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SUPER-II: Spatially resolved ionized gas kinematics and scaling relations in $z \sim 2$ AGN host galaxies

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ABSTRACT

Aims. The SINFONI survey for Unveiling the Physics and Effect of Radiative feedback (SUPER) aims at tracing and characterizing ionized gas outflows and their impact on star formation in a statistical sample of X-ray selected Active Galactic Nuclei (AGN) at z~2. We present the first SINFONI results for a sample of 21 Type-1 AGN spanning a wide range in bolometric luminosity (log L_{bol} = 45.4–47.9 erg/s). The main aims of this paper are determining the extension of the ionized gas, characterizing the occurrence of AGN-driven outflows, and linking the properties of such outflows with those of the AGN.

Methods. We use Adaptive Optics-assisted SINFONI observations to trace ionized gas in the extended narrow line region using the [O III] λ5007 line. We classify a target as hosting an outflow if its non-parametric velocity of the [O III] line, w_{80}, is larger than 600 km/s. We study the presence of extended emission using dedicated point-spread function (PSF) observations, after modelling the PSF from the Balmer lines originating from the Broad Line Region.

Results. We detect outflows in all the Type-1 AGN sample based on the w_{80} value from the integrated spectrum, which is in the range ~650–2700 km/s. There is a clear positive correlation between w_{80} and the AGN bolometric luminosity (99% correlation probability), but a weaker correlation with the black hole mass (80% correlation probability). A comparison of the PSF and the [O III] radial profile shows that the [O III] emission is spatially resolved for ~35% of the Type-1 sample and the outflows show an extension up to ~6 kpc. The relation between maximum velocity and the bolometric luminosity is consistent with model predictions for shocks from an AGN driven outflow. The escape fraction of the outflowing gas increase with the AGN luminosity, although for most galaxies, this fraction is less than 10%.

Key words. galaxies: active – galaxies: evolution – galaxies: high-redshift – quasars: emission lines – techniques: imaging spectroscopy

1. Introduction

Quasars represent some of the most energetic sources in the Universe which may regulate the gas flows in and out their host galaxies. A manifestation of the impact that super-massive black holes (SMBHs) may have on the galaxy are the well established black hole-host galaxy scaling relations such as the BH mass, M_{BH}, vs. galaxy mass, M_*, (e.g. Magorrian et al. 1998; Läsker et al. 2016; Schutte et al. 2019) and the M_{BH} vs. stellar velocity dispersion, σ_*, relations (e.g. Gebhardt et al. 2000; Batiste et al. 2017; Caglar et al. 2020).

One promising physical phenomenon to link the growth of the SMBH and the evolution of its host is that of fast winds launched from the AGN accretion disk (>1000 km/s, e.g. King 2003; Begelman 2003; Menci et al. 2008; Zubovas & King 2012; Faucher-Giguère & Quataert 2012; Choi et al. 2014; Nims et al. 2015; Hopkins et al. 2016). These winds are hypothesized to shock against the surrounding gas and drive outflows that propagate out to large distances from the AGN, heat the interstellar medium (ISM) and potentially eject large amount of gas out of the system (e.g. Ishibashi & Fabian 2016; Zubovas 2018). Such fast winds are now observed in a vast number of AGN host galaxies at both low as well as high redshift, in different phases of gas - neutral phase using sodium absorption lines (e.g. Krug et al. 2010; Rupke & Veilleux 2011; Cazzoli et al. 2016; Concas et al. 2019; Roberts-Borsani 2020), cold molecular gas phase using different transitions of CO, HCN and [C II] for instance (e.g. García-Burillo et al. 2014; Tadhunter et al. 2014; Feruglio et al. 2017; Aladro et al. 2018; Michiyama et al. 2018; Zschaechner et al. 2018; Aalto et al. 2019; Husemann et al. 2019; Cicone et al. 2020; Veilleux et al. 2020), warm and hot molecular gas phase using transitions in the mid- to near-infrared (Veilleux et al. 2009; Davies et al. 2014; Hill & Zakamska 2014; Riffel et al. 2015; Emonts et al. 2017; May et al. 2018; Petric et al. 2018; Riffel et al. 2020), and ionized gas phase observed using the rest-frame optical emission lines such as the forbidden transitions of [O III] λ5007 (e.g. Harrison et al. 2014; Kakkad et al. 2016; Zakamska et al. 2016; Fiore et al. 2017; Venturi et al. 2018; Baron & Netzer 2019; Coatman et al. 2019; Förster Schreiber et al. 2019). Due to the higher surface brightness of the ionized gas traced by the forbidden transition [O III] λ5007 relative to other optical transitions (e.g. [O II] λ3727, [S II] λ6716), outflows in this phase can be studied in detail for a large number of galaxies. In AGN, these forbidden ionized transitions such as [O III] , [N II] , and [S II] are emitted from the Extended Narrow Line Region (ENLR), making these transitions ideal to trace kiloparsec scale ionized gas outflows from the AGN (e.g. Ben-