Active Galactic Nuclei

Third Exam will be given on April 24
Last observatory opportunity April 24 8:30pm

Website
http://casa.colorado.edu/~wcash/APS1120/APS1120.html
The Redshift

$$z = \frac{\lambda - \lambda_0}{\lambda_0}$$

z = 0 implies local

z of 1 or more implies near far edge of universe
Active Galactic Nuclei

- Seyfert Galaxies 1948
- Radio Galaxies 1954
- Quasars 1962
- BL Lac’s 1968
- Blazars 1980

They’re all manifestations of the same thing.
Seyfert Galaxies

Figure 6.4: UV spectrum of Seyfert galaxy NGC 4151 observed with HST. Galactic Lyman-$\alpha$ emission has been subtracted, and remaining weak single features are indicated with Earth symbols (©). Emission and absorption features are marked above and below blaze data, respectively. Blaze data indicate a forbidden transition. A single bracket signifies a semi-forbidden transition. Iron with asterisks are in excited states. The absorbing gas may be responsible for collimating the ionizing radiation from the nuclear source. (From Koss et al. 2002.)
Quasar

QUAsi Stellar Radio source → Quasar

(Sometimes QSO)

Completely enigmatic for 1960-1980
Huge Redshifts

The Brightest Objects in the Universe
Quasar Spectrum

Originally found from radio
But not all have radio.

Broad spectral output from radio to gamma-ray
In a Galaxy
Far, Far Away
Long, Long Ago
The Most Distant Quasar

$z=5$
Host Galaxies

Quasars are in host galaxies
Mostly just outshine the entire galaxy
The AGN Model

The Nucleus of the Galaxy is the Clot of Stars around the giant black hole that’s fallen to the bottom of the galaxy gravitational well.

As more material falls in, the black hole grows and the nucleus can get very bright.

I think all major galaxies have a BBH (big black hole) in the center. This is yet proven. Certainly a substantial fraction do.
Feeding a Quasar

Accretion disk is formed of stars and clouds that wander too near the big black hole.

Tidal forces rip them apart. They settle into an accretion disk.

When there’s no material falling in, the quasar goes quiet.
Spectrum

Width of line implies velocities of 30,000 km/s!
High Orbital Speed implies deep gravitational well.
AGN Accretion Disk Simulations @ 0.1 μas

Courtesy of Phil Armitage, U. Colorado and C. Reynolds, U. Maryland
Jets
Jets
Fields Twist to Make Narrow Jet
Radio Galaxies

Very Large Array

Very Large Baseline Array
Radio Lobes

Lobes contain $10^{53}$ Joules of energy in relativistic electrons.

Mass energy equivalent of a million stars!
Wind Blows Jets
Superluminal Expansion

Radio interferometers see blobs emitted by AGN’s from base of jet.

Watch them expand.

Know distance, so can measure speed.

$v = 900,000 \text{km/s}$

$v = 3c$

Superluminal!? 

Is Einstein’s ghost worried?
Phase Velocity

Point of impact can move $v > c$
Nothing traveling that fast.
Blob moves close to speed of light toward us. Its closer later. Makes sideways motion appear speeded up.

\[ v_{app} = \frac{v \sin \theta}{1 - \frac{v \cos \theta}{c}} \]