Winds in Mrk 509:
A common origin for the X-ray and UV ionized gas

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Abstract

The Seyfert 1 galaxy Mrk 509 was subject to an extensive multi-wavelegth campaign in 2009. The study of the X-ray high-resultion spectrum indicates the presence of a warm absorber (WA) with at least 5 discrete ionization components in 3 velocity regimes. The HST/COS UV spectrum reveals a complex absorber with 13 kinematic components. The absorbing gas likely in high-density low-ionization clouds responsible for the UV absorption, which are embedded in a less dense highly ionized wind responsible for the X-ray absorption features.

The Mrk 509 campaign

The multiwavelength campaign on Mrk 509 aims to address a number of key questions such as the location and physics of the WA outflows, the nature of the continuum emission, the geometry and physical state of the BLR, the Fe-K complex, the metal abundances, and the ISM of our own Galaxy along our line of sight.

For that purpose data from 5 satellites (XMM, Chandra, Integral, Swift, and HST) and 2 ground-based facilities (WHT and Pairitel) were collected.

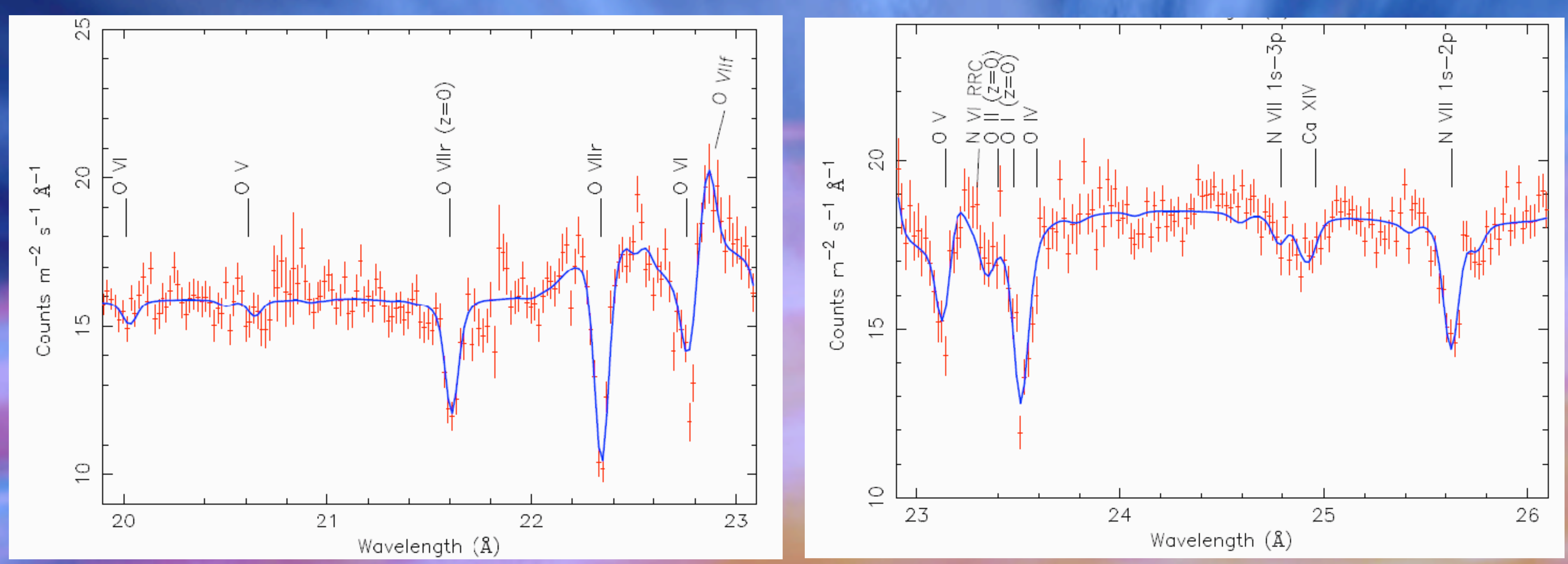
An overview of the campaign can be found in Kaastra +11.

The Mrk 509 outflow in X-rays and UV

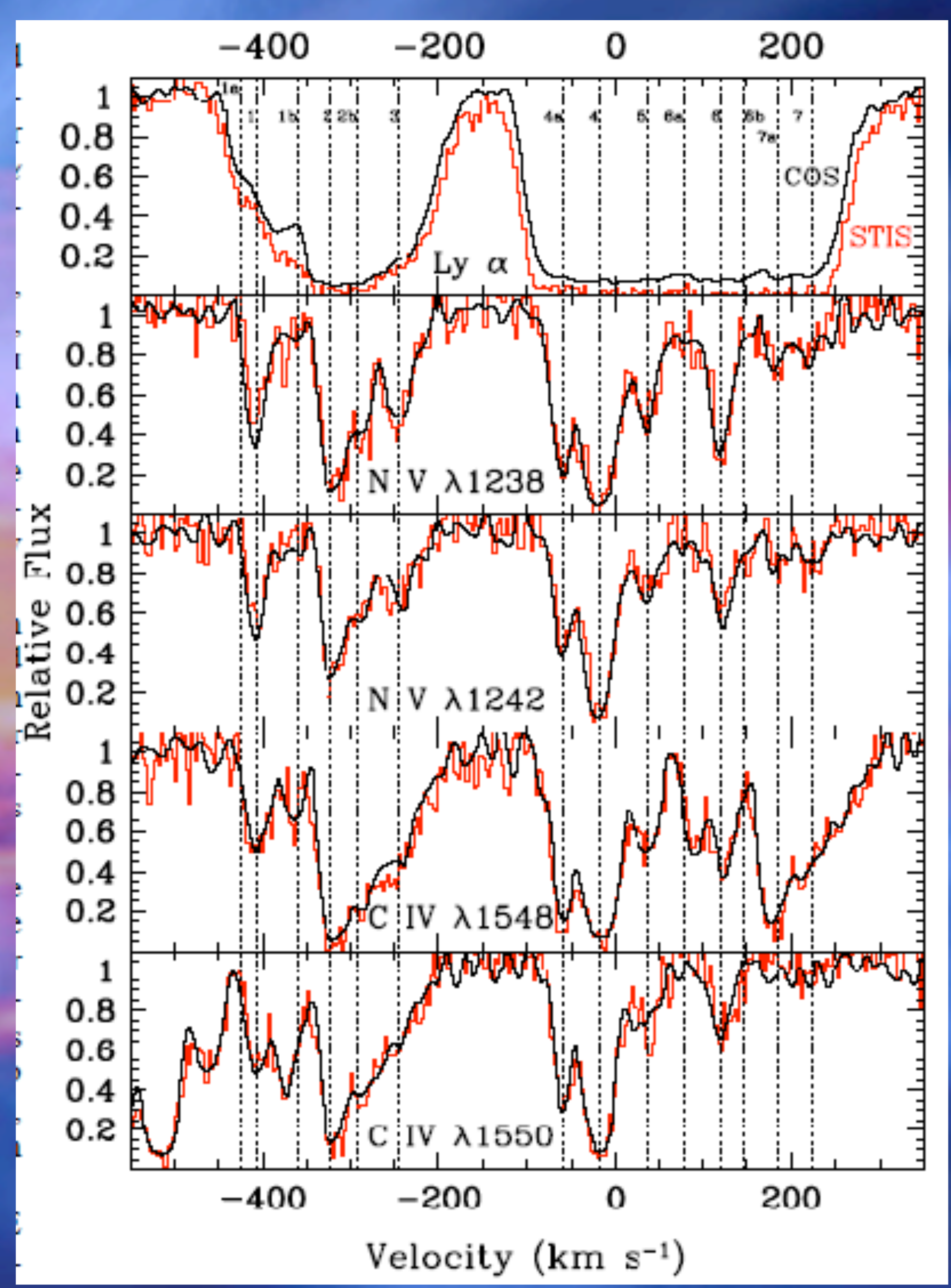
- **XMM-Newton RGS (600 ks; Detmers+11):**
  - 5 ionization components, 2 velocity regimes
- **Chandra LETGS (180 ks; Ebrero+11):**
  - 3 ionization components, 3 velocity regimes
- **HST/COS (simultaneous with Chandra; Kriss+11):**
  - 13 kinematic components

The X-ray absorbers can be kinematically associated to at least 3 UV components, suggesting a possible co-location.

The X-ray WA is made up of discrete components, likely in pressure equilibrium.



Upper panels: Detail of the stacked XMM-Newton RGS 600 ks spectrum of Mrk 509 in the oxygen region. The solid blue line represents the WA best-fit model of Detmers+11.



Right panel: UV spectral features in velocity space in the COS (black) and STIS (red) spectra of Mrk 509. The vertical dotted lines represent the different kinematic components detected in the UV spectrum (Kriss+11).

Co-location of the X-ray and UV absorbers

The UV spectrum of Mrk 509 showed a complex absoption system with 13 kinematic components ranging from Δv = -408 to +222 km/s (Kriss+11; see table on the right).

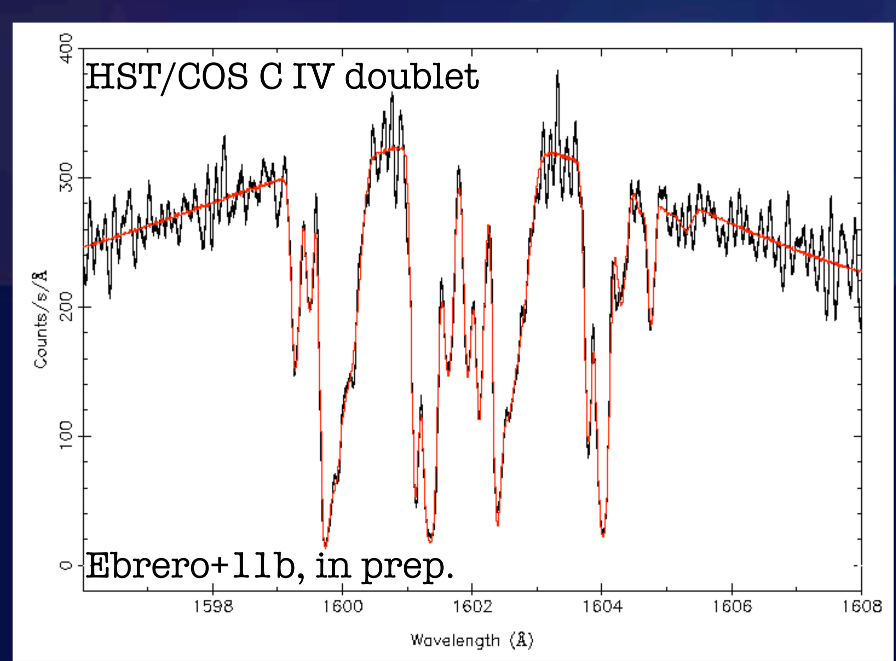
At least 3 of these components, one redshifted and two blueshifted with respect to the systemic velocity of the source, can be kinematically associated to the X-ray WA components seen in the LETGS spectrum (Ebrero+11). Likewise, the two velocity regimes detected in the RGS spectrum are consistent with the main absorption troughs in the UV (Detmers+11).

UV Component	v_{out}[a]	N_{CIV}[b]	N_{NV}[b]	N_{OVI}[b,c]	LETGS[d]
1	−408 ± 5	31.2 ± 1.5	107.0 ± 9.5	215.0 ± 47.2	3
1b	−361 ± 13	16.3 ± 6.1	17.5 ± 1.6	154.9 ± 39.0	3?
2	−321 ± 5	136.3 ± 41.7	149.0 ± 10.7	566.2 ± 118.0	3?
2b	−291 ± 6	128.9 ± 41.4	130.6 ± 11.3	1248.1 ± 395.5	2?
3	−244 ± 5	47.7 ± 7.2	88.6 ± 8.1	675.2 ± 157.1	2
4a	−59 ± 5	66.3 ± 2.1	93.6 ± 6.8	804.5 ± 387.2	
4	−19 ± 5	250.0 ± 11.0	323.6 ± 12.2	8797.0 ± 4120.3	
5	37 ± 5	36.2 ± 16.9	38.3 ± 11.1	683.5 ± 429.3	1
6a	79 ± 12	5.6 ± 2.3	20.6 ± 6.4	518.8 ± 398.5	1
6	121 ± 5	12.3 ± 6.4	56.1 ± 4.0	3436.1 ± 6985.0	1?
6b	147 ± 8	17.6 ± 5.3	5.5 ± 1.8	104.5 ± 234.6	
7a	184 ± 6	3.6 ± 1.1	21.0 ± 2.9	660.2 ± 176.7	
7	222 ± 6	6.4 ± 0.8	23.5 ± 2.7	667.4 ± 1105.3	

Properties of the HST/COS UV intrinsic features in Mrk 509: outflow velocity and ionic column densities for CIV, NV, and OVI (based on FUSE observations). The UV components are labeled following the Kriss+11 numbering. The last column denotes the possible X-ray counterparts of some kinematic components seen in the Chandra LETGS spectrum (Ebrero+11).

Structure of the outflow

If the UV and X-ray absorbing gas are co-located, from the definition of the ionization parameter $\xi = L/nR^2$ they share L and R. Since ξ is much lower for the UV gas, its density must be higher than that of the X-ray gas. This would be consistent with a scenario where high-density low-ionization UV-absorbing clouds are embedded in a low-density high-ionization X-ray wind (Ebrero+11b, in prep.).



References

Detmers et al. 2011, A&A, 534, A38

Ebrero et al. 2011a, A&A, 534, A40

Ebrero et al. 2011b, A&A, in preparation

Kaastra et al. 2011, A&A, 534, A36

Kriss et al. 2011, A&A, 534, A41

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