Anatomy of the AGN in NGC 5548: the X-ray Narrow Emission Lines

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Abstract

We present here a stacked XMM-RGS spectrum (660 ks) of NGC 5548. NGC 5548 has historically been seen as the 'typical' Seyfert 1 galaxy, but here narrow emission lines, including He-like triplets of Oxygen, Nitrogen and Neon, and radiative recombination (RRC) features dominate the spectrum due to the unexpectedly low soft X-ray continuum flux. The three O VII triplet lines appear to have different velocities. This inconsistency is resolved by allowing the X-ray narrow line region (NLR) to be absorbed by two of the six warm absorber components in this source.

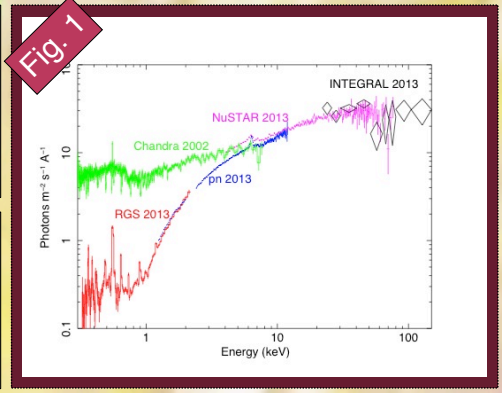
June 2013 – February 2014 NGC 5548 Campaign

- Six space observatories; XMM-Newton, Hubble Space Telescope, Swift, NuSTAR, INTEGRAL and Chandra
- New obscuring material discovered, causing soft X-ray (0.1 – 2 keV) flux to be 25 times weaker than median observations in 2002 (Fig. 1) (Kaastra et al; in press)

Observations with XMM-Newton's Reflection Grating Spectrometer (RGS)

- 12 observations of ~50 ks, each separated by a few days over June 2013-July 2013
- These observations have been stacked into one 660 ks spectrum (Fig. 2)

Fig. 1

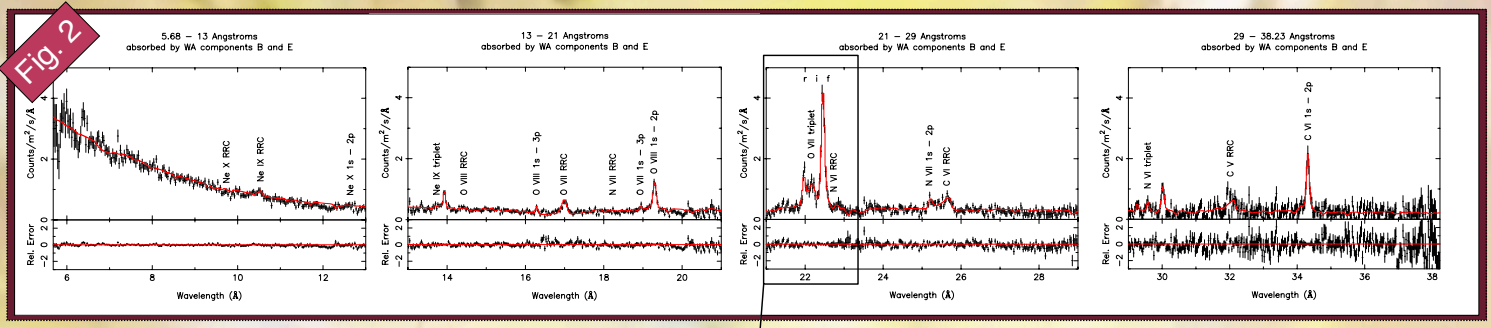


Analysis of stacked 660 ks RGS spectrum (Fig. 2)

- 15 narrow emission lines
- 8 RRCs
- 4 broad emission lines

- Continuum modelled with a powerlaw and modified black body
- Two 'obscurer' and six warm absorber components absorb the continuum
- Continuum and absorption parameters from Kaastra et al (in press)

Fig. 2



O VII triplet – conflict of velocities

- With a simple gaussian model for each line, the O VII triplet in this spectrum shows velocities as follows:
  - *Resonance* line: 56 ± 53 km s^{-1} (consistent with being at rest)
  - *Intercombination* line: -300 ± 140 km s^{-1} (*outflowing*)
  - *Forbidden* line: -310 ± 30 km s^{-1} (*outflowing*)

Table 1

Parameters of the 2013 warm absorber components (WA comp.) from Kaastra et al. (in press)

WA comp.	$\log \xi$ (10^{-9} Wm)	N_H (10^{24} m^{-2})	v (km s^{-1})	σ_v (km s^{-1})	WA comp.	$\log \xi$ (10^{-9} Wm)	N_H (10^{24} m^{-2})	v (km s^{-1})	σ_v (km s^{-1})
A	0.33	2.0±0.6	-588±34	210±40	D	1.91	10.7±11.6	-254±25	68±14
B	1.06	7.0±0.9	-547±31	61±15	E	2.48	28±8	-792±25	24±12
C	1.70	15±3	-1148±20	19±6	F	2.67	57±17	-1221±25	34±13

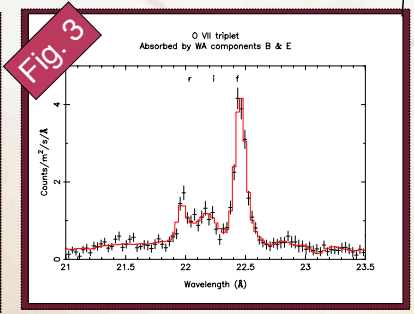
Table 2

Table 2 C-statistic values for fitting the O VII triplet with WA and obscurer absorption. The parameters of all the absorption components were fixed for this test. For each of these fits, all three O VII triplet lines had fixed outflow velocities of -300 kms^{-1}. In all cases, the expected C-statistic = 50.15±10.03 and d.o.f. = 44

Absorption applied [a]	C-statistic value
None	62.50
Obscurer & A, B, C, D, E, F	63.30
A, B, C, D, E & F	65.03
A	62.17
B	53.56
C	62.65
D	69.84
E	56.81
F	61.33
B & E	48.75

[a] Letters refer to Kaastra et al. (in press) WA components

Fig. 3



Comparison with archival data

- Unabsorbed flux values of narrow lines from this best-fit are consistent with archival data.
- Assuming the 2002 narrow lines are absorbed by 2002 WAs B & E improves the fit to the 2002 LETGS data

Using the Cloudy spectral synthesis program

- Work is ongoing to model the physical parameters of the NLR using Cloudy

Ruled out causes of velocity conflict

- Calibration effects
- Unresolved dielectronic recombination satellite lines changing apparent line centroids (Audard et al; 2001)

Absorption resolves velocity conflict

- Absorption could strongly affect *r* due to resonance scattering
- Blue-shifted *r* absorption can shift centroid of *r* to longer wavelengths
- Absorption by only two warm absorber components (B & E; Table 2) allows $v_f = v_i = v_r = -320 \pm 30$ km s^{-1} with a good fit (Fig. 3)

Conclusion

The X-ray NLR in NGC 5548 appears to be absorbed by two of the six known warm absorber components.

This was discovered by resolving discrepancies between the velocities of different parts of the Oxygen He-like triplet.

This result indicates that at least two WA components are outside the X-ray NLR and the remaining WA absorbers are located within the X-ray NLR.

Assuming the X-ray and Optical NLRs are co-located we can place both at a distance of 1- 3 pc (measured for the Optical NLR in Peterson et al; 2013).

These results are consistent with those from Detmers et al. 2008, who determined that the WA is within 7 pc from the ionising source.

References

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