Brian Punsly

Position: Research Scientist
Period covered: 12/2020-12/2022

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 2022. 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 holesthat 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 the Central Engine in the Powerful Quasar, 3C298**

Abstract:

The compact steep spectrum radio source, 3C 298, (redshift of 1.44) has the largest 178 MHz luminosity in the 3CR (revised Third Cambridge Catalogue) catalog; its radio lobes are among the most luminous in the Universe. The plasma state of the radio lobes is modeled with the aid of interferometric radio observations (in particular, the new Low Frequency Array observation and archival MERLIN data) and archival single-station data. It is estimated that the long-term time-averaged jet power required to fill these lobes with leptonic plasma is $\overline{Q} \approx 1.28 \pm 0.51 \times 10^{47} \rm{erg}\,\rm{s}^{-1}$, rivaling the largest time averaged jet powers from any quasar. Supporting this notion of extraordinary jet power is a 0.5 keV -10 keV luminosity of $\approx 5.2 \times 10^{46} \rm{erg}\, \rm{s}^{-1}$, comparable to luminous blazars, yet there is no other indication of strong relativistic beaming. We combine two new high signal to noise optical spectroscopic observations from the Hobby-Eberly Telescope with archival Hubble Space Telescope, Two Micron Survey and Galaxy Evolutionary Explorer data to compute a bolometric luminosity from the accretion flow of $L_{\rm{bol}} \approx 1.55 \pm 0.15 \times 10^{47} \rm{erg} \,\rm{s}^{-1}$. The ratio, $\overline{Q}/L_{\rm{bol}}\approx 1$, is the approximate upper limit for quasars. Characteristic of a large $\overline{Q}/L_{\rm{bol}}$, we find an extreme ultraviolet (EUV) spectrum that is very steep (the ``EUV deficit" of powerful radio quasars relative to radio quiet quasars) and this weak ionizing continuum is likely a contributing factor to the relatively small equivalent widths of the broad emission lines in this quasar.

3. **The Details of Limb Brightening Reveal the Structure of the Base of the Jet in M87 for the FirstTime**

ABSTRACT:

It has become commonplace is astronomy to describe the transverse coarse structure of jets in loosely defined terms such as ``sheath'' and ``spine'' based on discussions of parsec scale properties. But, the applicability, dimension and prominence of these features on sub-lt-yr scales has previously been unconstrained by observation. The first direct evidence of jet structure near the source in M\,87 is extreme limb brightening (a double-rail morphology), 0.3 - 0.6 mas from the source, that is prominent in observations with high resolution and sensitivity. Intensity cross-cuts of these images provide three strong, interdependent constraints on the geometry responsible for the double-rail morphology: the rail to rail separation, the peak to trough intensity ratio and the rail widths. Analyzing these constraints indicates that half or more of the jet volume resides in a thick-walled, tubular, mildly relativistic, protonic jet only ~ 0.25 lt-yr (or ~ 300 M, where M is the central black hole mass in geometrized units) from the source. By contrast, the Event Horizon Telescope Collaboration interprets their observations with the aid of general relativistic magnetohydrodynamic simulations that produce an invisible (by construction) jet with a surrounding luminous, thin sheath. Yet, it is shown that synthetic images of simulated jets are center brightened 0.3 - 0.6 mas from the source. This serious disconnection with observation occurs in a region previously claimed in the literature to be well represented by the simulations. The limb brightening analysis motivates a discussion of possible simulation modifications to improve conformance with observations.

2022 List of Publication

Punsly, Brian; Groeneveld, Christian; Hill, Gary J.; Marziani, Paola; Zeimann, Gregory R.; Schneider, Donald P.,“The Energetics of the Central Engine in the Powerful Quasar, 3C298”,2022 AJ 16314

Punsly, Brian “The Details of Limb Brightening Reveal the Structure of the Base of the Jet in M87 for the First Time”,2022ApJ93679