Mem. S.A.It. Vol. 84, 715

Memorie della

Extended soft X-ray emission in 3CR radio galaxies at $z < 0.3$: high excitation and broad line galaxies

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Abstract. We analyze the diffuse (0.5-2) keV emission of the complete 3CR sample of radio galaxies at z< 0.3 recently observed by Chandra, focusing on the properties of the sub-classes of high excitation galaxies (HEGs) and broad line objects (BLOs). Among the 33 HEGs we detected extended (or partially resolved) emission in more than half of the sources; the fraction is even higher (8/10) if we restrict the analysis to the objects with exposure times >10 ks. In the 18 BLOs, extended emission is seen only in 3 objects; this lower detection rate can be ascribed to the presence of their bright X-ray nuclei that easily outshine any genuine diffuse emission. A very close correspondence between the soft X-ray and optical line morphology emerges; the ratio [O III]/soft X-ray extended luminosity are confined within a factor of 2 around a median value of 5. Photoionization of extended gas, coincident with the narrow line region, is the favored mechanism to explain these properties.

Key words. Galaxies: active; X-rays: galaxies; ISM: jets and outflows

1. Introduction

We perform a complete analysis of the properties of X-ray emission in the soft band (0.5-2 keV) considering the 113 3CR radio galaxies at $z < 0.3$. Among the 33 HEGs we detect extended (or possibly extended) emission in 12 sources. In the 18 BLOs, extended emission is

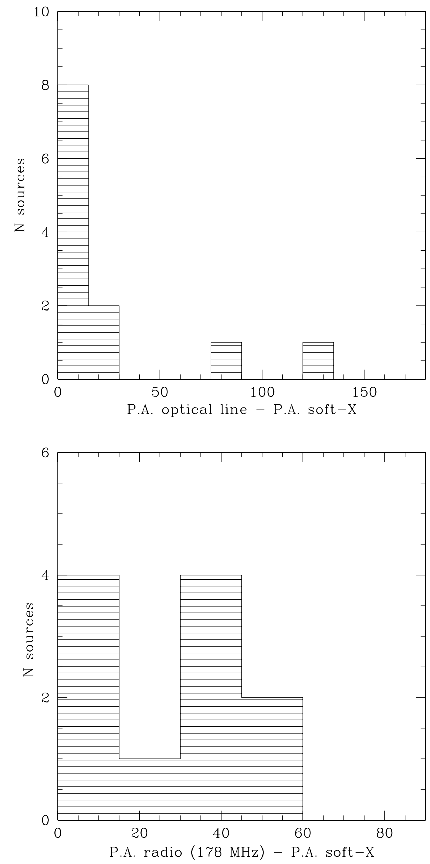

Fig. 1. Histograms of the offset between the position angle (P.A.) of extended regions measured in soft X-ray, with respect to the narrow line region (left) and the radio emission (right).

seen only in two objects: probably the presence of their bright X-ray nuclei easily outshine any genuine diffuse emission. We do not consider sources classified as LEGs.

We find a very strong correspondence between the morphology of the NLR and the soft X-ray emission. In most cases the two structures are closely co-spatial, an effect particularly clear when we focus on the objects classified as "extended" (Fig. 1).

We extract the spectrum of the extended and possibly extended sources. In order to quantitatively compare the optical line and the soft X-ray emission, we measure the [O III] flux in the available HST images using the same regions chosen for the X-ray spectral analysis. The median ratio of $\mathcal{R}$([O III]/sX) is 5.6, reminiscent of what is seen in Seyfert galaxies, and the scatter is low, with all sources confined to within a factor ~ 2 from the median value. No dependence of $\mathcal{R}$([O III]/sX) on luminosity is found. The line and X-ray fluxes are graphically compared in Fig. 2.

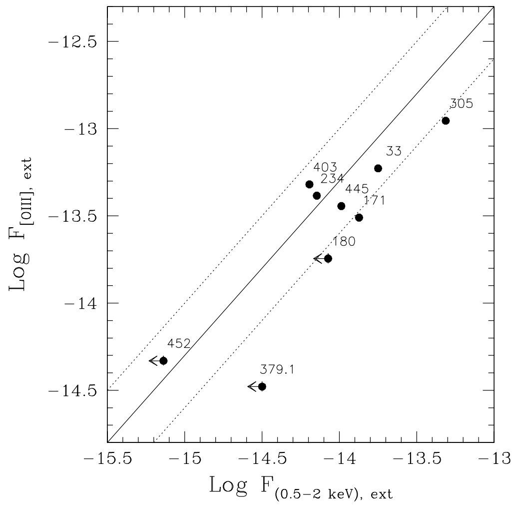

Fig. 2. Comparison of the [O III] and soft X-ray fluxes measured in the extended regions drawn. The solid line corresponds to a constant ratio F([O III])/F(soft X-ray) = 5; the two dashed lines mark a ratio equal to 2.5 and 10.

The presence of extended soft X-ray emission can be attributed to various mechanisms, nonetheless, in the light of the results of the somewhat limited spectral modeling possible with the available data, the favored mechanism to account for the extended soft X-ray regions appears to be emission from a photoionized plasma.

Acknowledgements. We wish to honor the memory of our great friend and colleague David Axon, who has been the steadfast inspiration and participant in this and many other key papers that through many years of dedicated efforts have led to significant breakthroughs and greater understanding of the physics of active galaxies. He will be greatly missed by all of us.