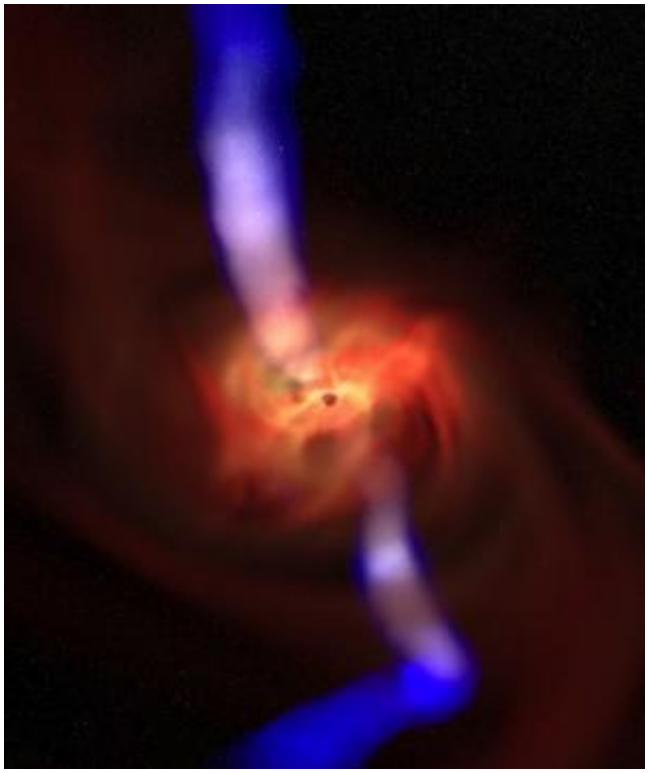
Computer model shows strong magnetic fields may alter alignment of black hole accretion disks and plasma jets

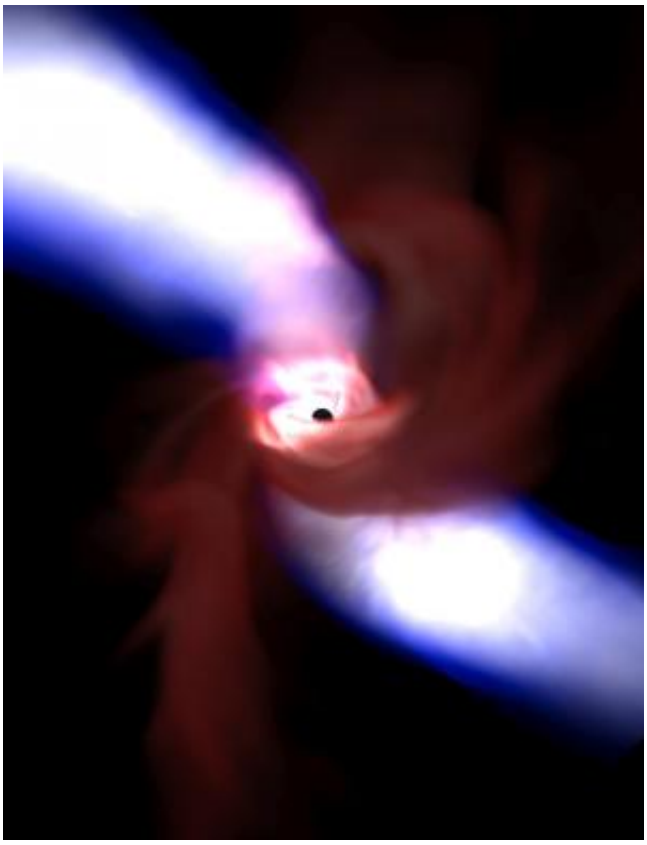
16 November 2012, by Bob Yirka



Version 1: A spinning black hole (at center) produces a powerful jet (white-blue) along its spin axis. While near the hole, the disk rotational axis and jet direction are aligned with the black hole spin axis, but farther away the jet deviates and eventually points along the outer disk's rotational axis. Credit: Jonathan McKinney, University of Maryland, and Ralf Kaehler, SLAC National Accelerator Laboratory

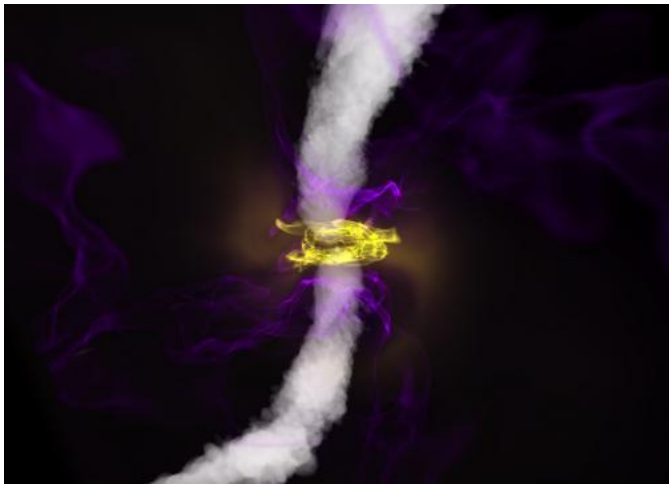
(Phys.org)—Researchers from Stanford University and Princeton suggest in a paper they've had published in the journal *Science* that magnetic fields associated with some black holes may be strong enough to cause thick accretion disks to align with the spin of the black hole itself. Jonathan McKinney, Alexander Tchekhovskoy and Roger Blandford created three dimensional models based on relativistic magnetohydrodynamical simulations to show that strong magnetic field buildup in black holes may also explain why plasma jets fly out of some black holes along its spin of axis.

The researchers note that black holes with thin accretion disks tend to align with the axis of spin of a black hole due to the Bardeen-Petterson effect (viscous forces that cause the accretion flow to divide into two discrete regions). Why those with larger accretion disks do the same on occasion however, has remained a mystery. Now, based on results from a simulation the researchers have built, the team suggests it's due to the buildup of a strong magnetic field.



Version 2: Spinning black hole (at center) produces a

powerful jet (white-blue) along its spin axis. The jet affects the orientation of the surrounding accretion disk (infalling hot plasma as white-red near the hole) causing the disk to align with the spin axis near the hole, but at larger distances the disk dominates the jet and the jet re-aligns with the outer disk. Credit: Jonathan McKinney, University of Maryland, and Ralf Kaehler, SLAC National Accelerator Laboratory



Spinning black hole (at center) produces a powerful jet (white smoke) along its spin axis.

The researchers propose that as gravity pulls material into the black hole, the magnetic fields of those materials are absorbed along with it. This results in the buildup of a stronger and stronger magnetic field which once a certain point is reached, begins impacting the spin of both the accretion disk surrounding the black hole and the direction of the plasma jets that it emits.

The team's simulation showed that as a black holes' magnetic field grows stronger, a twist in space-time can occur around it which in turn can cause its magnetic field lines to form spirals aligned with the black holes' axis of rotation. They note also that it's the black holes' magnetic field lines that produce the plasma jets that have been observed here on Earth. They also found that if a black hole had a strong enough magnetic field, it could impact a thick accretion disk to the point of causing it to align with the black holes' axis of rotation as well.

Because the simulations the team built are based on the theory of general relativity, their results may lead to new ways to test its fundamental soundness in ways that have never been tried before.

More information: More movies of the new black hole simulations are available on McKinney's YouTube page.

Paper: Alignment of Magnetized Accretion Disks and Relativistic Jets with Spinning Black Holes, *Science*, DOI: 10.1126/science.1230811

ABSTRACT
Accreting black holes (BHs) produce intense radiation and powerful relativistic jets, which are affected by the BH's spin magnitude and direction. While thin disks might align with the BH spin axis via the Bardeen-Petterson effect, this does not apply to jet systems with thick disks. We used fully three-dimensional general relativistic magnetohydrodynamical simulations to study accreting BHs with various BH spin vectors and disk thicknesses with magnetic flux reaching saturation. Our simulations reveal a "magneto-spin alignment" mechanism that causes magnetized disks and jets to align with the BH spin near BHs and further away to reorient with the outer disk. This mechanism has implications for the evolution of BH mass and spin, BH feedback on host galaxies, and resolved BH images for SgrA* and M87.

Press release