Brian Punsly

Position: Research Scientist
Period covered: 12/2019-12/2020

I Scientific Work

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Black Holes and Quasars

1. Introduction

This report describes the research performed by Brian Punsly and collaborators in cooperation with ICRANet in 2020. The research was directed at finding environmental factors that are related to the switch-on of the general relativistic engine responsible for the few percent of accreting black holes that drive powerful relativistic jets. This is important since this will relate directly to constraints on the initial state and boundary conditions on numerical models of black hole driven jets.

2. The Energetics of Launching the Most Powerful Jets in Quasars: A Study of 3C 82

Abstract:

3C 82 at a redshift of 2.87 is the most distant 3C (Third Cambridge Catalogue) quasar. Thus, it is a strong candidate to have the most luminous radio lobes in the universe. 3C 82 belongs to the class of compact steep-spectrum radio sources. We use single-dish and interferometric radio observations in order to model the plasma state of these powerful radio lobes. It is estimated that the long-term time-averaged jet power required to fill these lobes with leptonic plasma is \( \mathcal{Q} \approx 2.66 \pm 1.33 \times 10^{47} \text{ erg s}^{-1} \), among the largest time-averaged jet powers from a quasar. Positing protonic lobes is not tenable as they would require two orders of magnitude more mass transport to the lobes than was accreted to the central black hole during their formation. The first high signal-to-noise optical spectroscopic observation obtained of this object indicates that there is a powerful high-ionization broad-line wind with a kinetic power of \( \approx 10^{45} \text{ erg s}^{-1} \) and a velocity of \( \approx 0.01c \). We also estimate from the broad lines in 2018 and the UV continuum in three epochs spread out over three decades that the accretion flow bolometric luminosity is \( L_{\text{bol}} \approx 3.2 \pm 5.8 \times 10^{46} \text{ erg s}^{-1} \). The ratio of \( \mathcal{Q} / L_{\text{bol}} \approx 5.91 \pm 3.41 \) is perhaps the largest of any known quasar. Extremely powerful jets tend to strongly suppress powerful winds of ionized baryonic matter. Consequently, 3C 82 provides a unique laboratory for studying the dynamical limits of the central engine of outflow initiation in quasars.
3. The Extreme Red Excess in Blazar Ultraviolet Broad Emission Lines

ABSTRACT:

We present a study of quasars with very redward asymmetric (RA) ultraviolet (UV) broad emission lines (BELs). An excess of redshifted emission has been previously shown to occur in the BELs of radio-loud quasars and is most extreme in certain blazars. Paradoxically, blazars are objects that are characterized by a highly relativistic blueshifted outflow toward Earth. We show that the red emitting gas resides in a very broad component (VBC) that is typical of Population B quasars that are defined by a wide $\mathrm{H}\beta$ BEL profile. Empirically, we find that RA BEL blazars have both low Eddington rates ($\lesssim 1\%$) and an inordinately large (order unity) ratio of long-term time-averaged jet power to accretion luminosity. The latter circumstance has been previously shown to be associated with a depressed extreme UV ionizing continuum. Both properties conspire to produce a low flux of ionizing photons, two orders of magnitude less than typical Population B quasars. We use CLOUDY models to demonstrate that a weak ionizing flux is required for gas near the central black hole to be optimally ionized to radiate BELs with high efficiency (most quasars overionize nearby gas, resulting in low radiative efficiency). The large gravitational redshift and transverse Doppler shift result in a VBC that is redshifted by $\sim 2000–5000$ km $\text{s}^{-1}$ with a correspondingly large line width. The RA BELs result from an enhanced efficiency (relative to typical Population B quasars) to produce a luminous, redshifted VBC near the central black hole.

2020 List of Publication

Punsly, Brian; Hill, Gary J.; Marziani, Paola; Kharb, Preeti; Berton, Marco; Crepaldi, Luca; Indahl, Briana L.; Zeimann, Greg, “The Energetics of Launching the Most Powerful Jets in Quasars: A Study of 3C 82”, 2020 ApJ 189 169