Deep X-ray view of the bare nucleus Seyfert Ark120: unveiling the core of AGN

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J. Reeves, A. Lobban, V. Braito, E. Nardini, ...
G. Matt, A. Marinucci, A. Tortosa and the Nustar AGN team
The study of X-ray spectral features:

⇒ probe AGN from the inner part of the accretion disc to much larger scales: BLR, NLR, torus, Warm absorber, outflows, ...
The « relativistic » FeKα line

The shape of the Fe Kα line ⇒ BH spin

SMBH Spin ⇒ accretion mode: chaotic versus prolonged, plus mergers?
⇒ galaxy evolution.

See also Andy’s talk
However, two interpretations/contributions for the apparent broadening of some FeK line have been proposed ....

**Relativistic reflection on the disc**
- FeK broadening directly related to the BH spin

**Warm absorber(s)**
- Which distorts the underlying continuum and mimicks an apparent broadening of the FeK line or at least make the analysis rather complex

- Observation of **bare AGN** (i.e. without Warm absorber)
- Direct view of the inner part of the accretion disc
- Test for relativistic reflection contribution without any contamination on the line-of-sight
Study of the broad-band continuum (XMM-Newton + Suzaku + Swift) of a sample of bare AGN (Patrick et al. 2011)

Spin determination is strongly model-dependent, i.e. how the soft X-ray excess is modeled:

- If due to Comptonisation of the UV disc photons by the hot e- of a corona: low spin values ⇒ chaotic accretion

- If due to relativistic reflection: high spin values ⇒ prolonged accretion

See also Walton et al. 2013: relativistic reflection → high spin values
Deepest X-ray observations of a « bare » AGN: Ark 120

Ark 120: brightest and cleanest bare AGN (z~0.06398)
- No absorption signature in X-rays and UV.
- A prominent soft excess and a possible relativistic line...

PI: D. Porquet (XMM-Newton)

1) A very deep XMM-Newton Large Program observation of 480 ks (~5.5 j):
   OM + RGS + EPIC
   ✓ RGS: Confirm/infirm the bare AGN property, soft X-ray emission features?
   ✓ X-ray (+ UV, optical) spectral and timing analysis.
   • Soft excess origin: relativistic reflection versus Comptonization.
   • The properties of the accretion disc and the black hole spin

Highest S/N data for a bare AGN ⇒ will serve as a template for AGN in general?

2) A 120 ks simultaneous Chandra/HETG observation.
   ✓ Measurement of the narrow component of the FeK complex: origin: disc, BLR or torus?
   ✓ Remove possible degeneracy between the narrow core the broad component FeK contribution.
   ✓ Ionized iron lines: FeXXV, FeXXVI?

+ 😊 After the acceptance of this proposal:
   A simultaneous Nustar observation was planned (PI: G. Matt + Nustar AGN team)
Deep X-ray observations of a « bare » AGN: Ark 120

Observation log:

- 4 x 120ks consecutive XMM-Newton observations:
  Note: source flux was about twice than in 2013

- 3 (splitted) observations with Chandra/HETG (total: 120 ks):
  It was the first Chandra observation of Ark 120!

- One Nustar observation of 55 ks,
simultaneous with the third XMM-Newton observation.
A very deep RGS observations Ark 120

- Bare or not bare AGN? 480 ks of RGS data (Reeves et al. to be subm.):
  \( \geq 6.5 \times 10^5 \) counts (S/N > 25 per bin)

\[\Rightarrow \text{No absorption lines from Ark 120.}
\text{Only absorption lines from the ISM (Gal)}\]
A very deep RGS observations Ark 120

Reeves et al.

- No absorption line from Ark 120 but several broadened emission lines

Best-fit ISM absorption model (tbnew, Wilms et al. 2000)
A blend of narrow lines can be ruled out ($\chi^2$/dof = 3135/3565), the majority of the OVII flux is not accounted for.

Can be fitted by a blend of velocity broadened lines with a common velocity of 8500 (+1700, -1500) km/s (BLR = 5800 km/s)

Similar to the one found for MR 2251-178 (Reeves et al. 2013)!
Chandra/HETG observation of Ark 120: First Chandra observation!

Reeves et al.,

FeK narrow component resolved:

E = 6.41 ± 0.02 keV

EW = 81 (+26, -23) eV

Width = 42 (+20, -12) eV

FWHM = 4620 (+2200, -1650) km/s

≈ BLR (FWHM ~ 5800 km/s)
A very deep XMM-Newton pn observations Ark 120
(Porquet et al., in progress)

A prominent soft excess, and a significant FeK complex:

→ Confirmation of previous XMM-Newton and Suzaku observations
  (e.g., Vaughan et al. 2002, Nardini et al. 2011, Walton et al. 2013, Matt et al. 2014)
  See also A. Marinucci’s talk
• « Pure reflection » model (blurred + unblurred) to explain both the soft excess and the FeK complex
The very smooth soft excess → need for highly blurred relativistic reflection to explain it.
Good fit ($\chi^2 \sim 1.06$) with high spin value : $a \sim 0.97$

• Comptonization model to explain the soft excess and blurred reflection for E>2keV:
Good fit ($\chi^2 \sim 1.07$) with spin $a >-0.5$ (TBC)

→ No discrimination between both scenario with pn only.
2014 broad-band X-ray view: (OM+) pn + Nustar
(Porquet et al.)
Summary:

2014 XMM-Newton LP + Chandra + Nustar:

• First Chandra observation of Ark 120: The FeK narrow core resolved and its width consistent with BLR

• XMM-Newton: deepest observation for a bare AGN

RGS: definitively confirmed the bare property + detection of broadened emission lines (OVII)

PN: Highest S/N of the Fe K complex
Confirmation of the significant soft excess: Both SE scenario possible

• (OM+) PN + Nustar:
For pure reflection modeling: hard X-ray excess above 30 keV
While a good fit with Comptonization + blurred reflection

Several papers to be submitted or in preparation:
RGS/HETG (Reeves et al.), FeK Complex (Nardini et al.), timing (Lobban et al.), broad-band analysis (Porquet et al.), detailed comptonization modeling (Tortosa et al.), Comptonization × reflection (Wilkins et al.), long-term spectral analysis (Matzeu et al.), ...