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LARGE SCALE ABSORBERS IN THE ENVIRONMENT OF HIGH-Z RADIO-GALAXIES

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RESUMEN

Se discuten interesantes cuestiones que surgen en estudios de absorbedores extendidos observados en radio-galaxias de alto corrimiento hacia el rojo. Se proponen observaciones de más objetos con espectroscopía 2D con OSIRIS.

ABSTRACT

We discuss a number of interesting questions that arise from studies of extended absorbers observed in high redshift radio-galaxies. We propose to carry out 2-D spectroscopy of more objects using OSIRIS.

Key Words: **COSMOLOGY: EARLY UNIVERSE — GALAXIES: FORMATION — GALAXIES: ISM — LINE: FORMATION**

1. INTRODUCTION

A prominent characteristic of high-redshift radio-galaxies (HzRGs) at $z > 2$ is their spatially extended emission line regions (hereafter EELR), which are often luminous in Lyα ($> 10^{44}\,\mathrm{erg\,s^{-1}}$) and extended over several to tens of kpc. The excitation mechanism for the *emission gas* is either shock excitation by jet material or AGN photoionization. The EELR is kinematically active. Villar-Martin et al. (2003) distinguish a kinematically perturbed gas component with FWHM $> 1000\,\mathrm{km\,s^{-1}}$and a quiescent component with FWHM of order $600\,\mathrm{km\,s^{-1}}$.

With observations of a sample of HzRGs, Van Ojik et al. (1997; hereafter VO97) discovered that the majority of HzRGs with small radio-source sizes ($<$ 50 kpc) exhibit narrow Lyα *absorption* when observed at intermediate resolution (1–2 Å). This absorption is superimposed upon the Lyα emission with a spatial extent comparable to that of the EELR. There appears to exist a bimodal distribution of H I columns (see Figure 1 and V04). Some HzRG spectra reveal up to 4 extended absorbers. The doppler width of the absorption Lyα is small, with $\sigma < 100\,\mathrm{km\,s^{-1}}$ in most cases, indicating that the *internal* kinematics of the absorbers is very quiescent with respect to the often very disturbed kinematics of the emission line gas. In addition to Lyα, the C IV $\lambda\lambda$1549 doublet has also been observed in absorption in two HzRGs, superimposed on the C IV emission line, first in 0943–242 (z_e=2.922) (Binette et al. 2000) and then in 0200+015 (z_e=2.230) (Jarvis et al. 2003, J03). This indicates that the gas is ionized and that the total amount of intervening gas (neutral + ionized) greatly exceeds that inferred from the H I column alone.

2. IONIZATION MECHANISM

The excitation mechanism of the large scale ionized absorbers is still a matter of debate. Using the column ratio $N_\mathrm{CIV}/N_\mathrm{HI}$ determined observationally in 0943–242 and 0200+015, Binette et al. (2006) showed that the most likely mechanism responsible for the ionization of the absorbers is photoionization by either the metagalactic background radiation or by UV radiation from hot stars belonging to the parent HzRG. The masses inferred for the absorbers in the case of metagalactic flux ionization were uncomfortably large, however, which leads these authors to favor stellar ionization.

Clearly, a larger sample of column ratio measurements is required to confirm the true ionization mechanism. Ideally, 2D spectroscopy presents many advantages for studying the spatial behavior of the velocity shift of the absorber with respect to that of the parent galaxy. The instrument OSIRIS, once coupled with a scanning Fabry-Pérot, would provide both sufficient spectral and spatial resolution to 'image' in velocity space the absorption gas against the background light of Lyα, C IV and even Mg II. So far, this has only been achieved by Wilman et al. (2005) in the case of the Lyα-emitting 'blob' LAB-2 in the protocluster SSA22 (z_e = 3.09), who used the SAURON integral field spectrograph on the

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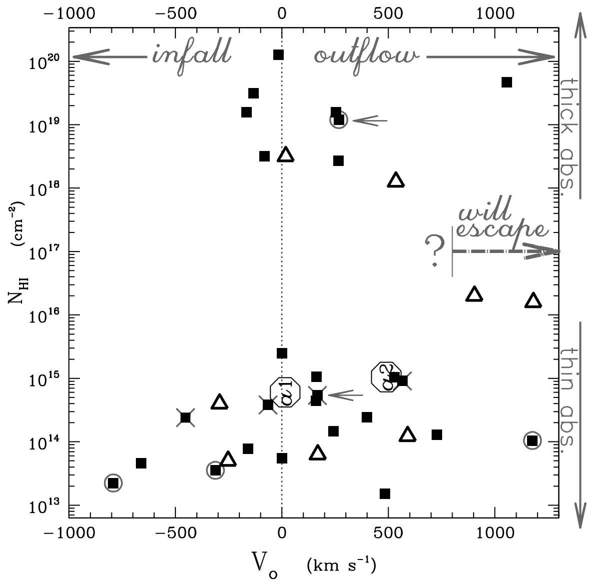

Fig. 1. Calculated outflow velocities as a function of the measured $N_{\rm HI}$. We assumed that the HzRG's systemic redshift $z_{\rm e}$ is exactly that given by the centroid of the emission Lyα profile, corrected for the absorption. Filled squares: HzRGs of radio-sizes *smaller* than 50 kpc, open triangles: HzRGs of *larger* radio-sizes. Measurements of 0943–242 are encircled, while those of 0200+015 are crossed. Arrows indicate the two absorbers with detected C IV in absorption. The octagons labeled $a1$ and $a2$ correspond to the Lynx Arc Nebula absorbers. Assuming an escape velocity of 800 km s^{-1}, shells to the right of the origin of the dashed-arrow should be escaping. On the other hand, if the measured velocities were terminal velocities rather than launch velocities, a fraction of all the shells with positive V_o might also be escaping. There appear to be a bimodal distribution of H I columns (W04): thin absorbers (10^{13}–10^{15} cm^{-2}) and thick absorbers (10^{18}–10^{20} cm^{-2}).

William Hershel Telescope. These authors found evidence of a foreground absorber ($N_{\rm HI} \simeq 10^{19}$ cm^{-2}) with remarkable velocity coherence over a scale of $\sim 76 \times 26$ kpc in the plane of the sky. The interpretation proposed is that of a *galaxy-wide* superwind of $\sim 10^{11}$ M$_\odot$, which is possibly a manifestation of the 'feedback' mechanism thought to be regulating the formation of galaxies.

3. SHELL EXPANSION AND FEEDBACK

J03 finds that the main absorber in 0943–242 remains as a single Lyα system of column density $\sim 10^{19}$ cm^{-2} over the full observed extent of the EELR, it is completely black at the base of the Lyα trough, with no evidence of substructure or a multiphase environment. The absorption trough is blueshifted by 265 km s^{-1} with respect to the centroid of the background emission profile. Such spatial and kinematical coherence of the absorber is the basis of the proposed shell structure for the absorber, which contrasts with the chaotic multi-phase medium encountered in the Galactic ISM. It also contrasts with the (warm) emission line gas in general, which is characterized by a minuscule *volume* filling factor (10^{-5} – 10^{-3}) whether it is observed in H II regions, the NLR or the EELR. Furthermore, in the case of the NLR gas in Seyfert I or in quasars, the covering factor inferred is statistically much lower than unity (absence of Lyman breaks in $\sim$ 90% of quasars). The HzRG absorbers on the other hand require a covering factor of unity over tens of kpcs, so that the proposed shell structure is conceptually a more attractive proposition than that of a huge number of cloudlets ($\sim 10^{12}$, VO97) randomly distributed.

An important aspect to elucidate is the ordered kinematics of the shells. For instance, is shell outflow more frequent than shell infall? In explaining the kinematic properties of the *emission* line gas, Humphrey et al. (2006a,b) favor a scenario in which the quiescent (unperturbed) gas is in infall, while the perturbed gas is in outflow. As for the extended absorbers (i.e. absorption shells) discussed in this Paper, since we cannot measure their distances from the parent HzRG, it is not clear whether they are gravitationally bound or have escaped the gravitational pull of the HzRG long ago. In Figure 1 we show a plot of the outflow velocity, V_o, as a function of $N_{\rm HI}$ of all the shells that have been measured so far. V_o is given by the expression $c[(1+z_e)^2-(1+z_a)^2]/[(1+z_e)^2+(1+z_a)^2]$, where c is the speed of light, $z_{\rm e}$ the HzRG systemic redshift and $z_{\rm a}$ the absorber's redshift. The data are from Wilman et al. (2004) and VO97. We also overlay the two absorbers found in the Lynx Arc Nebula at redshift of 3.36, which is a high-redshift metal-poor gravitationally lensed H II galaxy believed to be photoionized by young massive stars (Fosbury et al. 2003; Villar-Martín et al. 2004). Another unanswered question is the origin of these massive shells in HzRGs. Binette et al. (2006) suggested the possibility that they arise from massive stellar winds, following short but major episodes of star formation within the HzRG bulge.

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REFERENCES

Binette, L., Kurk, J. D., Villar-Martín, M., & Röttgering, H. J. A. 2000, A&A, 356, 23

Binette, L., Wilman, R. J., Villar-Martín, M., Fosbury, R. A. E., Jarvis, M. J., & Röttgering, H. J. A. 2006, A&A, 459, 31

Fosbury, R. A. E., et al. 2003, ApJ, 596, 797

Humphrey, A., Villar-Martín, M., Fosbury, R. A. E., Vernet, J., & di Serego Alighieri, S. 2006, MNRAS, 369, 1103

Humphrey, A., Villar-Martín, M., Fosbury, R. A. E., Binette, L., Vernet, J., de Breuck, C., & di Serego Alighieri, S. 2007, MNRAS, 375, 705

Jarvis, M. J., Wilman, R. J., Röttgering, H. J. A., & Binette, L. 2003, MNRAS, 338, 263 (J03)

van Ojik R., Röttgering, H. J. A., Miley, G. K., & Hunstead, R. W. 1997, A&A, 317, 358 (VO97)

Villar-Martín, M., Vernet, J., di Serego Alighieri, S., Fosbury, R., Humphrey, A., & Pentericci, L. 2003, MNRAS, 346, 273

Villar-Martín, M., Cerviño, M., & González Delgado, R. M. 2004, MNRAS, 355, 1132

Wilman, R. J., Jarvis, M. J., Röttgering, H. J. A., & Binette, L. 2004, MNRAS, 351, 1109

Wilman, R. J., Gerssen, J., Bower, R. G., Morris, S. L., Bacon, R., de Zeeuw, P. T., & Davies, R. L. 2005, Nature, 436, 227