Radiative Processes

Properties of Astrophysical Radiation
Radiation and Radiative Transfer
Black Body Radiation
Radiation from Moving Charges
Bremstrahlung
Synchrotron Radiation
Compton scattering
Background Material

Special Relativity
Statistical and Thermal Physics
Vector Calculus
Electrodynamics
Fourier Transforms
The Parts of an Active Galactic Nucleus

AGN Unification
(Diagram from Urry & Padovani 1995)

- Jets
- Black Hole
- Narrow Line Region ($T_{\text{eff}} \approx 60 \text{ K}$)
- Broad Line Region ($T_{\text{eff}} \approx 2000 \text{ K}$)
- Obscuring Torus ($200 - 800 \text{ K}$)
- Accretion Disk ($T_{\text{eff}} \approx 10^5 \text{ K}$)

Annotated by M. Voit
The Spectral Energy Distribution of AGNs

- 1 micron - 0.2 keV: Thermal emission from optically thick accretion disk
- X-rays: Synchrotron, Inverse Compton, Hot corona + reflection
- Mm-1 micron: Dust emission
- Radio: Synchrotron (relativistic electrons in B-field)
• RGs constrain the total energy output of central engine ("kinetic" plus radiative)
• RG life time and stability of ejection axis constrain accretion disk & BH physics
• RGs may be an important source of magnetic field and cosmic rays in the ICM/IGM
• The interaction of jets with the ambient medium probes the gaseous environment of host galaxies
• RGs at high z are obscuration-independent signposts to the early formation of massive bulges
Models of classical doubles assume radio sources are supersonic flows.

The jets terminate in strong shocks and fill an over pressured cocoon which drives a bow shock into the ambient medium.

The Intracluster Medium

Abell 2199

Chandra (X-ray)

DSS (Optical)

redshift, $z = 0.0309$

50 thousand light years
X-rays in the Centaurus Cluster

The X-ray emission is a combination of thermal bremsstrahlung (electrons and protons) in the ionized plasma and line emission from partially ionized metals.

ROSAT image and ASCA spectrum of the Centaurus Cluster of galaxies. (U Cambridge X-ray Astronomy Group).
Calculated X-ray Spectrum of ICM

The continuum contributions from bremsstrahlung (blue), recombination radiation, characterized by the sharp ionization edges (green), and 2-photon radiation (red) are indicated. (Bohringer & Werner 2009)
Orion HII Region

HST image
(Robberto etal 2006)
Spectrum of Free-free Radiation from HII Region