Black Hole Spins of Radio Sources

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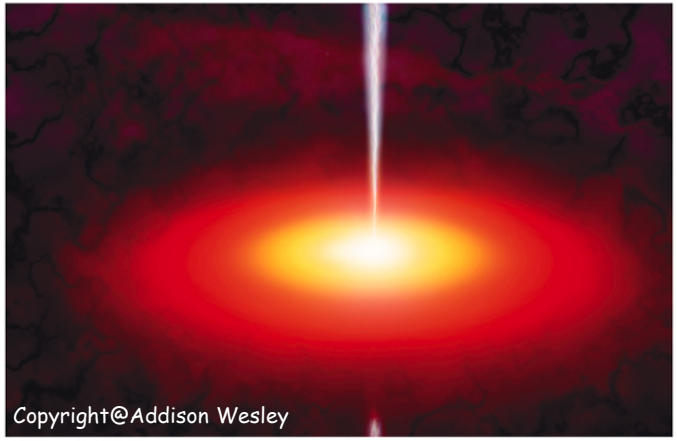
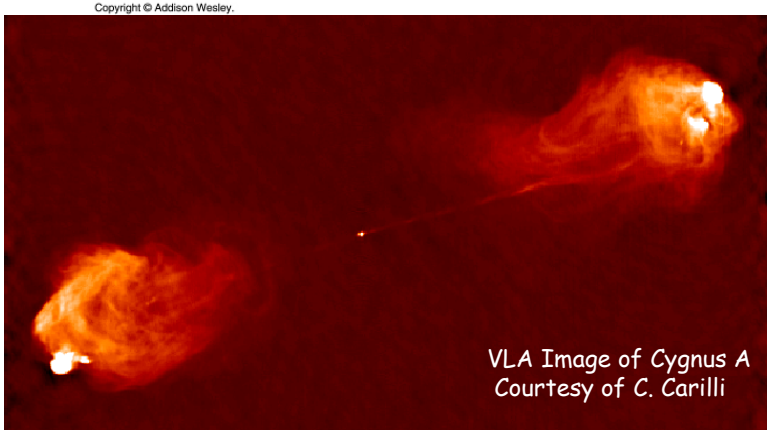
Two key characteristics of a black hole are: MASS and SPIN
When a black hole spins:
the "event horizon = boundary of no return"
is a "squashed sphere"
that bulges near the equator



The space surrounding a spinning black hole
is swept into a swirl or vortex,
like a tornado, with dramatic consequences.

The energy of the swirling space
and spinning hole can lead to
enormously energetic beams
of collimated outflows
from the black hole region.



The study of collimated and energetic outflows tells about the spin of the black hole. The outflows produce radio emission observed and studied using radio data such as the data obtained at the Very Large Array (VLA) in New Mexico.

--New method for determination of black hole spin based on black hole mass and beam power proposed (Daly 2009).

--Beam power = energy per unit time extracted from the spinning hole and its vicinity

energy leads to the production of jets.

--55 systems for which both the beam power and black hole mass were known or could be determined were identified

--The black holes studied have masses of a few hundred million to several billion suns, each located near the center of the host elliptical galaxy

--The "boundary of no return" is similar to the size of the solar system.

--The jet powers range from a power similar to the total optical output of an average galaxy to over a thousand times larger.

-- This enormous outflow power travels through a nozzle that is <u>only the size of the solar system!</u>

Black hole spins were found to have values that range from about 0.1 to 1, or about 10% to 100% of the maximum possible spin

The maximum possible black hole spin is close to 1

For a supermassive black hole rotating with the maximum possible spin that has a mass of a billion suns, the event horizon of the black hole rotates about once per day

The size is similar to the size of Saturn's orbit around the sun
(or about a thousand times the size of the sun).

Saturn orbits the Sun in about 30 years

A maximally spinning black hole with an event horizon of similar size takes only one day to rotate

Imagine!

Distances of the 55 radio sources from earth range from about 50 million light years to about 10 billion light years, corresponding to "look back times" of about 50 million to 10 billion years

We study the change of black hole spin from the time when the age of the universe was about 3 billion years to present (with the present age of the universe estimated at 13 billion years)

More distant sources

those that existed when the universe was younger

have larger spins than the more nearby sources

The change of black hole spin with "look back time" tells us how the black holes

have been altered by mergers

provides an indication of accretion disk structure.

Summary - Black Hole Spins of Radio Sources

Spins determined for 58 supermassive black holes

55 radio sources studied by Daly (one also studied by another group)

3 spins determined by other groups for black holes in nearby Seyfert galaxies.

Black holes spins range from the maximum possible spin to about 10% of the maximum possible spin

Most rapidly spinning holes associated with radio sources have look back times of about 10 billion years

Radio waves we are studying were emitted when the universe had ages from about

3 to 13 billion years

Spin of radio sources gradually decreases as we move to more nearby sources

It is observationally easier to study nearby sources, and these sources are found to have a broad range of black hole spin.

This black hole spin study provides information on the merger and accretion history of supermassive black holes and accretion disk structure

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