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The Extreme Quasar Main Sequence of Super-Eddington DESI-DR1 NLSy1 Galaxies

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Abstract

Context: The quasar main sequence, or Eigenvector 1 (EV1), describes the optical diversity of active galactic nuclei (AGN), with Narrow-Line Seyfert 1 (NLSy1) galaxies anchoring the high-accretion end. Recent discoveries of overly massive black holes in the early Universe highlight the need to study local, low-mass super-Eddington accretors as analogs for rapid black hole seed growth.

Aims: We aim to map a newly discovered large population of 18,749 NLSy1 galaxies identified in the Dark Energy Spectroscopic Instrument Data Release 1 (DESI DR1) onto the EV1 plane to determine whether they represent a distinct population of super-accretors.

Methods: We compare the spectral properties of the DESI DR1 NLSy1 sample with the classical SDSS DR17 NLSy1 catalog. We extract key parameters, including the broad H beta full width at half maximum (FWHM) and Fe II strength (R4570). To robustly evaluate their accretion states, we derive single-epoch virial black hole masses using two independent approaches: an Fe II strength-dependent scaling relation and a recently established Eddington rate-dependent fundamental plane. Both methods confirm their extreme accretion rates.

Results: The DESI DR1 NLSy1 population shows a striking shift toward the extreme end of the EV1 parameter space, with stronger Fe II emission (median log R4570 = -0.03) compared to the SDSS sample (-0.31). Furthermore, the DESI sources systematically host less massive black holes (median log black hole mass in solar masses approximately 6.73 in both calibrations) than the SDSS objects (6.77–6.91). Given their comparable continuum luminosities, a consistently larger fraction of the DESI sample (43.8%–47.7%) exceeds the Eddington limit (log Eddington ratio > 0) compared to the SDSS sample (20.6%–37.4%).

Conclusions: The unprecedented sensitivity of DESI has unveiled a large population of low-mass, super-Eddington accreting AGN that were largely missing from previous surveys. These extreme EV1 objects struggle to process luminous accretion flows, naturally producing the observed intense Fe II emission. This catalog provides a rich statistical dataset of local super-Eddington accretors, serving as laboratories for understanding early-Universe black hole growth.

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