Punsly Brian

Position: Research Scientist

Period covered: 2009

I Scientific Work

Brian Punsly/ICRANet Research 2009 and 2010

ABSTRACT:

This report describes the research performed by Brian Punsly in cooperation with ICRANet in 2009 and 2010.

1. Introduction

In 2009 and 2010, the research was concentrated in three areas, long term 3-D MHD numerical simulations of black hole magnetospheres, in depth high resolution VLBA monitoring of the nearby quasar MRK 231, and X-ray observations of quasars with polar broad UV absorption line outflows. I summarize these three lines of research in the next three sections.

2. Three Dimensional Simulations of Vertical Magnetic Flux in the Immediate Vicinity of Black Holes

This article was written with Igor V. Igumenshchev (Laboratory for Laser Energetics, University of Rochester) and Shigenobu Hirose (The Earth Simulator Center, JAMSTEC) (Punsly et al 2009).

This paper highlights the theoretical work developed in Punsly (2008) in intricate 3-D detail.

Abstract: This article reports on three-dimensional (3-D) MHD simulations of non-rotating and rapidly rotating black holes and the adjacent black hole accretion disk magnetospheres. A particular emphasis is placed on the vertical magnetic flux that is advected inward from large radii and threads the equatorial plane near the event horizon. In both cases of non-rotating and rotating black holes, the existence of a significant vertical magnetic field in this region is like a switch that creates powerful jets. There are many similarities in the vertical flux dynamics in these two cases in spite of the tremendous enhancement of azimuthal twisting of the field lines and enhancement of the jet power because of an “ergospheric disk" in the Kerr metric. A 3-D approach is essential because two-dimensional axisymmetric flows are incapable of revealing the nature of vertical flux near a black hole. Poloidal field lines from the ergospheric accretion region have been visualized in 3-D and much of the article is devoted to a formal classification of the different manifestations of vertical flux in the Kerr case.

3. VLBA Observations of Sub-Parsec Structure in Mrk 231: Interaction between a Relativistic Jet and a BAL Wind

I am leading an effort to study Mrk 231 at the highest resolution. It is the nearest

broad absorption line quasar and we have proven that it conforms with the idea of a polar broad absorption line outflow (instead of the popular notion of an equatorial outflow) that was developed in Punsly (1999a,b). This effort was done in collaboration with Cormac Reynolds (Curtin University of Technology, Department of Imaging and Applied Physics), Preeti Kharb and Christopher P. O'Dea (Department of Physics, Rochester Institute of Technology) and Joan Wrobel (NRAO, Socorro).

Abstract: We report on the first high frequency VLBI observations of the nearby broad absorption line quasar (BALQSO), Mrk 231. Three epochs of observations were achieved at 15 GHz and 22 GHz, two of these included 43 GHz observations as well. The nuclear radio source is resolved as a compact double. The core component experienced a strong °are in which the flux density at 22 GHz increased by > 150% (45 mJy) in three months. Theoretical models of the flare imply that the emission is likely enhanced by very strong Doppler boosting of a highly relativistic ejecta with a kinetic energy flux, $Q \sim 3 \times 10^{43}$ ergs/sec. Combining our data with two previous epochs of 15 GHz data, shows marginal evidence for the slow advance of the secondary component (located ≈ 0.97 pc from the core) over a 9.4 year span. We estimate that the long term time averaged kinetic energy flux of the secondary at $Q \approx 10^{42}$ ergs/sec. Low frequency VLBA observations indicate that the secondary is seen through a shroud of free-free absorbing gas with an emission measure of $\approx 10^{8} cm^{-6}$ pc. The steep spectrum secondary component appears to be a compact radio lobe that is associated with a working surface between the ram-pressure confined jet, and a dense medium that is likely to be the source of the free-free absorption. The properties of the dense gas are consistent with the temperatures, displacement from the nucleus and the column density of total hydrogen commonly associated with the BAL wind.

3.1. Large VLBA Proposal Approved

We have already received approval for a more aggressive look at this object.

3.1.1. Abstract

We propose VLBA monitoring at 8.4, 15, 22 and 43 GHz of a high frequency flare in the nearby quasar MRK231. The “target of opportunity" observation (ToO) would be triggered by a flare detected by VLA monitoring at 22 and 43 GHz (see related proposal). The primary goals would be to detect a superluminal motion, estimate the internal energy of the flare from the spectrum and component sizes, and monitor the temporal evolution in order to understand the energy injection mechanism (rise) and the cooling mechanism (decay).

3.1.2. Background

From previous VLBA studies of MRK231 in Reynolds et al (2009) and other RQ (radio quiet) quasar studies, we have seen that RQ AGN can have relativistic outflows with significant kinetic luminosities (but maybe for short periods of time). So this raises the question what is it that makes some sources RQ and others radio loud (RL)? At a redshift of 0.042, MRK231 is one of the nearest

radio quiet quasars to earth. The radio core is perhaps the brightest of any radio quiet quasar at high frequency (22 and 43 GHz). The combination of significant 43 GHz flux density and its proximity to earth makes MRK231 the optimal radio quiet quasar for study with VLBA. No other radio quiet quasar central engine can be explored with such high resolution, so it is ideal for studying the high kinetic luminosity relativistic ejecta in radio quiet quasars. 43 GHz VLBA observations can fully resolve nuclear structure to within 3.5 x 10^{17} cm. We propose to use sensitive high resolution observations to study the temporal evolution of the size and spectrum of a strong flare in MRK231 in order to shed light on why such strong flares cool off and never link to large scale powerful radio lobes.

3.1.3. Coordinating with X-ray Observations

I am working with Jesper Rasmussen of the Carnegie Observatories in Pasadena in proposal work to coordinate X-ray observations with the target of opportunity VLBA observations of Mrk 231. We are collaborating with Chris O'Dea, Cormac Reynolds and Joan Wrobel on a recently submitted XMM proposal. The proposal is aimed at seeing inverse Compton emission flares that are correlated with the microwave flares. We also hope to see how the absorption column varies as the flare propagates away from the central engine

4. X-ray observations of Polar Broad Absorption Line Quasars

Developing more on the models of Punsly (1999a,b) I have been working with Kajal Ghosh (Universities Space Research Association, NASA Marshall Space Flight Center) to study other polar broad absorption line quasars (BALQSOs) particularly in the X-ray. This year, we have already observed 3 polar BALQSOs with Chandra and 1 with Suzaku (90 ks observation). The objects were proven to be polar in our paper Ghosh and Punsly (2007). We have also been granted observing time to look at 6 more with Chandra and three long exposures with XMM.

REFERENCES

Ghosh, K. and Punsly, B. 2007 ApJL 661 139

Punsly, B., Igumenshchev, I. and Hirose, S. to appear in October 20 issue of ApJ 2009

http://arxiv.org/abs/0908.3697

Punsly, B. 1999, ApJ 527 609

Punsly, B. 1999, ApJ 527 624

Punsly, B. 2008, Black Hole Gravitohydromagnetics, second edition (Springer-Verlag, New

York)

Reynolds, C. et al to appear in ApJ