The changing X-ray corona in Ark 120

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Outline

Introduction

The source – Ark 120

The Model – MoCA

The results
One of the main open problems for AGN is the nature of the primary X-ray emission. It is due to Comptonization of soft photons, but the geometry, optical depth and temperature of the emitting corona are largely unknown.

Most popular models imply $E_{\text{cut}} = 2-3x kT_e$ (Petrucci+00,+01), so measuring $E_{\text{cut}}$ helps constraining Comptonization models.
Before the launch of NuSTAR, we only had a handful of results based on non-focusing, and therefore strongly background-dominated, satellites (BeppoSAX-PDS, Suzaku HXD-PIN, INTEGRAL, Swift-BAT)

Perola+02

De Rosa+12; Molina+13
So far, about twenty sources have been observed and their primary continua investigated.

No statistically significant correlations are found with accretion rate/BH mass.
Ark 120 – A ‘bare Seyfert’ galaxy

- Nearest and brightest
  \[ D = 144 \text{ Mpc} \]
  \[ F_X = 7 \times 10^{-11} \text{ erg/cm}^2/\text{s} \]

- Bare line of sight (Reeves+16)
  \[ N_H < \text{a few } 10^{19} \text{ cm}^{-2} \]

- BH mass known from reverberation mapping
  \[ M_{\text{BH}} = 1.5 \times 10^8 M_{\odot} \]

**2013 X-ray campaign (PI: G. Matt)**
- One XMM-Newton orbit (net exposure 80 ks)
- Simultaneous NuSTAR observation (80 ks)

**2014 X-ray campaign (PI: D. Porquet)**
- Four consecutive XMM-Newton orbits (7.5 days, net exposure 330 ks)
- Chandra HETG spectrum overlapping with XMM#2 + XMM#3 (120 ks)
- NuSTAR observation simultaneous with XMM#3 (65 ks)
Ark 120 – A ‘bare Seyfert’ galaxy

Matt+2013
- Soft X-ray excess due to Comptonization
- No relativistic Iron Kα detected

Reeves+2016 (Paper I)
- XMM RGS data analyzed and $N_H$ inferred
- Several emission lines associated with the AGN detected

Nardini+2016 (Paper II)
- Chandra HETGS analyzed and more complex Iron Kα structure revealed
- Accretion disk hotspots originating at 60-120 $r_g$

Lobban+2017 (Paper III)
- Timing analysis of the XMM EPIC-pn data
- Previous findings are confirmed

Porquet+2017 (Paper IV)
- Comprehensive study of the XMM/NuSTAR 2014 campaign
- Warm+Hot Comptonization, relativistic reflection from ~25 $r_g$
In the four XMM observations taken in 2014, both the hot and warm Comptonization components are found to be variable in amplitude.
A significant steepening has been observed in the 2014 XMM/NuSTAR spectra: our aim is to investigate the hot coronal component. The warm Comptonization is found to be variable only in terms of relative normalizations, while kT and τ are compatible (kT=0.5 keV, τ=10).

2014: $\Gamma=1.87\pm0.02$ $E_c=183^{+83}_{-43}$ keV

2013: $\Gamma=1.79\pm0.03$ $E_c>190$ keV
A MC code for Comptonization in Astrophysics (MoCA)

Assumptions and advantages:
1. Shakura-Sunyaev neutral accretion disc
2. Extended coronae
3. Single photon approach
4. Polarization signal

We generated two table models (slab, sphere) in the ranges:
kT: 40-120 keV
τ: 0.5-2.5

Tamborra+, submitted
Different Comptonization codes (comptt, compPS) give similar predicted spectra but cannot be applied to particular ranges of kT and optical depth.
Once we apply the two models to the XMM/NuSTAR data set we are not able to statistically discriminate between a spherical or slab geometry. (Reduced $\chi^2=1.05$ for 750 d.o.f.)

Marinucci +, in prep.

**SLAB**

$kT=65\pm10$ keV  
$\tau=1.2\pm0.2$

**SPHERE**

$kT=105\pm10$ keV  
$\tau=1.1\pm0.2$

$kT=110\pm10$ keV  
$\tau=1.2\pm0.2$

$kT>95$ keV  
$\tau=1.5\pm0.3$

A clear evolution in the hot coronal configuration is observed. This could be due to geometrical effects (changes in the height/truncation radius?) or to the heating/cooling mechanism.
Two different Comptonization systems (warm/hot coronae) are necessary to explain the spectral behavior of Ark 120

Detailed studies (Paper I-V) of the long 2014 observing campaign have provided a unique insight on the disk-corona environment in this bare AGN

Perfect example of the synergy between the major X-ray observatories (NuSTAR-XMM-Chandra).

References:
- Paper V: Marinucci et al., in prep.