consistent with fits of broken power-law emissivity profiles. We provide good constraints on parameters describing the compact reprocessing corona, i.e., the reflection fraction and the lamp-post height, while the latter are found to be prevalent within 1–10 r_g. Our models consistently find close-to-maximal black hole spins.

Primary Source Geometry

Unobscured Seyfert Galaxies allow a direct line of sight onto the compact accreting AGN and its corona, a source of reprocessed thermal disk photons. Whenever X-rays are reflected off the inner accretion disk in close vicinity of the black hole, general relativistic effects strongly affect photon trajectories, energies and therefore the shape of the reflected spectrum. The shape of the Fe Kα line can be used to infer information on the prevalent physics, the coronal geometry and in particular the black hole spin.



The geometry of the primary X-ray source, however, is still subject to debate and has strong implications on the models. In particular, the often measured steep inner emissivity profile can be well explained with a lamp-post geometry, where the corona needs to be compact and situated at low heights. Prominent examples are Mrk 335 (Parker 2014), 1H 0707−495 (Dauser 2012) or NGC 4151 (Beuchert 2016). Independent reverberation studies also find that the corona can be either horizontally or vertically extended

Method: Sample Analysis

We reduced a sample of joint XMM-Newton and NuSTAR spectra spanning a range of 1-70 keV, carefully taking cross-calibration and source variability into consideration. The resulting broadband spectra are analyzed using a generic model. Depending on the individual source, it contains some or all of the following components:

- Galactic Absorption (**tbnew**)
- Source Absorption (**zxipcf**)
- Cut-off powerlaw
- Cold distant Reflection (**xillver**)
- Relativistic Reflection (**relxill**)

We fit relativistic reflection in two flavours, comparing a lamppost model of **free normalization** and one **self-consistent** model. In the latter one, the reflected intensity is derived from the height of the primary point source above the accretion disk.

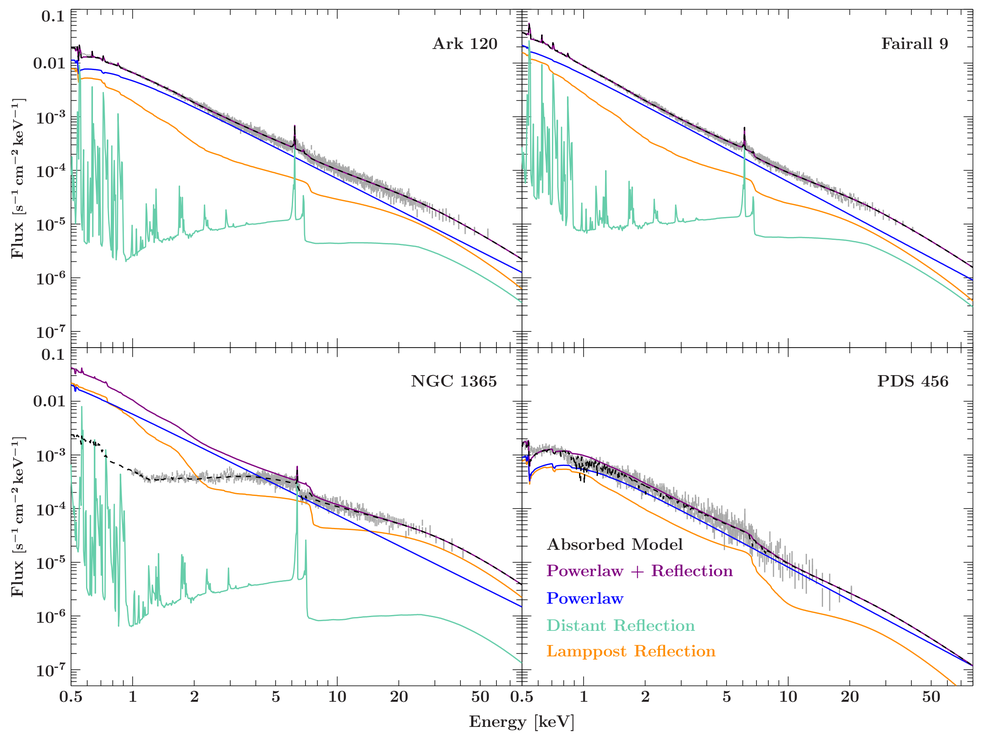


Figure 1: A subset of our sample to illustrate the multitude of spectral features and the contributions of model components.

Results: Consistent Lamppost Measurements

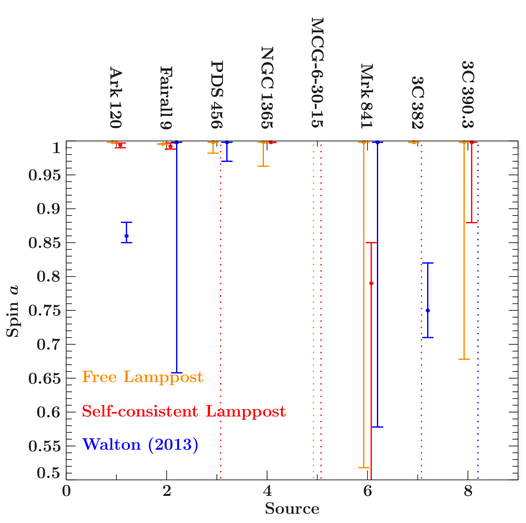


Figure 2: Spin values for the sample, measured with both model flavours. Dotted lines were unconstrainable. For comparison, the values gained by Walton (2013) are included.

All broadband reflection spectra of our sample can be modelled assuming a broken powerlaw emissivity profile. However, a lamp-post geometry model can reproduce all reflection spectra at comparable fit statistics. The physically motivated lamp-post model contains less parameters, thus removing degeneracies in the χ^2-landscape and allows us to probe the geometry of the primary source.
We find spin values constrained closely to the theoretical maximum (plot above) and present a range of source height measurements (plot to the right).

Both trends for high spin values and low source heights are caused by the selection effect of analyzing sources with visually distinct broad iron lines

Summary

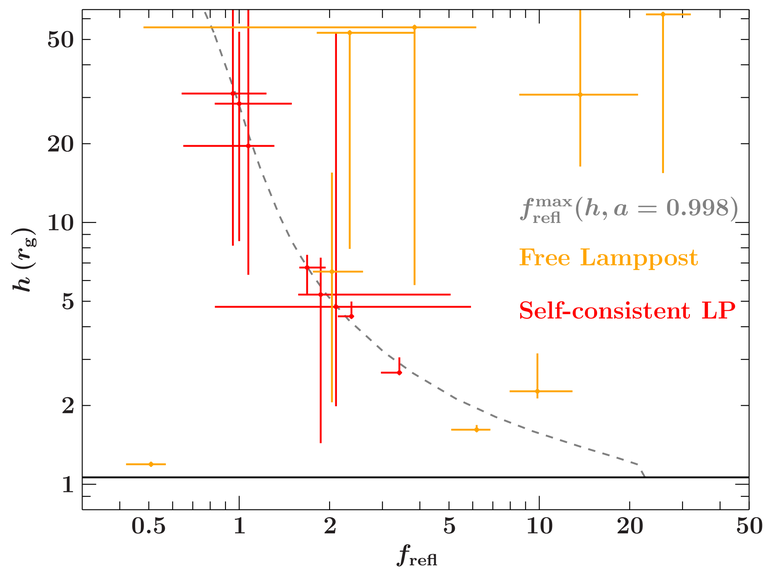


Figure: Measured heights and reflection fraction for both model flavors. Dashed line: theoretically allowed maximum curve.

- We analyze joint XMM-Newton and NuSTAR spectra with exposures of 50 to 150 ks.
- The physically motivated lamp-post model is able to reproduce spectra equally well as empirical emissivity profiles.
- We are able to model broadband spectra from 1-70 keV with a self-consistent reflection model connecting primary and reflected radiation.
- A self-consistent implementation of the lamp-post model rules out unphysical parameter combinations (see plot above).
- Where we are able to constrain them, we find black hole spins to be constrained close to the maximum of 0.998

References

- D. J. Walton et al. 2013, MNRAS, Vol. 428, Iss. 4, p.2901-2920
- García & Dauser et al. 2014, ApJ, Vol. 782, Iss. 2, article id. 76, 14 pp.