Active Galaxies

Guiding Questions

1. Why are quasars unusual? How did astronomers discover that they are extraordinarily distant and luminous?
2. What evidence showed a link between quasars and galaxies?
3. How are Seyfert galaxies and radio galaxies related to quasars?
4. How can material ejected from quasars appear to travel faster than light?
5. What could power the incredible energy output from active galaxies?
6. Why do many active galaxies emit ultrafast jets of material?
7. What are gamma-ray bursters? How did astronomers discover how far away they are?

Quasars look like stars but have huge redshifts

<table>
<thead>
<tr>
<th>Redshift</th>
<th>Velocity (km/s)</th>
<th>Distance (Mpc)</th>
<th>(21 cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6.7</td>
<td>0</td>
<td>6.7</td>
<td>0</td>
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<tr>
<td>6.8</td>
<td>0.73</td>
<td>6.8</td>
<td>0.73</td>
</tr>
<tr>
<td>10</td>
<td>0.94</td>
<td>10</td>
<td>0.94</td>
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</tbody>
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These redshifts show that quasars are several hundred megaparsecs or more from the Earth, according to the Hubble law.

• To be seen at such large distances, quasars must be very luminous, typically about 1000 times brighter than an ordinary galaxy.
About 10% of all quasars are strong sources of radio emission and are therefore called "radio-loud"; the remaining 90% are "radio-quiet."

Some of quasars' energy is synchrotron radiation produced by high-speed particles traveling in a strong magnetic field.

Quasars are the ultraluminous centers of distant galaxies.

Seyfert galaxies seem to be nearby, low-luminosity, radio-quiet quasars. Seyfert galaxies are spiral galaxies with bright nuclei that are strong sources of radiation.

Radio galaxies are elliptical galaxies located midway between the lobes of a double radio source.
Relativistic particles are ejected from the nucleus of a radio galaxy along two oppositely directed beams.

Seyferts and radio galaxies bridge the gap between normal galaxies and quasars.

- Blazars are bright, starlike objects that can vary rapidly in their luminosity.
- They are probably radio galaxies or quasars seen end-on, with a jet of relativistic particles aimed toward the Earth.

Quasars, blazars, Seyfert and radio galaxies are active galaxies.

- Quasars, blazars, and Seyfert and radio galaxies are examples of active galaxies.
- The energy source at the center of an active galaxy is called an active galactic nucleus (AGN).
- Rapid fluctuations in the brightness of active galaxies indicate that the region that emits radiation is quite small.
Supermassive black holes are the “central engines” that power active galactic nuclei

- The evidence suggests that an active galactic nucleus consists of a supermassive black hole onto which matter accretes
- As gases spiral in toward the supermassive black hole, some of the gas may be redirected to become two jets of high-speed particles that are aligned perpendicularly to the accretion disk.
Quasars, blazars, and radio galaxies may be the same kind of object seen from different angles.

An observer sees a radio galaxy when the accretion disk is viewed nearly edge-on, so that its light is blocked by a surrounding torus.

Gamma-ray bursters produce amazingly intense flashes of radiation.

By observing the afterglow of long-duration gamma-ray bursters, astronomers find that these objects have very large redshifts and appear to be located within distant galaxies.

- Short, intense bursts of gamma rays are observed at random times coming from random parts of the sky.
- The origin of short-duration gamma-ray bursters is unknown.

- At a steeper angle, the observer sees a quasar.
- If one of the jets is aimed almost directly at the Earth, a blazar is observed.
The bursts are correlated with supernovae, and may be due to an exotic type of supernova called a collapsar.