A project to constrain emission from giant gaseous shells around high redshift radio galaxies

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Resumen / Aproximadamente la mitad de las radiogalaxias (fuertes emisores en radio con cuásares tipo 2) con $z > 2$ muestran espectros con una fuerte absorción en Lyα, además de una extensión espacial al menos tan grande como la nebulosidad de fondo en Lyα estrechamente asociado en el AGN de la galaxia anfitriona (∼10-100 kpc). En base a sus propiedades observadas hasta la fecha, se cree que estos absorbedores presentan estructuras de "cáscaras" gaseosas a gran escala que rodea la galaxia anfitriona y a su halo en Lyα. Su origen no está claro, pero estaría probablemente relacionado con los procesos de retroalimentación en la galaxia anfitriona.
En este trabajo realizamos una discusión de nuestro estudio, actualmente en curso, de estas estructuras de absorción utilizando el archivo del Telescopio Espacial Hubble (*HST*), correspondientes a imágenes en emisión UV (en el marco de reposo) de radiogalaxias con z ∼2.5 con el objetivo de buscar estas estructuras en emisión o establecer restricciones en su luminosidad.

Abstract / Around half of the radio galaxies (radio-loud, type 2 quasars) at $z > 2$ are known to show strong Lyα absorption features in their spectra, with a spatial extent at least as large as the background Lyα nebulae closely associated with the AGN host galaxy (∼ 10-100 kpc). Based on their observed properties to date, these absorbers are thought to be large-scale shells of gas surrounding the host galaxy and its Lyα halo. Their origin is unclear, but is likely related to feedback processes in the host galaxy.
In this work, we discuss our ongoing study of these absorbing shells using archival Hubble Space Telescope (*HST*) images of the rest-frame UV emission of $z \sim 2.5$ radio galaxies in order to search for these shells in emission, or to place constraints on their emission luminosity.

Keywords / Galaxies: high-redshift — galaxies: active — galaxies: quasars — ultraviolet: ISM

1. Introduction

Many powerful radio galaxies at redshift $z > 2$ are embedded within giant nebulae of ionized gas which strongly emits both metal lines (e.g., CIII] $\lambda\lambda$1907,1909, [OIII] $\lambda\lambda$4959,5007, etc.) and recombination lines of H and He (McCarthy et al., 1987; Villar-Martín et al., 2003). In addition, they often show strong absortion features in Lyα (Röttgering et al., 1995; van Ojik et al., 1997; Binette et al., 2000; Wilman et al., 2004; Humphrey et al., 2008, 2013), and sometimes in metal lines such as CIV (Binette et al., 2000; Jarvis et al., 2003; Humphrey et al., 2008, 2013). These absorption lines are thought to be formed in cold/warm gas located between the emission source and the observer, providing information about the active nucleus, the host galaxy and its environment (Hamann & Ferland, 1999). The observed properties of this absorbing gas strongly implies that is part of an expanding super shell of gas, driven by a powerful feedback event/s (Binette et al., 2000; Humphrey et al., 2008, 2013).

If the absorbing structures are indeed shells, and if they lie partially within the photoionizing beams of the central quasar, then they ought to be detectable in emission lines and in continuum emission (Humphrey et al., 2013). Detecting them in emission would significantly improve our understanding of their physical properties, their size, and their origin.

In this work, we show the methodology and objecs preliminary selected in a project that aims to place new constraints on the existence, location and physical properties of the putative gaseous shells around high redshift radio galaxies, using publicly available Hubble Space Telescope (*HST*) images. Further results and analysis will be presented in a future paper.

2. Dataset and Methodology

We have searched the *HST* data archive for observer-frame optical (sampling rest-frame ultraviolet emission) or near-infrared (sampling rest-frame optical emission) images of radio galaxies with redshifts greater than 2.0, with an additional requirement that the image includes an area around the radio galaxy of at least $200'' \times 200''$. Four radio galaxies met our selection criteria: TXS 0922-218 (z=5.19), B2 0140+32 (z=4.41), TXS 0647+415 (z=3.79), and TXS 0828+193 (z=2.57), for which we have retrieved and processed all available *HST* images.

Poster presentation – September 2014

Our methodology is as follows. For each of the radio galaxies, we first conduct a visual inspection of *HST* image, to look for morphological features on 10-100 kpc scales that may be related to the putative gas shell, using (a) the raw image, (b) the image after smoothing to increase the signal to noise of faint structure, and (c) the image after application of unsharp-masking.

In addition, we measure the surface brightness in concentric annuli centred on the radio galaxy, to obtain an upper limit on the flux (or luminosity) of otherwise unseen gaseous shells as a function of radius. This will allow us to place constraints on the size and content of gas and dust of the putative shells.

The analysis of TXS 0828+193 (one of the selected sources) is described in the next section. The analysis of the other sources is in progress.

3. TXS 0828+193

TXS 0828+193 (z=2.57) is among the most UV-luminous radio galaxies at $z \geq 2$, and has been well studied in previous works. This radio galaxy shows a strikingly large Lyα nebula with a spatial extent of ∼80 kpc, and with a very extended Lyα absorption feature in front of the nebula, showing a slight blueshift (see van Ojik et al., 1997; Villar-Martín et al., 2002).

Among the archival images of TXS 0828+193, we found several unpublished optical and near-infrared images that are substantially deeper than the *HST* images previously published by Pentericci et al. (1999). Upon visual inspection, these newer F606W, clear, F110W and F160W images show two striking shell or bubble-like emission features, located ∼2″(∼16 kpc) from the AGN, at the north-east edge of the optically emitting structure of this galaxy (see Fig. 1). The nature of these structures is not immediately clear; in this context the following questions arise: are these line or continuum dominated structures?, and, are they related to the large-scale Lyα absorbing structures? Nonetheless, it seems plausible that we are witnessing an explosive feedback event, with energy injected by the AGN leading to the formation and growth of outflowing superbubbles (see Tenorio-Tagle et al., 1999; Humphrey et al., 2013).

We are currently undertaking a detailed study of these structures, using a combined analysis of imaging and spectroscopic data.

4. Summary

Associated, large scale Lyα absorbers are frequently detected in the spectra of powerful radio galaxies at z>2. These absorbing structures are thought to be giant, expanding shells, but their origin and physical properties remain elusive. Nonetheless, they are likely to carry important information about massive galaxy evolution and the impact of feedback activity. In this work, we discuss a project which aims to detect these shells in emission, in order to place stronger constraints on the size, mass, and nature of the shells. We show preliminary results using new HST images of TXS 0828+193, in which we detect a pair of possibly feedback-driven shells in emission. Further results and analysis of our project will be presented in a future publication.

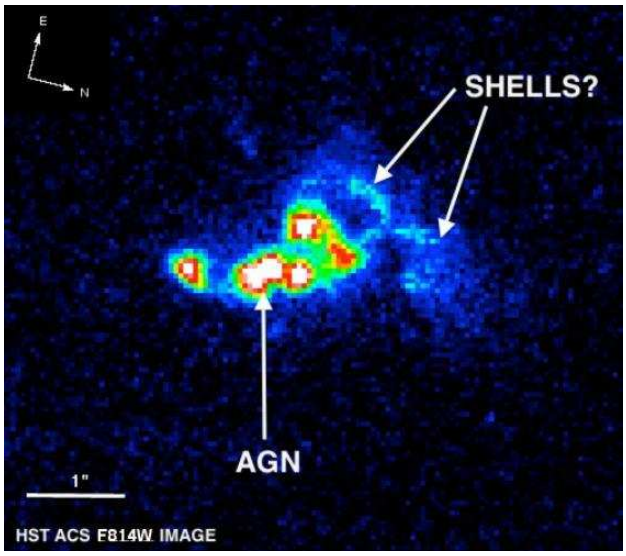

Fig. 1: TXS 0828+193 showing two striking shell or bubble-like emission features.

Acknowledgements: One of the authors (MM) wishes to thank the ERASMUS MUNDUS Program for has been benefited by an Erasmus Mundus ARCOIRIS scholarship, which allowed him to stay and work at the University of Porto (Portugal). MM would also like to thank everyone in the Centro de Astrofisica da Universidade do Porto for the excellent welcome and work environment. AH acknowledges support by the Fundação para a Ciência e a Tecnologia (FCT) under project FCOMP-01-0124-FEDER-029170 (Reference FCT PTDC/FIS-AST/3214/2012), funded by FCT-MEC (PIDDAC) and FEDER (COMPETE), and acknowledges FCT support through UID/FIS/04434/2013. AH also acknowledges a Marie Curie Fellowship co-funded by the FP7 and the FCT.

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