Quasars

Discovery

• 1st – 3C273
• Optical ID of radio sources
  – While studying a radio source
  – a star in visible light was seen in a photograph
  – ID’d as radio source/quasar, not star - 1963
• Spectrum unusual, not star-like, stronger in the radio part of spectrum than visible, large redshift – 15% wavelength shift
Quasars

• Energy Source
  – The accretion of matter into a large black hole in an active galactic nucleus

• Properties
  • Quasars emit radiation in several wavelengths and are especially strong in the radio and ultraviolet wavelengths
  • In visible light they are star-like
  • Very bright with large redshifts
  • They are variable in their energy output
  • They have an ultraviolet excess, which means that they are bright in the ultraviolet, more than expected from their visual brightness
  • Have jets, some extending millions of light years out

Quasar PRC2000-18b
Varying Energy Output

• Variable energy output
  – Places an upper limit on their size
  – If brightness of object varies in time $t$, the region is no larger than $ct$
  – Brightness, does not vary faster than size of region divided by $c$
  – Source of brightness smaller than distance light travels in time $t$
  – Quasars have time scale of few months
    • Limits emitting region to $10^{12}$ km

Jets

• High energy outflows in a narrow beam
  – Mass flowing into the black hole from the galaxy orbits in an accretion disk around the black hole
    • A magnetic field from the gas is in the orbit
      – It winds up and shoots out particles perpendicular to the BH
        » Particles are carried out in a jet
Red Quasars

- Redder than normal quasars
- Normal quasars
  - Matter falling into black hole heats up and glows
  - Hot, appears blue
- Red quasars
  - Dust in front absorbs blue, so redder and fainter than normal
  - Dust makes them difficult to find
Discovering new quasars

• Star-like objects with colors different from typical stars
  – Associated with radio/x-ray emission
  – With unusual spectrum with large redshift that suggests quasar nature
• Looking for ultraviolet excess

Black Holes as Energy Source

• Material ejected over long period of time along a single axis – jets observed
• Quasars vary brightness in short time scale
• Black hole with accretion disk
  – Friction and compression heats gas
    • Gas hot, so most quasars appear blue
  – Cause high energy emission
NGC 4261

Gas and dust disk around a black hole which is powering a quasar

Companion Galaxy and Galaxy Nucleus
References

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• William Keel, *Quasar Explained*, Astronomy, Feb. 2003, p. 34-41