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A new discovery space opened by eROSITA

Ionised AGN outflows from X-ray selected samples

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ABSTRACT

Context. In the context of an evolutionary model, the outflow phase of an active galactic nucleus (AGN) occurs at the peak of its activity, once the central supermassive black hole (SMBH) is massive enough to generate sufficient power to counterbalance the potential well of the host galaxy. This outflow feedback phase plays a vital role in galaxy evolution.

Aims. Our aim in this paper is to apply various selection methods to isolate powerful AGNs in the feedback phase, trace and characterise outflows in these AGNs, and explore the link between AGN luminosity and outflow properties.

Methods. We applied a combination of methods to the Spectrum Roentgen Gamma (SRG) eROSITA Final Equatorial Depth survey (eFEDS) catalogue and isolated ~1400 candidates at $z > 0.5$ out of ~11 750 AGNs (~12%). Furthermore, we narrowed down our selection to 427 sources that have $0.5 < z < 1$. We tested the robustness of our selection on the small subsample of 50 sources with available good quality SDSS spectra at $0.5 < z < 1$ and, for which we fitted the [OIII] emission line complex and searched for the presence of ionised gas outflow signatures.

Results. Out of the 50 good quality SDSS spectra, we identified 23 quasars (~45%) with evidence of ionised outflows based on the presence of significant broad and/or shifted components in [OIII]λ5007 Å. They are on average more luminous ($\log L_{\rm bol} \sim 45.2\,{\rm erg\,s^{-1}}$) and more obscured ($N_{\rm H} \sim 10^{22}\,{\rm cm^{-2}}$) than the parent sample of ~427 candidates, although this may be ascribed to selection effects affecting the good quality SDSS spectra sample. By adding 118 quasars at $0.5 < z < 3.5$ with evidence of outflows reported in the literature, we find a weak correlation between the maximum outflow velocity and the AGN bolometric luminosity. On the contrary, we recovered strong correlations between the mass outflow rate and outflow kinetic power with the AGN bolometric luminosity.

Conclusions. About 30% of our sample have kinetic coupling efficiencies, $\dot{E}/L_{\rm bol} > 1\%$, suggesting that the outflows could have a significant effect on their host galaxies. We find that the majority of the outflows have momentum flux ratios lower than 20 which rules out an energy-conserving nature. Our present work points to the unequivocal existence of a rather short AGN outflow phase, paving the way towards a new avenue to dissect AGN outflows in large samples within eROSITA and beyond.

Key words. galaxies: active – galaxies: high-redshift – X-rays: galaxies – surveys

1. Introduction

Active galactic nuclei (AGNs) are central nuclei of massive galaxies that are powered by the accretion of matter towards the central supermassive black holes (SMBHs; Soltan 1982; Rees 1984). The energy produced during the accretion episodes by AGNs in the form of winds, radiation or jets is argued to have a great impact on the interstellar medium (ISM; Alexander & Hickox 2012; Fabian 2012; Harrison 2017). The link between the energy produced by the AGNs and the surrounding ISM is called AGN feedback (Silk & Rees 1998; Di Matteo et al. 2005; Hopkins & Elvis 2010), and it is considered a key element in galaxy evolution models and simulations (e.g. Schaye et al. 2015).

To better understand galaxy evolution, it is crucial to determine how SMBHs form and evolve. Various processes have been proposed to trigger the formation and evolution of SMBHs, including internal processes such as disc or bar instabilities and external processes such as mergers, among others (Hopkins et al. 2008). In the merger scenario, the black hole grows within a dust-enshrouded and star-forming environment, followed by high accretion close to the Eddington limit. This in turn releases a tremendous amount of energy (the blow-out phase) through radiation pressure-driven winds or outflows to the surrounding environment.

These AGN-driven outflows may provide the mechanism needed to remove the gas and thus quench star formation (SF; Costa et al. 2018a), limiting the further growth of the galaxy and the SMBHs as well (e.g. Di Matteo et al. 2005). As discussed in Harrison et al. (2018), an alternative mechanism is the injection of energy in the ISM or intergalactic medium (IGM), which indirectly heats the halo and prevents future in-fall of matter onto the galaxy. Referred to as the maintenance mode of feedback, this phenomenon is primarily caused by jet-driven outflows at large scales. When these outflows collide, they introduce turbulence and generate shocks in their vicinity, effectively preventing cooling and impeding star formation (Croton et al. 2006; Ciotti et al. 2010; Nelson et al. 2019). The outflows influence further fueling the AGN activity affects the fueling of star formation and regulates its duty cycle.

According to hydrodynamical simulations, during the key "blow-out phase", the AGN is characterised by high nuclear obscuration with column densities $(N_{\rm H}) > 10^{22}\,{\rm cm^{-2}}$, high AGN bolometric luminosities, and accretion close to the Eddington limit (Hopkins et al. 2005; Di Matteo et al. 2005; Blecha et al. 2018). As discussed in the recent study by Blecha et al. (2018)