The high-energy view of Seyfert galaxies through broad-band monitoring campaigns

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AGN 13 - Beauty and the Beast
The two-corona model

Petrucci et al. (2013)

UV-Opt-Soft X component

warm upper layer: $T_e \sim 1$ keV, $\tau \sim 15$
depth layers: $T_{bb} \sim 3$ eV

Hard X component

Hot corona $T_e \sim 100$ keV $\tau \sim 0.5$

Black hole

10-20 $R_g$

see also Magdiarz et al. (1998)
The two-corona model

Petrucci et al. (2018)
High-energy campaigns

- Goals: Study the spectrum and variability of AGNs testing physical models for the high-energy emission
- Broad-band: XMM+NuSTAR (optical/UV to 80 keV)
- Variability: $5 \times 20$ ks observations
- A classical Seyfert 1: NGC 4593
- A broad-line radio galaxy: 3C 382
- A highly accreting Seyfert 1: HE 1143-1810
NGC 4593: a day time-scale monitoring

NGC 4593 XMM/pn and NuSTAR light curves and hardness ratios

Ursini et al. (2016)
XMM/pn and NuSTAR/FPMA data fitted with a power law

Counts s⁻¹ keV⁻¹ cm⁻²

Data/model ratio

Energy (keV)

variable
soft excess

Ursini et al. (2016)
The average spectrum

Middei et al., submitted
Warm/hot coronae: correlated variability

Middei et al., submitted
XMM/pn and NuSTAR/FPMA+FPMB light curves and hardness ratios

XMM/pn 0.5−2 keV

XMM/pn 2−10 keV

XMM/pn 2−10 keV/0.5−2 keV

NuSTAR 3−10 keV

NuSTAR 10−50 keV

NuSTAR 10−50 keV/3−10 keV

Time (ks)

Counts/s

Hardness ratio

Ursini et al. (2018)
no Compton bump

Ursini et al. (2018)
Counts/s

XMM/pn 0.5−2 keV

XMM/pn 2−10 keV

XMM/pn 2−10 keV/0.5−2 keV

Counts/s

XMM/pn and NuSTAR/FPMA+FPMB light curves and hardness ratios

Counts/s

NuSTAR 3−10 keV

NuSTAR 10−50 keV

Counts/s

NuSTAR 10−50 keV/3−10 keV

Hardness ratio

Time (ks)

Hardness ratio

Ursini et al. (in prep.)
<table>
<thead>
<tr>
<th></th>
<th>NGC 4593</th>
<th>3C 382</th>
<th>HE 1143-1810</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_{BH}$</td>
<td>$1 \times 10^7 , M_\odot$</td>
<td>$1 \times 10^9 , M_\odot$</td>
<td>$1 \times 10^7 , M_\odot$</td>
</tr>
<tr>
<td>Eddington ratio</td>
<td>$\sim 0.1$</td>
<td>$\sim 0.01$</td>
<td>$\sim 1$</td>
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**hot corona**

<table>
<thead>
<tr>
<th>Temperature</th>
<th>variable</th>
<th>high</th>
<th>low</th>
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</thead>
<tbody>
<tr>
<td>Optical depth</td>
<td>$\sim 30$ to $&gt;150$ keV</td>
<td>$&gt;40$ keV</td>
<td>$\sim 20$ keV</td>
</tr>
<tr>
<td></td>
<td>$&lt;0.9$ to $\sim 2$ compact†</td>
<td>$&lt;4$ compact†/outflowing?</td>
<td>$\sim 4$ slim disc??</td>
</tr>
<tr>
<td>Geometry</td>
<td>compact†</td>
<td>compact†</td>
<td>slab</td>
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</table>

**warm corona**

<table>
<thead>
<tr>
<th>Temperature</th>
<th>$\sim 0.12$ keV</th>
<th>$\sim 0.6$ keV</th>
<th>$\sim 0.5$ keV</th>
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<tbody>
<tr>
<td>Optical depth</td>
<td>$\sim 35$ to $\sim 45$ slab</td>
<td>$\sim 20$ slab</td>
<td>$\sim 20$ slab</td>
</tr>
<tr>
<td>Geometry</td>
<td>slab</td>
<td>slab</td>
<td>slab</td>
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**reflection**

<table>
<thead>
<tr>
<th>Components</th>
<th>2 (cold+ionized)</th>
<th>none</th>
<th>1 (ionized)</th>
</tr>
</thead>
</table>

† Covering factor $\approx 10\%$

More to come: Mrk 359 (NLS1), archival data...
Conclusions

- The two-corona model provides a viable scenario in different types of AGNs - see also campaigns with different strategies on Ark 120 (Porquet et al. 2018) and NGC 7469 (Middei et al. 2018)

- A complex interplay is expected between the warm and hot coronae.
  - The warm corona provides the seed photons to the hot corona
  - The hot corona illuminates the warm corona → reflection features?

- The existence of a warm corona implies the presence of strong magnetic fields and/or outflows (Rozanska et al. 2015) → there could be a link with disc winds and/or radio jets!

- Potential limitations: e.g. absorption/emission lines due to the presence of the warm corona?


Middei et al., submitted to MNRAS: *High-energy monitoring of NGC 4593 II. Broadband spectral analysis: testing the two-corona model*


Porquet et al., 2018, A&A 609, A42: *A deep X-ray view of the bare AGN Ark 120. IV. XMM-Newton and NuSTAR spectra dominated by two temperature (warm, hot) Comptonization processes*

Rozanska et al., 2015, A&A, 580, A77: *The existence of warm and optically thick dissipative coronae above accretion disks*
