Brian Punsly

Position: Research Scientist
Period covered: 10/2016-10/2017

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 2016-2017. The research was directed at finding environmental factors that are related to the switch-on of the general relativistic engine responsible for a few percent of quasars driving 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 Origin of the Event Horizon Scale Jet in M87**

Global millimeter wavelength Very Long Baseline Interferometry (VLBI) is an ambitious program to study the event horizon scale physics of nearby active galactic nuclei (AGN). The shortest wavelength receivers have been designated as the Event Horizon Telescope (EHT). It has been widely advertised that the experiment will reveal how astrophysical black holes can drive powerful jets near the event horizon – possibly proving the Blandford-Znajek mechanism that drives jets from the even horizon itself. There is only one powerful relativistic jet source that can be explored by the EHT with resolution on the order of the event horizon dimension, the jet in the enormous radio galaxy M87. Thus, M87 is the most studied object in radio jet research.

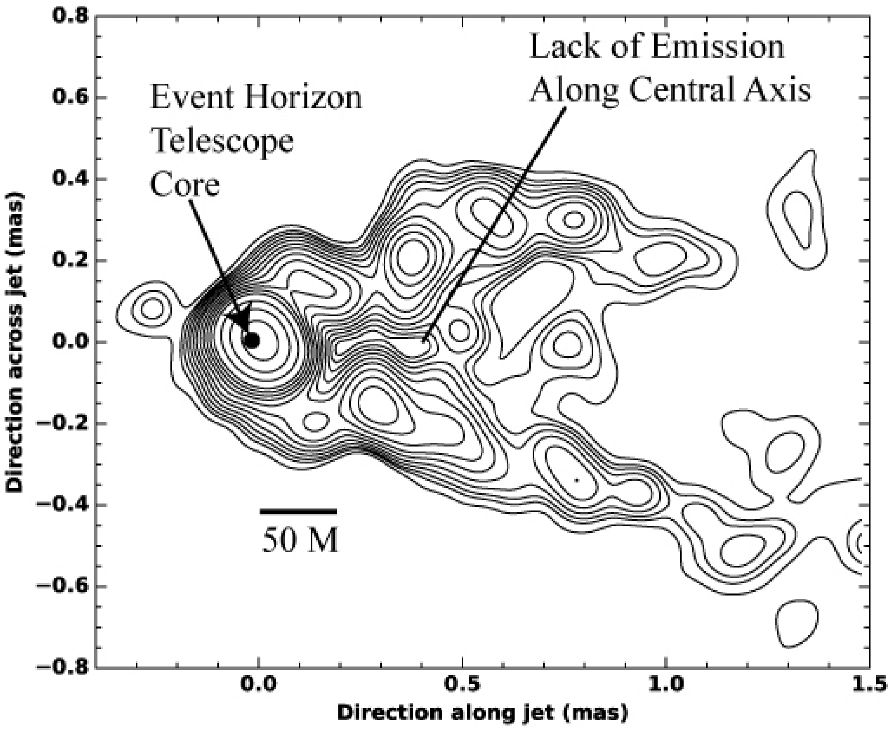

Figure 1. The 3.5 mm, global VLBI, image of Hada et al. (2016) with the EHT detected core at 1.3 mm from Akiyama et al. (2016) and Doeleman et al. (2012) overlaid. Note the extreme absence of emission along the central spine within 50 M of the black hole (the limit of the resolution of the radio image)

There is radio imaging of M87 at 3.5 mm (86 GHz) and detections with the EHT at 1.3 mm (230 GHz). The newest t and most sensitive 86 GHz published image is shown in Figure 1. There is currently no imaging capability at 230 GHz. However, it seems clear from the 86 GHz image in Figure 1 that there is a flux void along the central spine above the event horizon. More specifically, the image reveals a central flux nadir within 50M (where M is the black hole in geometrized units) of the super-massive black hole.

ICRANet adjunct professor, Brian Punsly, has been collaborating with Kazuhiro Hada of Mizusawa VLBI Observatory, National Astronomical Observatory of Japan (the prinicipal investigator on the 86 GHz observation in Figure 1) and Martin Hardacastle of Centre for Astrophysics Research, School of m Physics, Astronomy and Mathematics, University of Hertfordshire in order to study this lack of emission of along the spine. There are two papers. Paper 1 is a collaborative, “A New Solution to the Plasma Starved Event Horizon Magnetosphere: Application to the Forked Jet in M87”. It is currently under review with Astronomy and Astrophysics. It explains the physics that does not allow the event the event horizon magnetosphere to launch a powerful jet in M87, thereby producing the weak flux emission along the spine above the event horizon evident in Figure 1. This will be reported in detail in a future newsletter. In summary, for low luminosity AGN, such as M87, it is shown that accreted large scale poloidal magnetic flux is dissipated when it approaches the event horizon and no significant magnetosphere can be obtained.

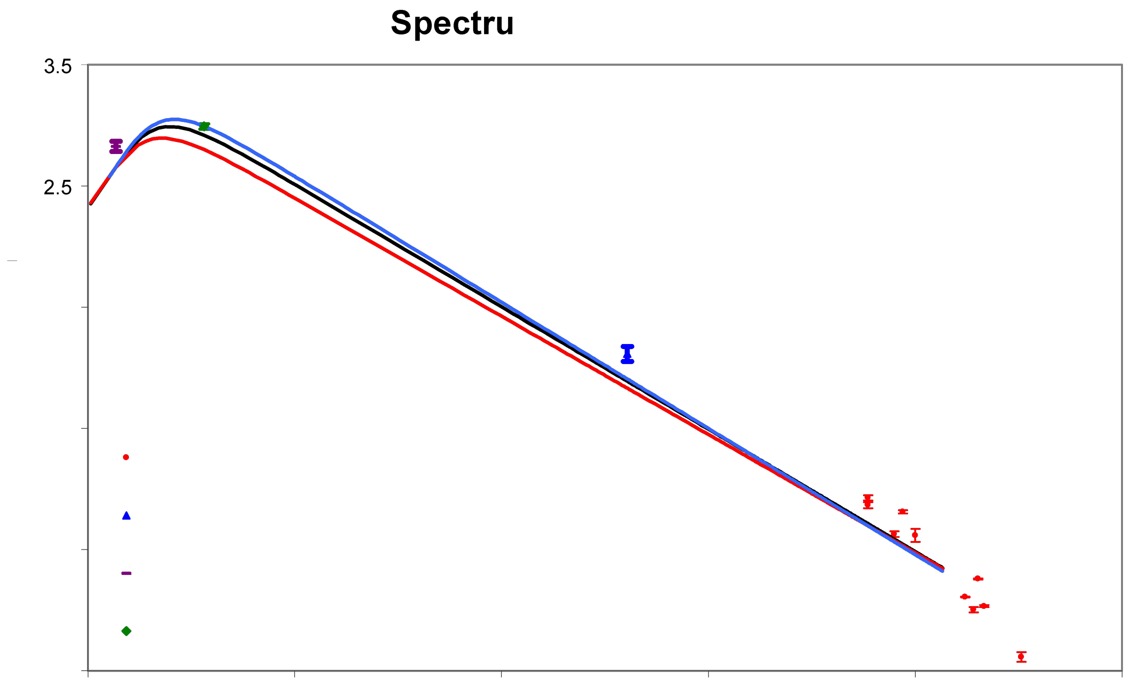

Figure 2. A hollow jet from the inner accretion can explain the broadband spectrum of the region that is the source of the correlated flux detected by the EHT (from Punsly 2018).

The second paper is s solo effort of Brian Punsly, “A Jet Source of Event Horizon Telescope Correlated Flux in M87” ApJ (2017). This is an important supporting work since it shows that a jet from the inner accretion flow can not only explain the broadband spectra from millimeter to the ultraviolet of the plasma responsible for the correlated flux detected by the EHT (see Figure 2), but it also shows that such a jet can supply all the power required to explain the large scale jet in M87. This is critical because the Blandford-Znajek school claims that Figure 1 is an optical illusion. The horizon jet is far more powerful than the enveloping hollow jet, but is invisible on these scales due to a low plasma energy density. It can never be seen by any telescope, but works silently behind the scenes energizing the outer sheath and this is needed to explain the global energetics of the jet. However, the new ICRANet paper of Punsly shows that a jet from the inner accretion flow has plenty of power and no invisible powerful “ghost jet” is needed. Furthermore, the hollow jet is a direct interpretation of Figure 1 and the EHT correlated flux detection, neither of which is explained by a Blandford-Znajek “ghost jet”. There is a clear straightforward observation that could prove the EHT very valuable in this line of research. It is pointed out in Punsly (2017) that if a luminous forward jet is detected by future EHT observations on scales of less than 30 micro-arc-seconds, it would contradict the notion of a Blandford-Znajek jet and corroborate a prediction of the hollow jet with a void above the event horizon magnetosphere.

2017 List of Publication

Punsly, Brian; A Jet Source of Event Horizon Telescope Correlated Flux in M87 2017 ApJ 850 190

Punsly, Brian;, Kharb, Preeti The kinetically dominated quasar 3C 418 2017 MNRAS Lett. 468 72

Reynolds, Cormac; Punsly, Brian; Miniutti, Giovanni; O'Dea, Christopher P.; Hurley-Walker, Natasha., The Relativistic Jet-accretion Flow-Wind Connection in Mrk 231 2017 ApJ 836 155