Long-term Variability of NGC 5548

Changing like the wind

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Variability in AGN

- Solution Variability is best way to learn geometry and physics of AGN (absorption + emission)
- Can reveal location and physics of warm absorber (outflow) --> origin + feedback
- Well-known from opt/UV reverberation mapping
- X-ray variability seen in absorption + emission with high-res X-ray spectroscopy



Why NGC 5548 ?

 Best monitored AGN (Optical campaigns, RXTE)

Seven high-res X-ray spectroscopic observations spanning 7 years !

Onique opportunity to study long-term variability in detail and effects on emission & absorption components !

RXTE Lightcurve 1996 - 2007







The Warm Absorber

Variability --> t_rec --> t_rec ∝ (nα_r)⁻¹
Upper limit t_rec is 3 years (2002-2005)
ξ = L / nr² --> L + ξ known , use n from t_rec

Lower limit n --> upper limit r --> r < 7 pc.
 </p>

Narrow line region

O VII forbidden line (22.1 Å) measured with decent errors

Normal cross-correlation method not possible --> RXTE cannot measure lines

Correlate average flux before a spectral observation with emission line (multiple timescales, from weeks --> years)



Timescales X-ray NLR



OVIIf Line - Average Continuum



Light Travel Time ?

Best fit at 64 days

- Correlation real? Use physics to get the answer!
- If light travel delay (r=0.05 pc) + Keplerian rotation --> V_fwhm = 2500 km/s

But line not resolved -->V_fwhm < 600 km/s!</p>

Orientation ? Extreme anisotropy needed!

Recombination Timescale?

- ø If 64 days is t_rec --> gives n
- SEM = n²V, compare predicted to observed EM --> gives V
- V = 10^{51} m³, if spherical + uniform --> size = 3 pc.
- But if size that large, response should be slow!



Conclusions

Variability is valuable tool to investigate AGN central region.

- Variability --> Warm absorber < 7 pc</p>
- Variability --> NLR at 1 pc, include physics + geometry not just correlations !
- Continuous monitoring + regular high-res spectroscopy observations crucial, need to know history of source !

Spearman Ranks

Instead of fitting use Spearman rank analysis
 Highest coefficient (ρ=0.86) at 256 days with 1% probability of ρ=0 correlation.

If light travel = 256 days --> V_fwhm = 1300 km/s, so need geometry f = 4-6 --> possible for cone-geometry ?