

Anatomy of the AGN in NGC 5548: A twin of NGC 4151?

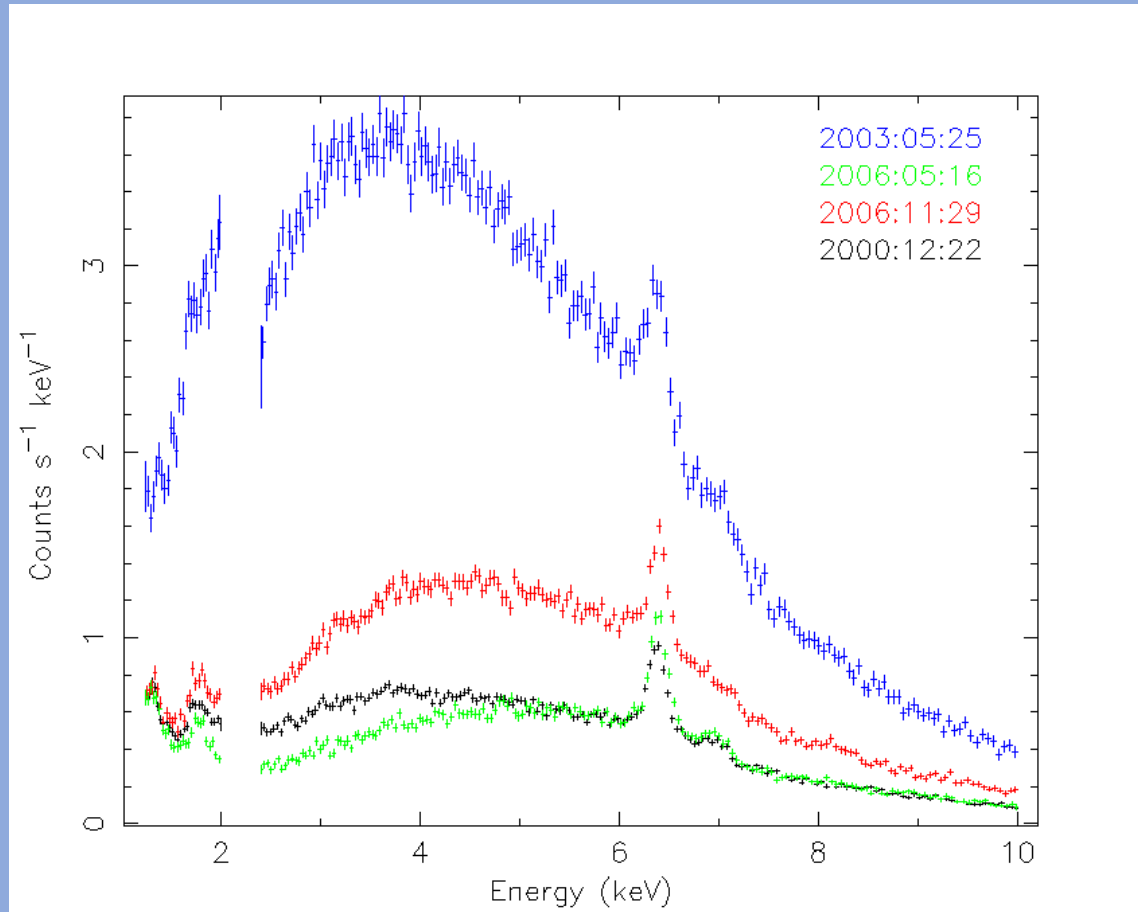
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NGC 5548 versus NGC 4151

- Main difference is that we know the structure of the warm absorber in the X-rays in NGC 5548 before it became obscured.
- With that, and an iterative process, we managed to separate warm absorber from obscurer (Kaastra et al. 2014).
- NGC 4151 has been obscured since at least 1996, when it was first observed by BeppoSAX, was observed in 1997 by HST-STIS.
- So disentangling the warm absorber, obscurer and continuum components is very tricky and the solution I present is too simple.
- But the data does not uniquely allow to add further components.

pn spectra: 1 per observational campaign for NGC 4151



pn spectra of NGC 4151

- The 2-4 keV range is much more variable (by about a factor 10) than the 6-10 keV range (only a factor of 3) and the 1-2 keV band.
- The variability is larger than for the obscured NGC 5548 observations, but that is to be expected from the difference in timescales sampled.
- On day timescale there is variability in the properties of the obscurer in NGC 4151 already known from BeppoSAX data (de Rosa et al. 2007) and confirmed by the XMM-Newton pn data.
- Interestingly, the Fe K α line strength changes on a 3 year timescale, in contrast to NGC 5548.

pn spectra: obscurer properties

- The obscurer is modelled with 2 components, one that is consistent with being neutral and $\log\xi = -4$ and covering factor of around 0.6.
- For the 2nd obscurer component the $\log\xi$ ranges between -0.55 and -0.9 and has a covering factor near unity.
- The column density and/or covering factor (these are somewhat degenerate in the fit) are variable between the different pn observations.
- I fitted the warm absorber (WA) with just 1 component (6 for NGC 5548). It has an ionization parameter of $\log\xi$ of about 2.5. In the UV 8 different WA components are present (Kraemer et al. 2006).

Obscurer properties comparison

- For NGC 5548 (Kaastra et al. 2014):

	Component 1	Component 2
N_H (10^{26} m^{-2})	1.21 ± 0.03	9.6 ± 0.5
$\log \xi$ (10^{-9} Wm)	-1.20 ± 0.08	< -2.1
f_{cov}	0.86 ± 0.02	0.30 ± 0.10

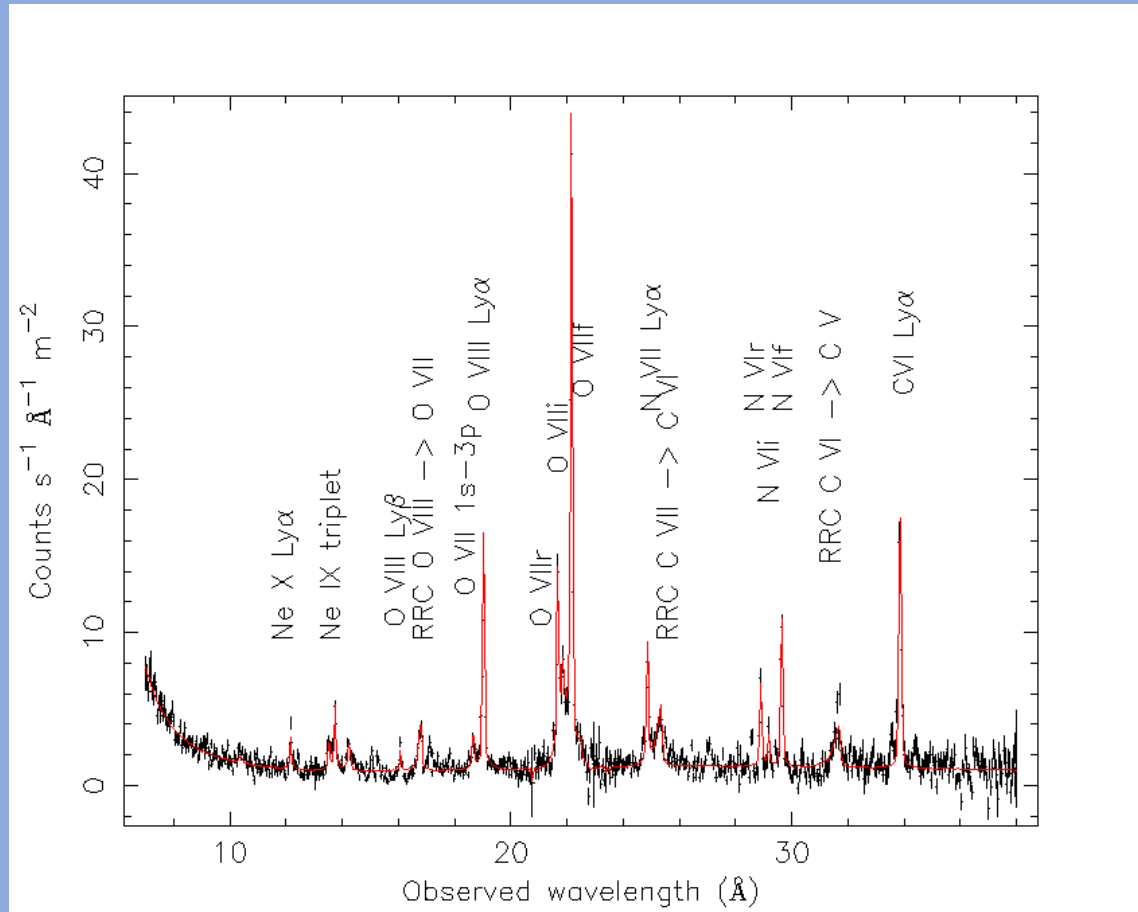
- For NGC 4151 (using high state 2003 spectrum) :

	Component 1	Component 2
N_H (10^{26} m^{-2})	2.97 ± 0.04	6.1 ± 0.3
$\text{Log } \xi$ (10^{-9} W)	-0.61 ± 0.2	< -2.9
f_{cov}	> 0.98	0.6 ± 0.05

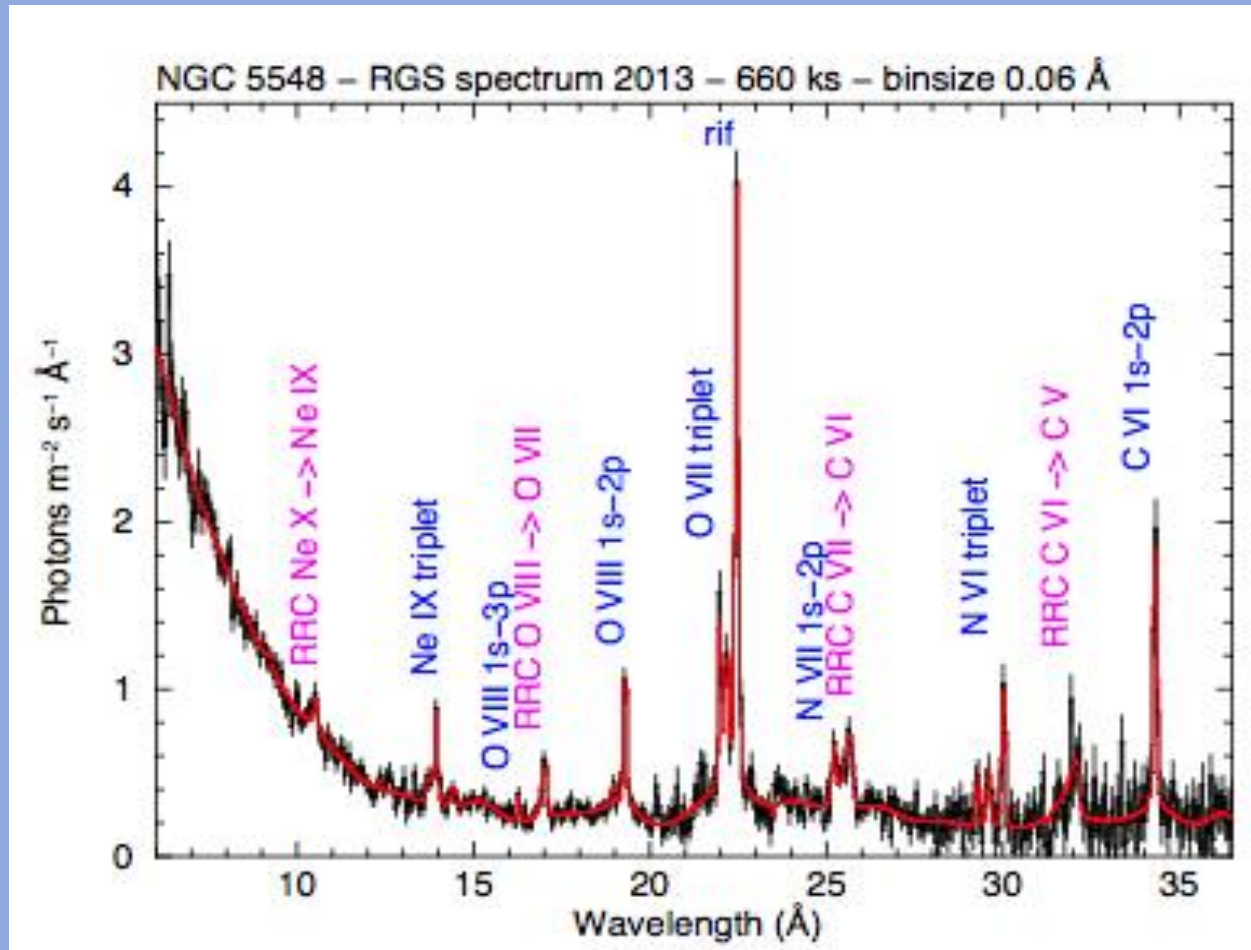
RGS spectra

- To optimize signal-to-noise ratio, and as no changes in the narrow emission lines are expected on day timescales, I combined the RGS spectra to get 1 spectrum per observing campaign normally lasting 3 days.
- So there are 4 RGS spectra only.
- Even in the high state of 2003, the source is more obscured than NGC 5548 currently is.
- The same emission lines and RRCs are observed in both sources.
- In NGC 5548 the NLR is absorbed by 2 of the 6 WA components, see poster F36 by Megan Whewell.
- However, for NGC 4151 it is not straightforward to determine which, if any, of the warm absorber components absorbs the narrow emission lines.
- In comparing the strength I assumed that the narrow line region is not absorbed in NGC 4151. However, from the intercombination to forbidden line ratio obtained, it seems likely that also in NGC 4151 NLR is absorbed by at least some of the warm absorber components.

RGS spectra: spectrum from the 2003 (high state) campaign of NGC 4151



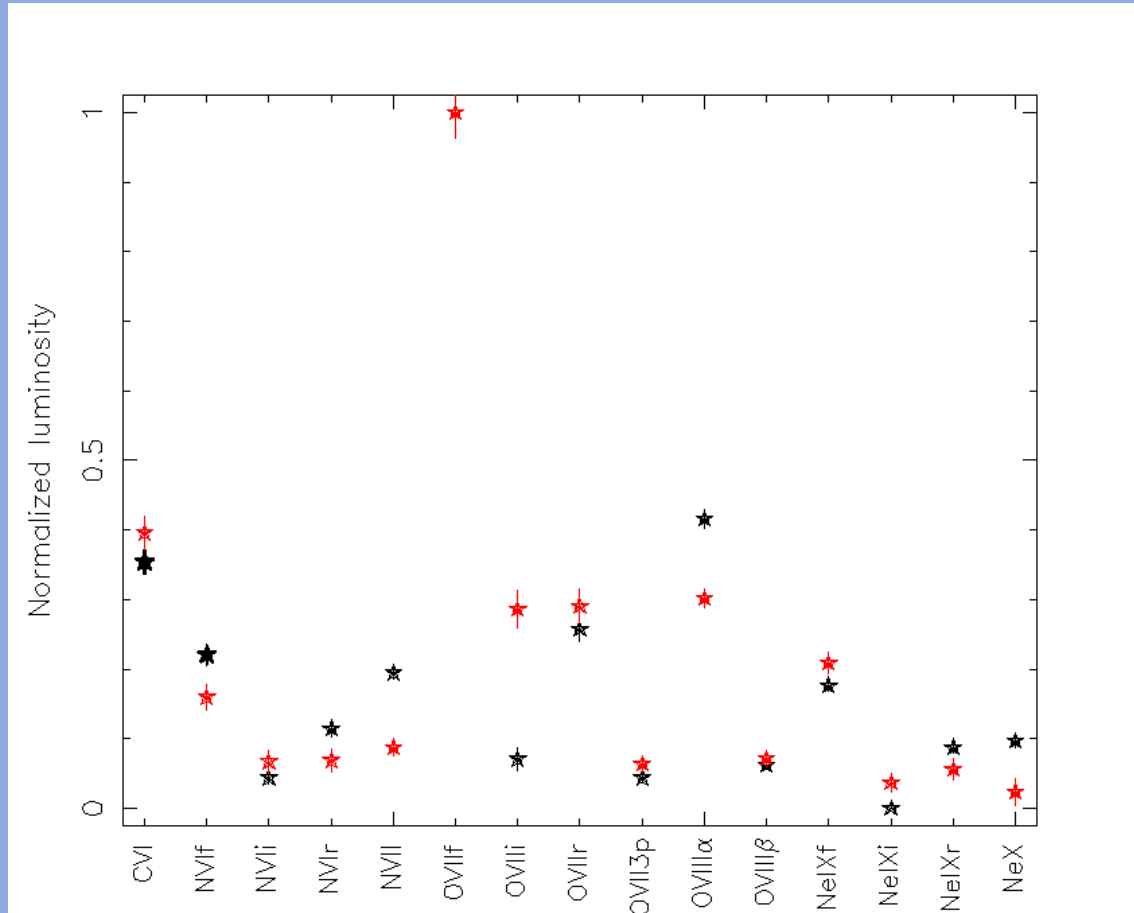
RGS spectrum from NGC 5548:



Comparison narrow emission lines

Line	Ne X 1s–2p	Ne IX r	Ne IX i	Ne IX f	O VIII 1s–3p
NGC 4151 L(10^{33} W)	0.11±0.01	0.10±0.01	---	0.20±0.01	0.07±0.007
NGC 5548 L (10^{33} W)	0.09±0.07	0.22±0.06	0.14±0.05	0.78±0.06	0.27±0.04
Line	O VIII 1s–2p	O VII 1s–3p	O VII r	O VII i	O VII f
NGC 4151 L (10^{33} W)	0.47±0.015	0.05±0.008	0.29±0.02	0.08±0.02	1.13±0.04
NGC 5548 L (10^{33} W)	1.13±0.05	0.24±0.04	1.09±0.09	1.07±0.10	3.74±0.14
Line	N VII 1s–2p	N VI r	N VI i	N VI f	C VI 1s–2p
NGC 4151 L (10^{33} W)	0.22±0.01	0.13±0.014	0.05±0.01	0.25±0.016	0.40±0.02
NGC 5548 L (10^{33} W)	0.33±0.05	0.26±0.06	0.25±0.06	0.60±0.07	1.48±0.09

Comparison of Narrow emission lines between NGC 4151 and NGC 5548



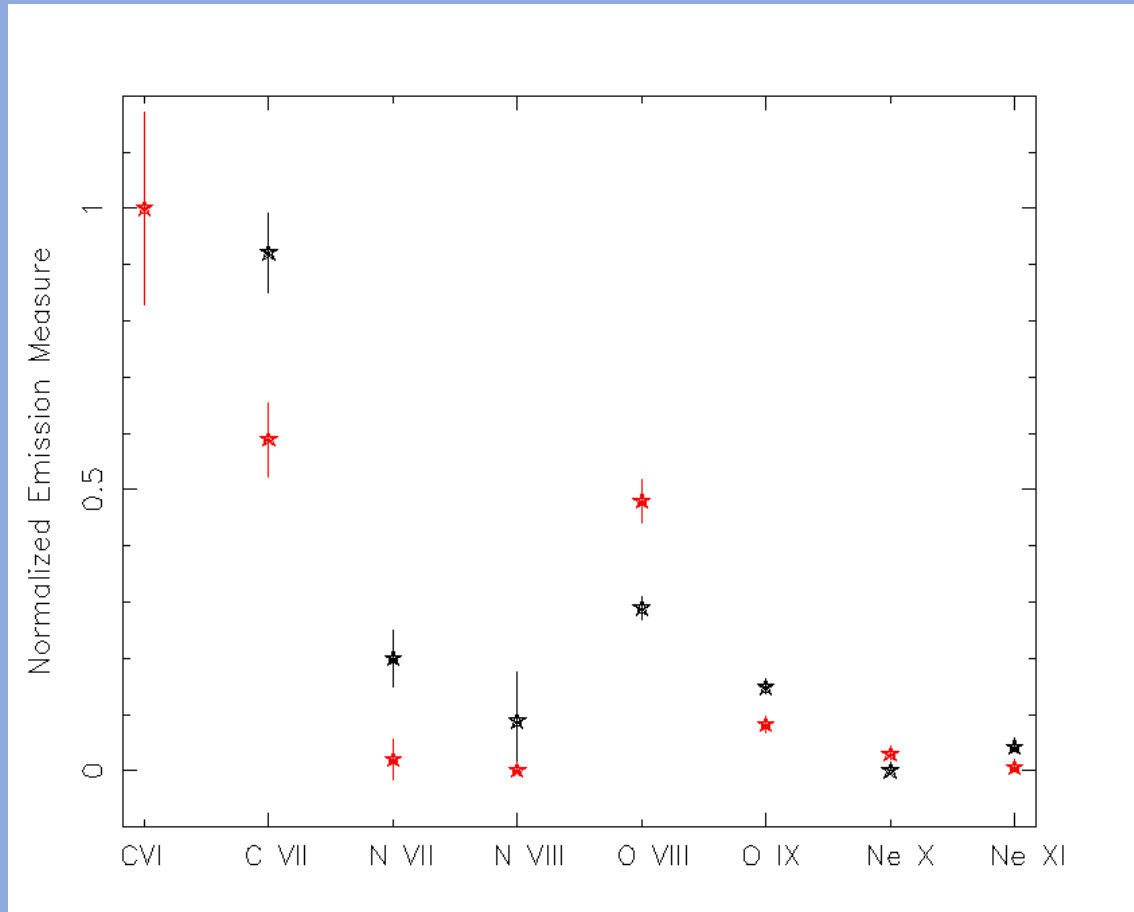
Luminosity was normalized to the luminosity of O VII forbidden line. Black is for NGC 4151 and red for NGC 5548.

Comparison of RRC's

Ion	NGC 4151 (10^{64} m^{-3})	NGC 5548 (10^{64} m^{-3})
C VI	142±16	844±140
C VII	131±10	497±55
N VII	27.8±7	16 (-16, +45)
N VIII	<12.8	0.5 (-0.5, +7.5)
O VIII	41.0±2.7	405±30
O IX	21.2±1.8	69±12
Ne X	6.0±1.1	25±9
Ne XI	-----	5 (-5, +9)

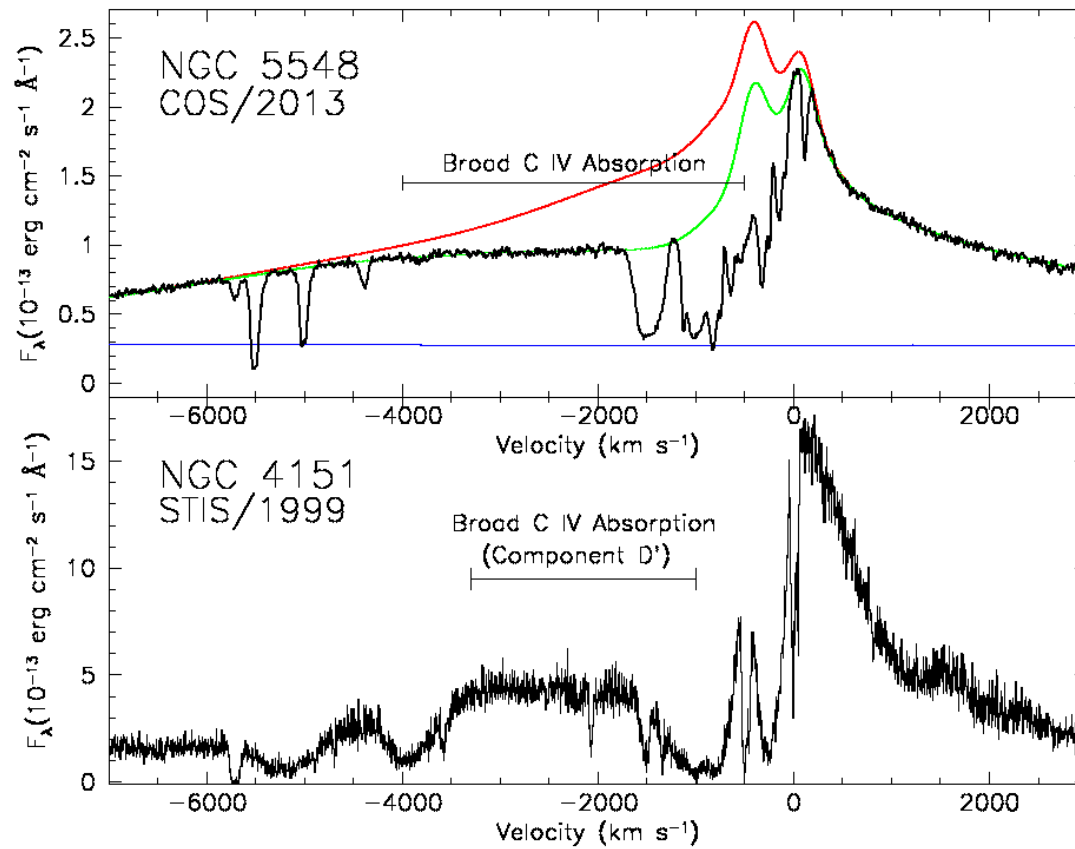
Temperature for RRCs in NGC 4151 is 3.6 ± 0.2 eV. For NGC 5548 it is 4.1 ± 0.5 eV. So the temperature are consistent, the emission measures are very different. The values for NGC 5548 are corrected for WA absorption.

Comparison of normalized RRCs

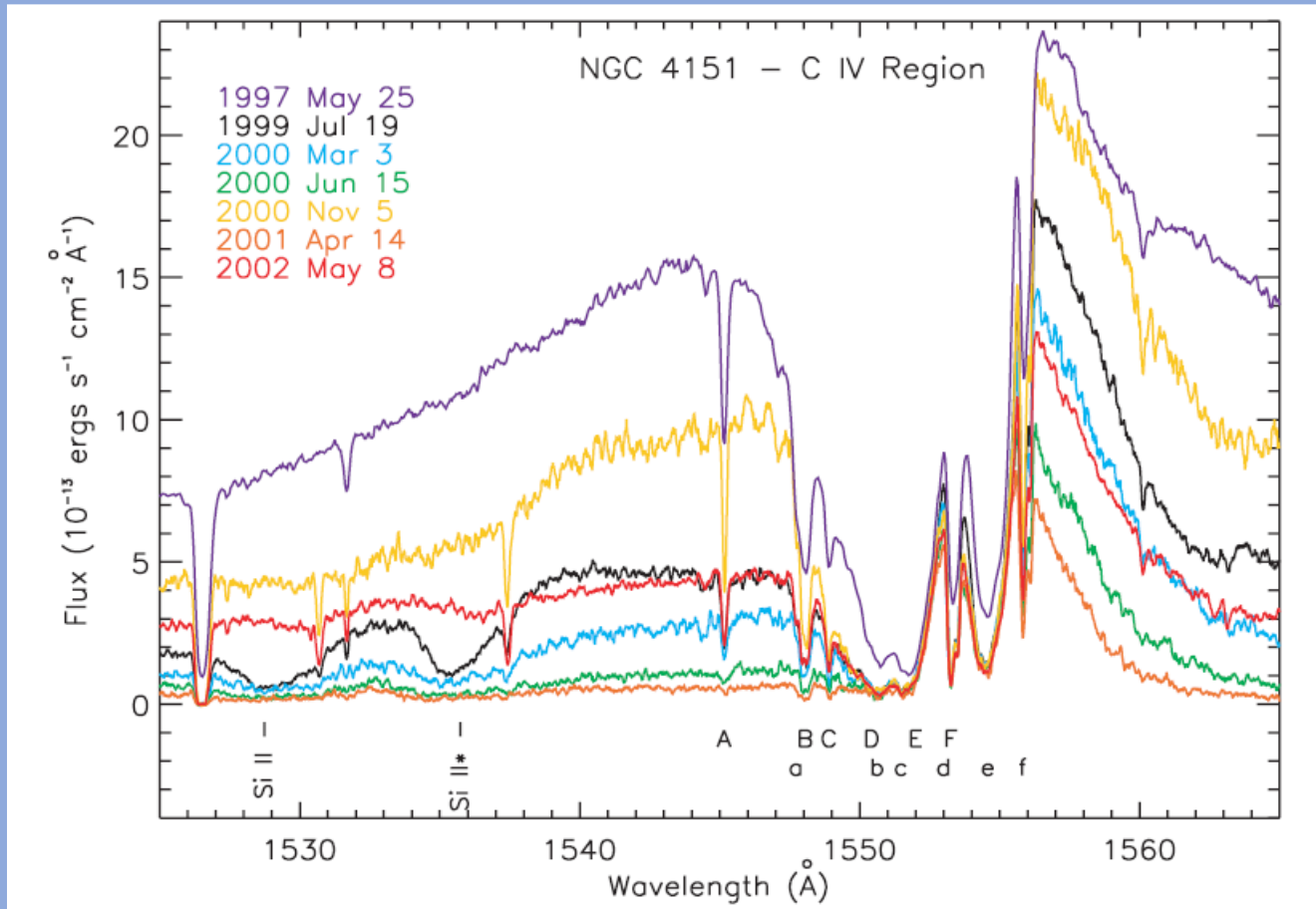


Black is NGC 4151, red NGC 5548, absorbed by 2 WA components. Normalized to C VI.

UV spectra comparison



UV spectra NGC 4151



Kraemer et al. 2006

Conclusions:

- Obscurer is deeper in NGC 4151 than in NGC 5548.
- The column density and/or covering factor of the obscurer is variable on very short time scales: on 1 day (NGC 4151) and 2 day (NGC 5548) timescales.
- The same emission lines and RRC's are observed in both spectra.
- However, the line and RRC luminosities are much lower in NGC 4151.
- The line ratios are more similar and the differences could be explained if absorption of the narrow line region by some of the warm absorber can be taken into account.
- It seems that NGC 4151 is a smaller twin of NGC 5548 in its current obscured state.