Multiwavelength Campaign on NGC 7469: Photoionisation Modelling of the Emission Line Regions

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Abstract

The Seyfert 1 galaxy NGC 7469 was the target of an extensive observing campaign with XMM-Newton in 2015. Analysis of the 640 ks RGS spectrum[1] with the spectral fitting code SPEX, and the physically self-consistent photoionisation model PION, shows that the emission line region (ELR) is multi-phased, while still accounting for three warm absorber (WA) components. We discuss how adjusting the volume filling factor (C_v) could resolve the differences of distance estimates obtained from variability arguments. Further comparisons made with other AGN (NGC 5548 and NGC 3783) are presented.

- We find three WA components and three emission components (two narrow and one broad) within the nucleus of NGC 7469.
- We characterise the emission features in NGC 7469 for the first time, deriving estimates for the minimum distances of the ELR from the central engine using Eq. 1, below.
  - $r \gtrsim 2.5$ pc for the two narrow line components (EM1 & EM2).
    - Adopt an extended emission region;
    - Assume $C_v = 0.1$ (see third column in Table 1).
  - This places the ELR further out from the black hole than the WA (Figure 1).
- For the broad emission line region (EM3) the distance is found at either 0.03 pc (assuming $C_v = 0.001$) using the ionisation parameter (ξ), or 0.004 pc if the outflow velocity (v = -4460 km s^{-1}) is used.

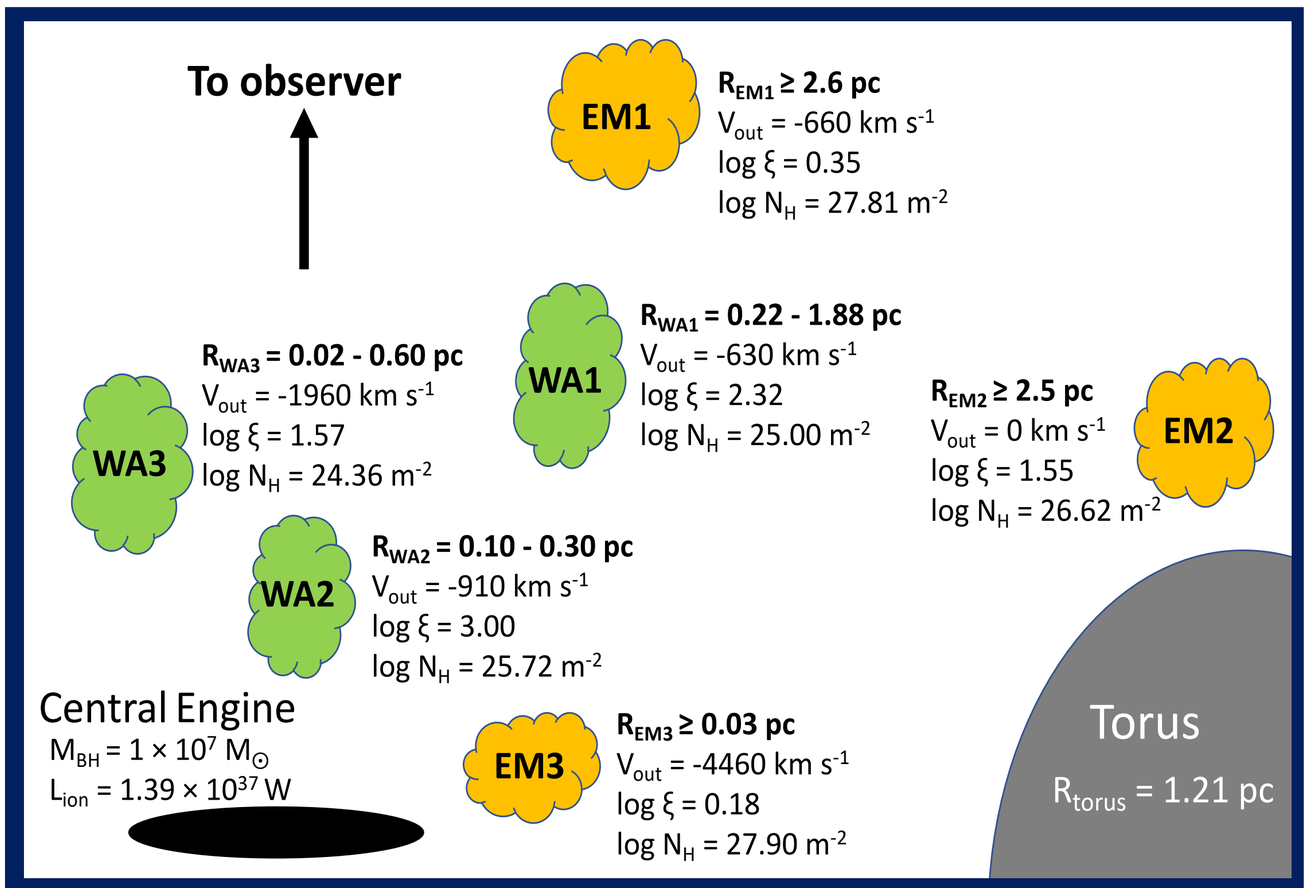

Figure 1: Comparing the distances between the WAs (green) and the ELRs (orange) with respect to the central black hole.

- From variability arguments [2, 3], on the other hand, the distance of the WA is ~ 10 times larger than EM1 and EM2 (Figure 2).
- Therefore, $0.1 < C_v < 1$ will place the narrow ELR at a similar distance to that derived from variability arguments for the WA components.

$$r_{min} = \frac{L_{ion}\, C_v}{N_H \xi} \qquad \text{(Eq. 1)}$$

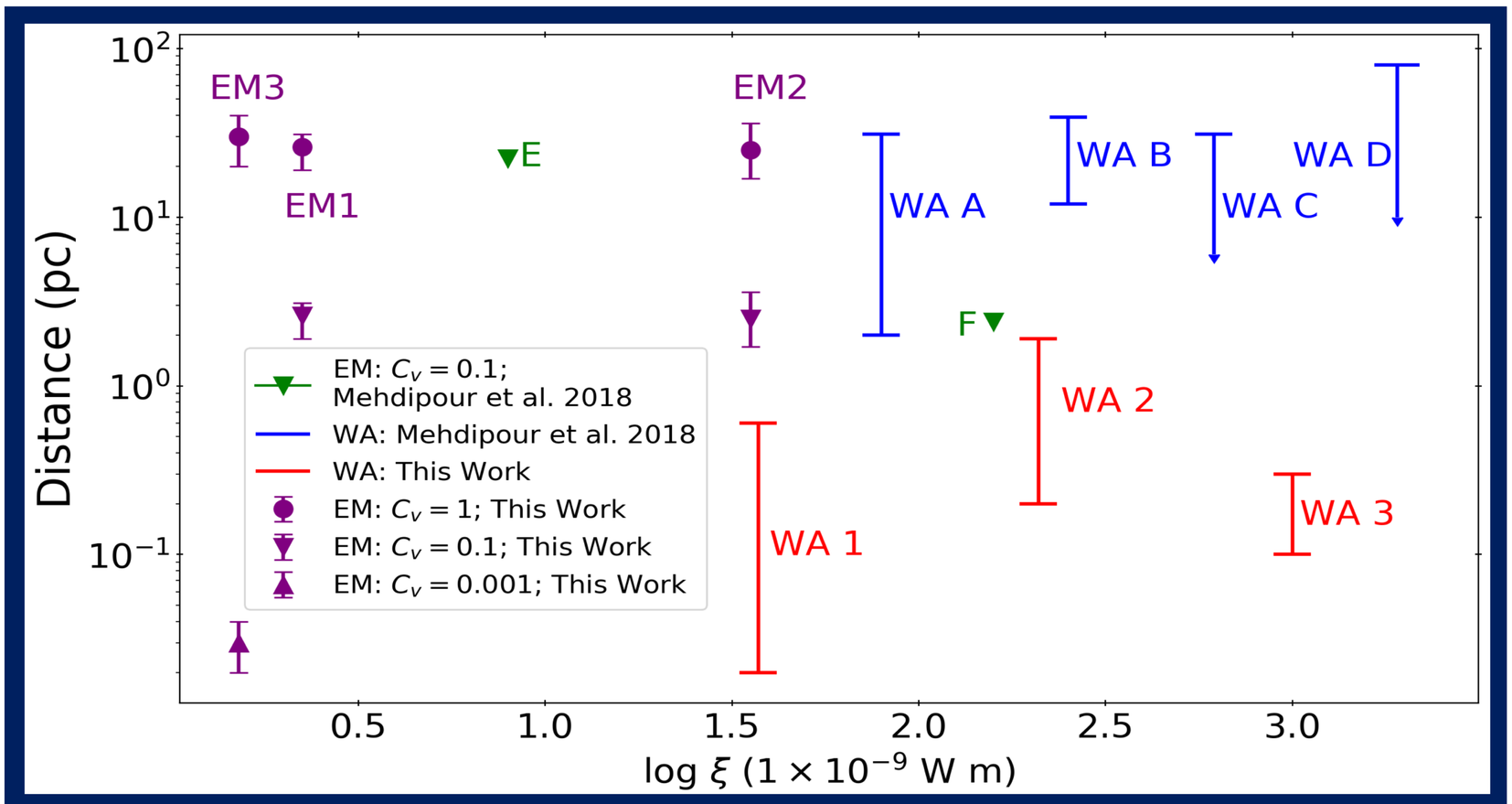

Figure 2: Comparing the distances of the ELR (purple) to the WA distances (red) in this work, and from variability arguments (blue) [2]. It shows that if $0.1 < C_v < 1$, then the ELR is at a similar distance as the WA.

Emission Comp.	R (pc)	R (pc)
EM1	26^{+3}_{-7}	$2.62^{+0.31}_{-0.73}$
EM2	25^{+11}_{-8}	$2.52^{+1.05}_{-0.81}$
EM3	30 ± 10	0.03 ± 0.01

Table 1: Comparing the distances of the ELR in NGC 7469 if we use C_v= 1 (left) or C_v = 0.1 (right).

- We compare the ELR of NGC 7469 with those within NGC 5548 [4] and NGC 3783 [5], calculating the lower ELR distance limits within each AGN using Eq. 1 (see Table 2).
- The ELR distances in NGC 5548 are comparable to previous analysis of the NLR (r = 13.9 pc) [6].
- The narrow (N1) and broad (B1) ELR distances in NGC 3783 are comparable to each other (Table 2) due to the large ionisation parameter of N1.
  - We overcome this problem by allowing $0.1 < C_v < 1$ for the narrow ELRs.
  - Alternatively, the broad emission component may have $C_v < 0.001$.

	N1 (pc)	N2 (pc)	B1 (pc)
Model	NGC 5548		
D	13	142	-
T	19	93	0.09
Date	NGC 3783		
2000/01	0.01	1.94	0.01
11 Dec 2016	0.03	10.4	0.01
21 Dec 2016	0.04	15.6	0.01

Table 2: Comparing the ELR distances within NGC 5548 (top)[4] and NGC 3783 (bottom)s[5].

Conclusions

- **Minimum distances of the narrow ELR within NGC 7469 have been estimated at $r \gtrsim 2.5$ pc (Figure 1).**
  - **For the ELR to be further away from the black hole than the WA, $C_v = 0.1$ (third column of Table 1).**
- **However, from variability arguments, the WA distance is ~ 10 times larger than ELR distance.**
  - **Therefore, we require a range of $0.1 < C_v < 1$ to overcome this inconsistency (Figure 2).**
- **If the broad ELR has $C_v < 0.001$, then the ionisation and kinematic distance measurements for EM3 are consistent within NGC 7469.**
- **Large uncertainties in C_v mean further work is required to investigate this parameter.**

References

[1] Behar et al. 2017, A&A, 601, A17
[2] Mehdipour et al. 2018, A&A, 615, A72
[3] Peretz et al. 2017, A&A, 609, A35
[4] Mao et al. 2018, A&A, 612, A18
[5] Mao et al. 2019, A&A, 621, A99
[6] Whewell et al. 2015, A&A, 595, A85