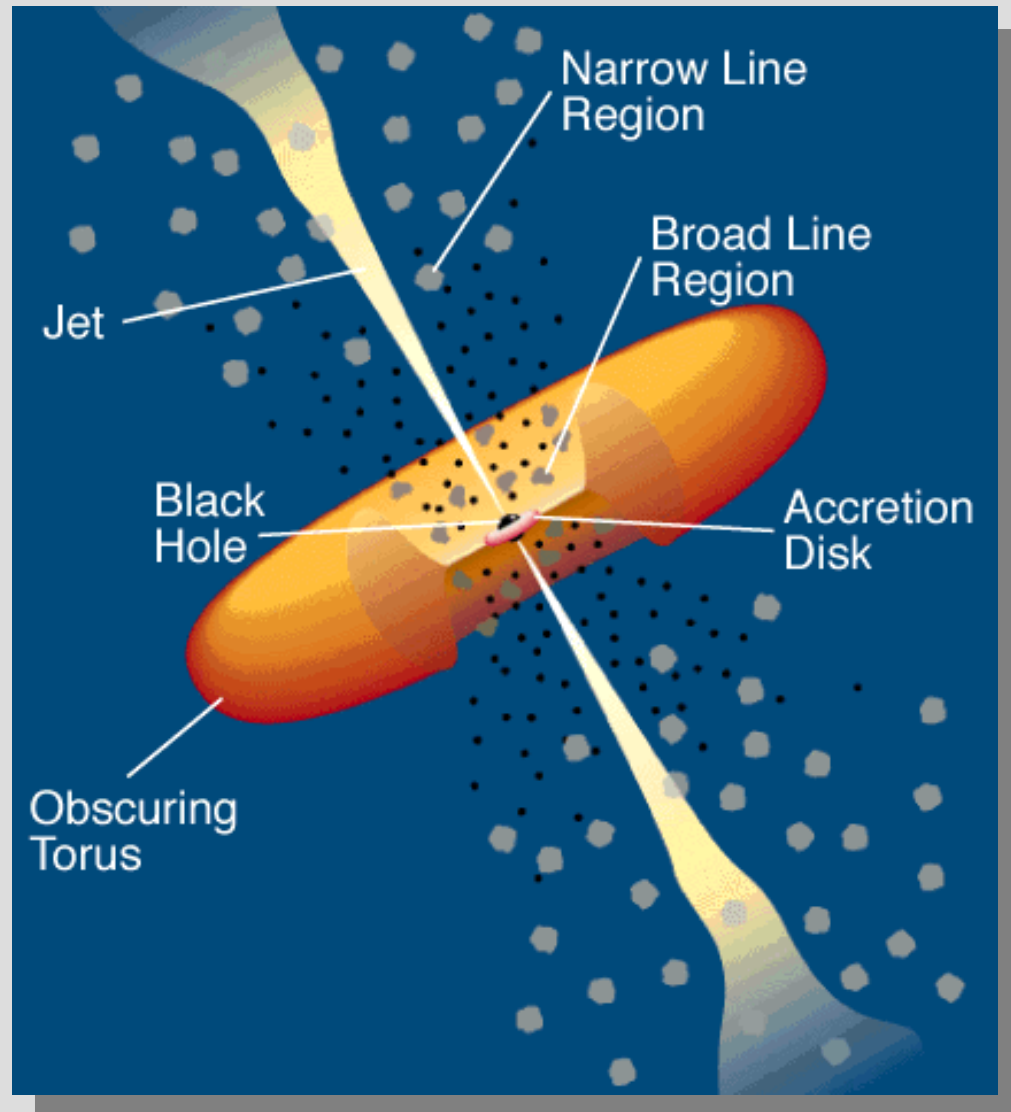


# Introduction Active Galactic Nuclei

## Overview & What you need to know



# What do you need to know for the exam

## Peterson + BB Notes

- Chapter 1
- Chapter 2.1-6, 8
- Chapter 3 - 4
- Chapter 5 - 6 (w/o equations, but study them)
- Chapter 7 - 8
- **SKIP** Chapter 9 (cosmology)
- Chapter 10 - 11 (study, but slides more important)
- Chapter 12

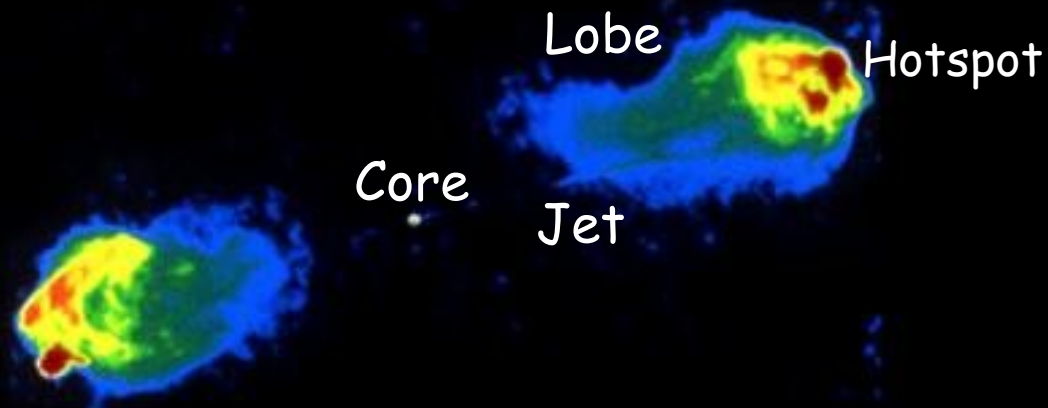
Look at the chapters in **Krolik** as extra background material (chapters indicated on slides)

# Lecture -1-

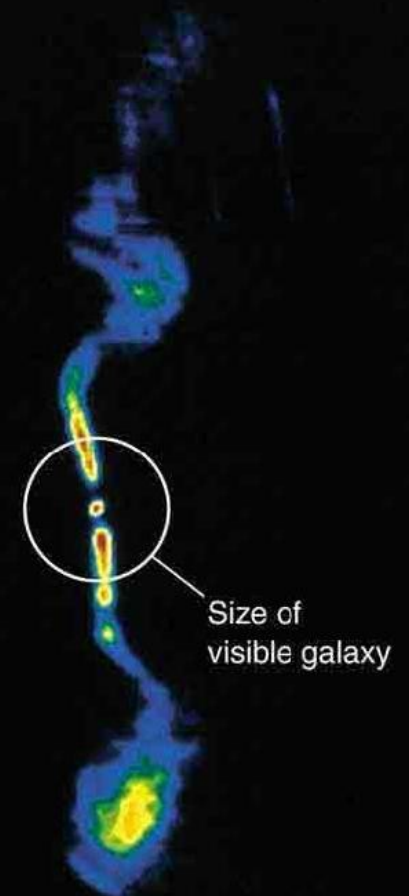
- Some general history of AGN discovery/study
- Signs of AGN activity
- Classification/taxonomy of AGN
- General properties of their SED/Spectral Lines
- Radio Galaxies (vs radio-quiet AGN)
- Variability

# General AGN Structure

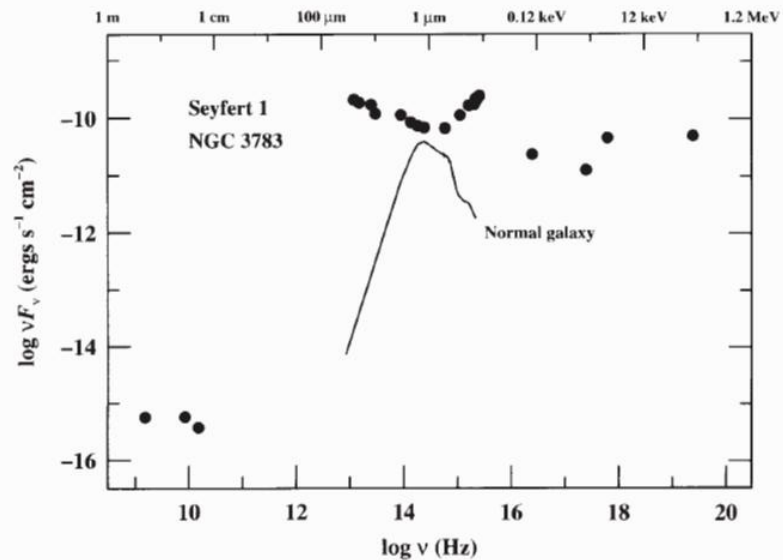
Radio image  
of Cygnus A



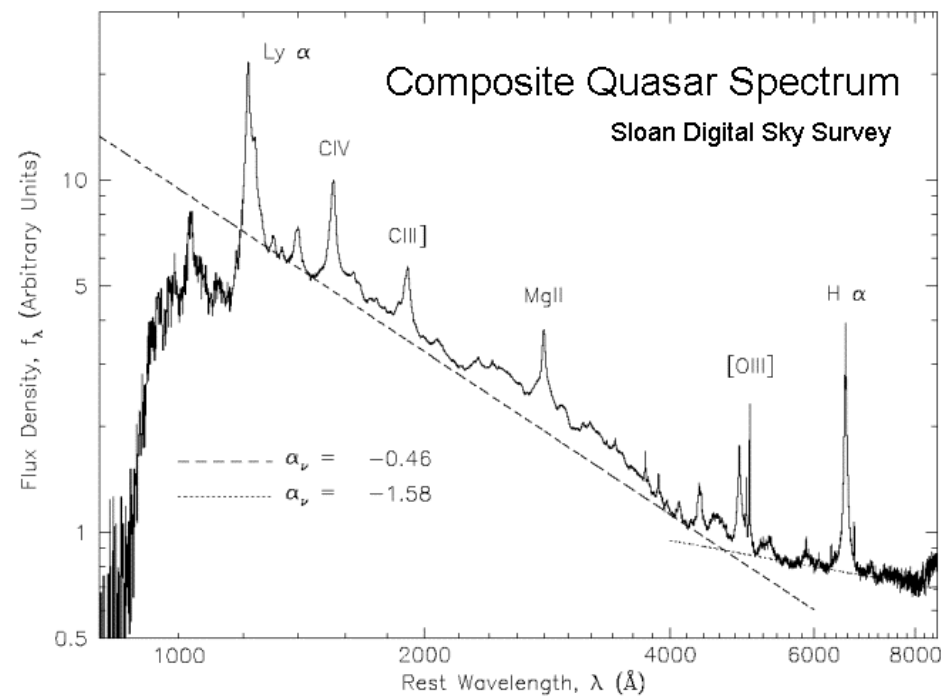
3C 449



# General Spectral Features



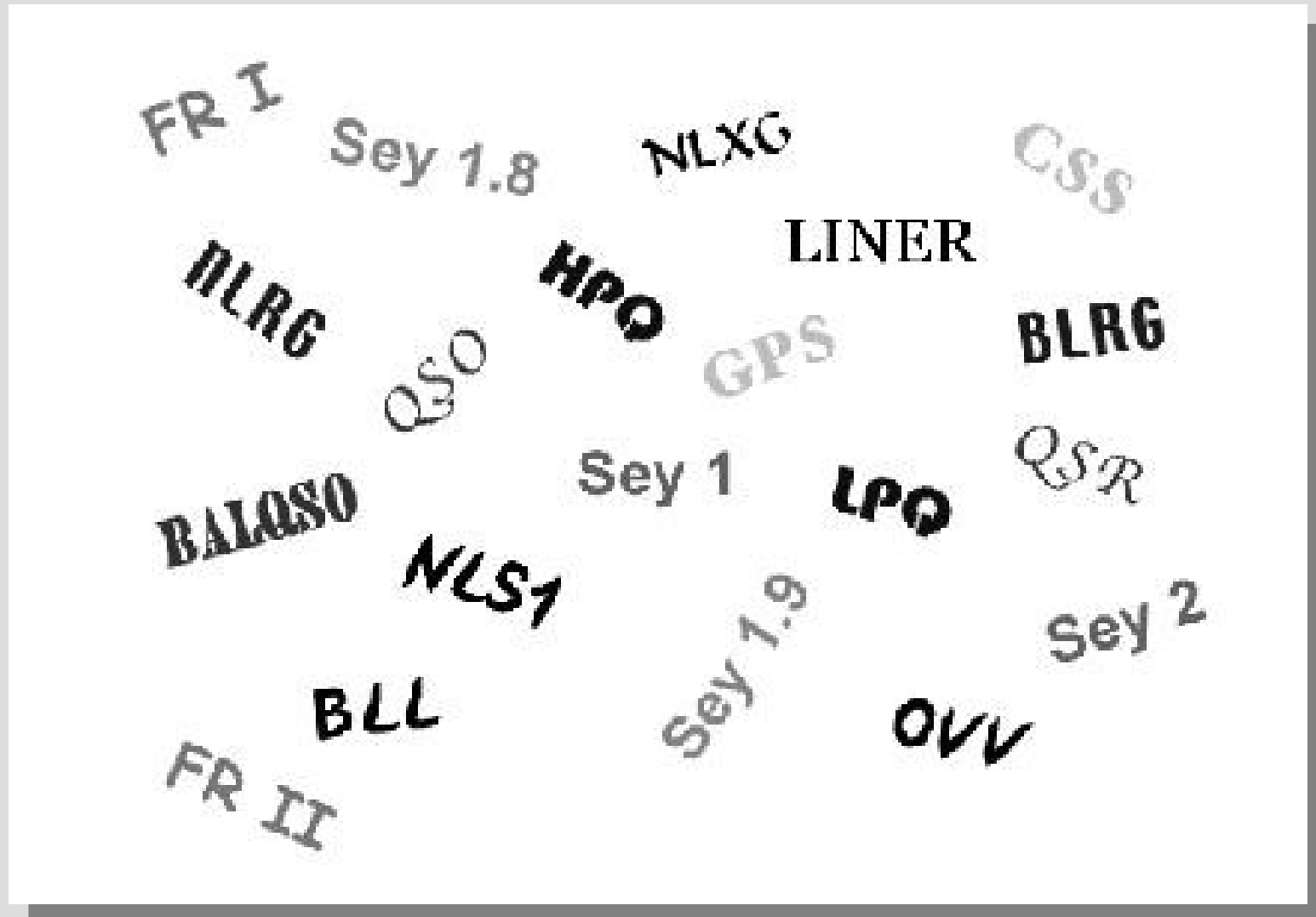
**Fig. 1.3.** The spectral energy distribution (SED) of the Seyfert 1 galaxy NGC 3783 (Alloin *et al.* 1995), from radio to  $\gamma$ -ray energies. Shown for comparison is SED for a normal (type Sbc) galaxy, from a template spectrum compiled by Elvis *et al.* (1994). The flux scale of the normal galaxy spectrum has been adjusted to give the correct relative contribution of AGN component and starlight for NGC 3783 (in mid-1992) at 5125  $\text{\AA}$  through a  $5'' \times 10''$  spectrograph aperture.



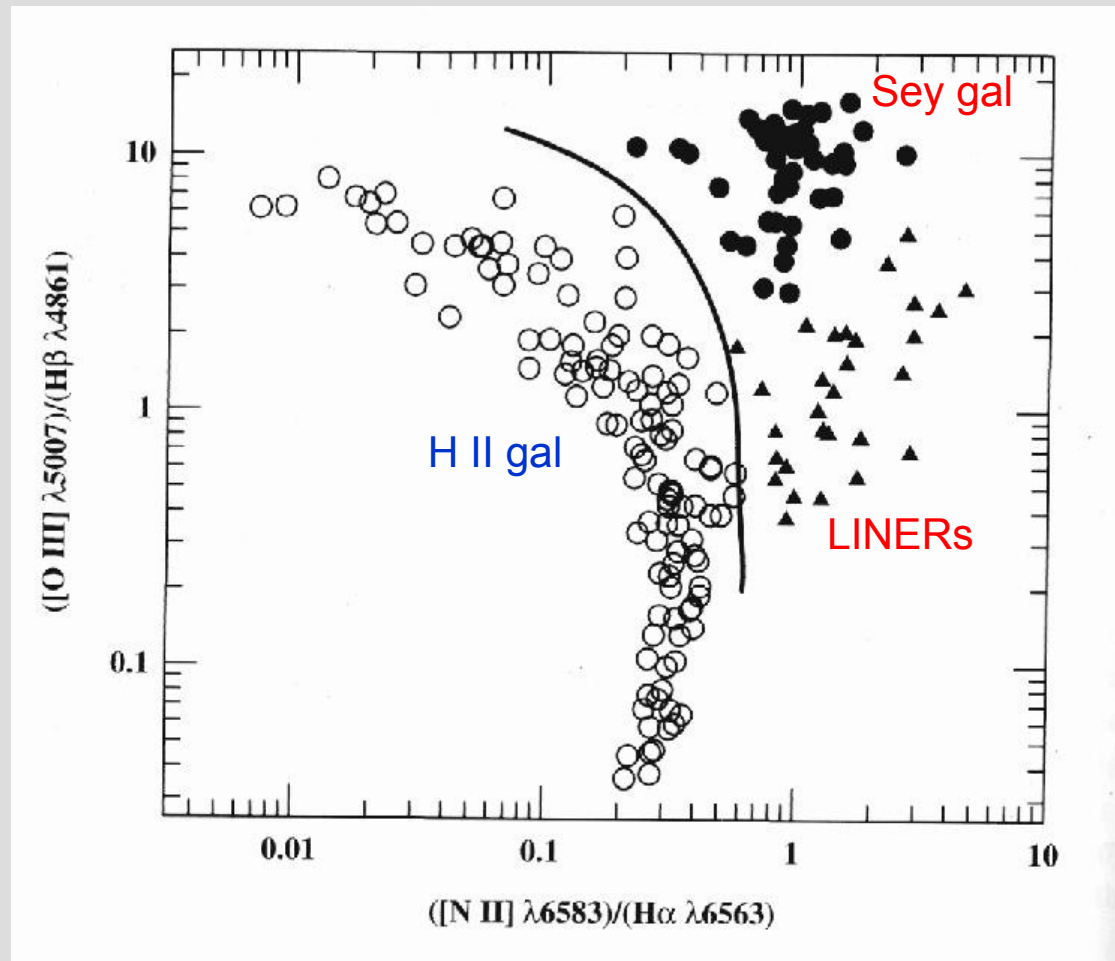
# Lecture -2-

- BPT diagram (active vs non-active galaxies based spectral line ratios)
- Unification models and evidence for/against
- e.g. Type I versus type-II quasars

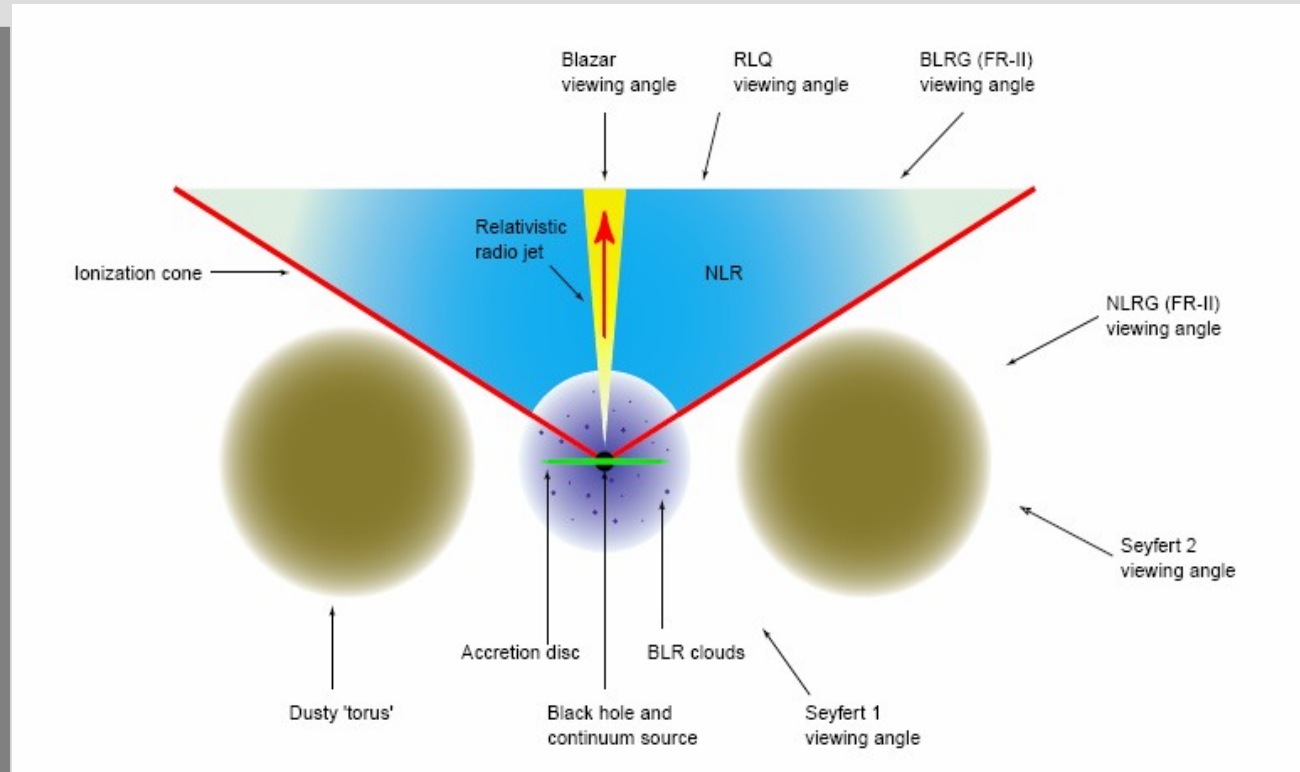
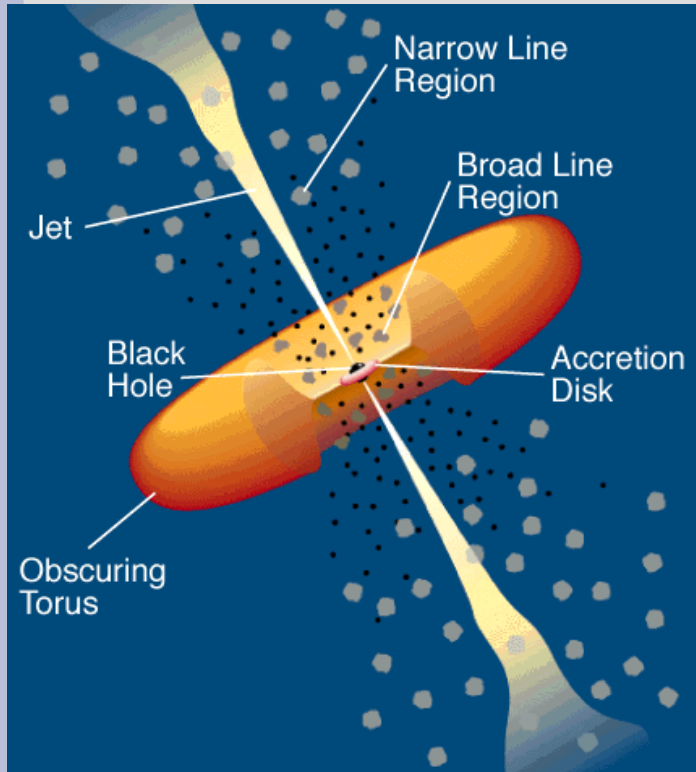
# AGN Taxonomy



# Spectral Selection of AGN



# Unification & Evidence for it

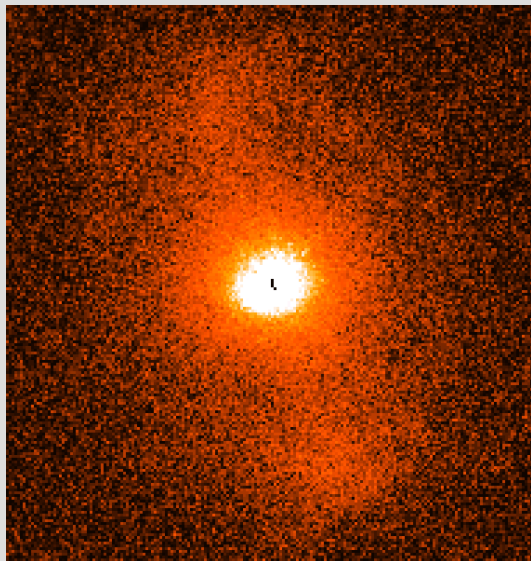


# Lecture -3-

- Host galaxy properties (Seyfert vs QSOs/QSR)
- Environment of quasars
- Effects of interaction on fueling
- Observational techniques in AGN studies
- Importance of the BH on AGN activity
- M-sigma relation (BH mass versus stellar vel. Disp.)
- Reverberation mapping

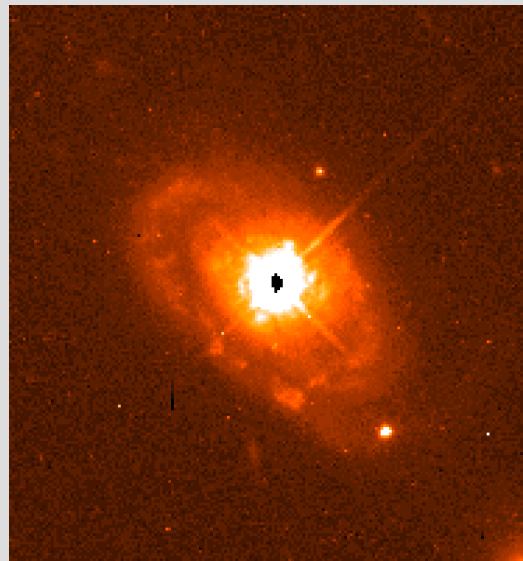
# AGN Host Galaxies

SB



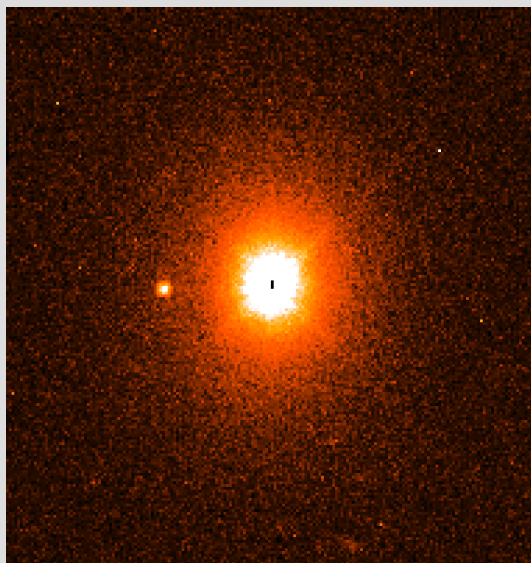
MS 0801.9+2129

S



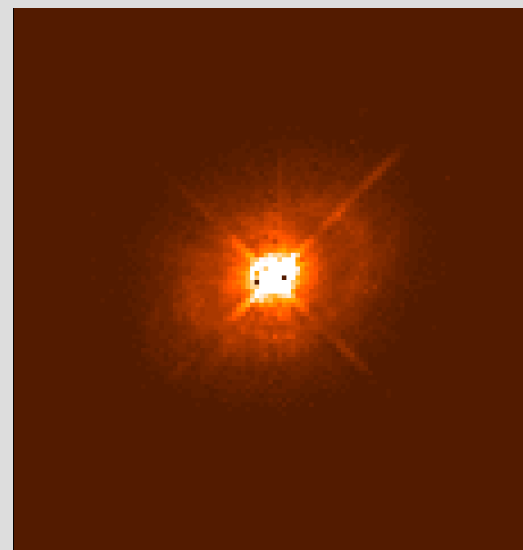
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E



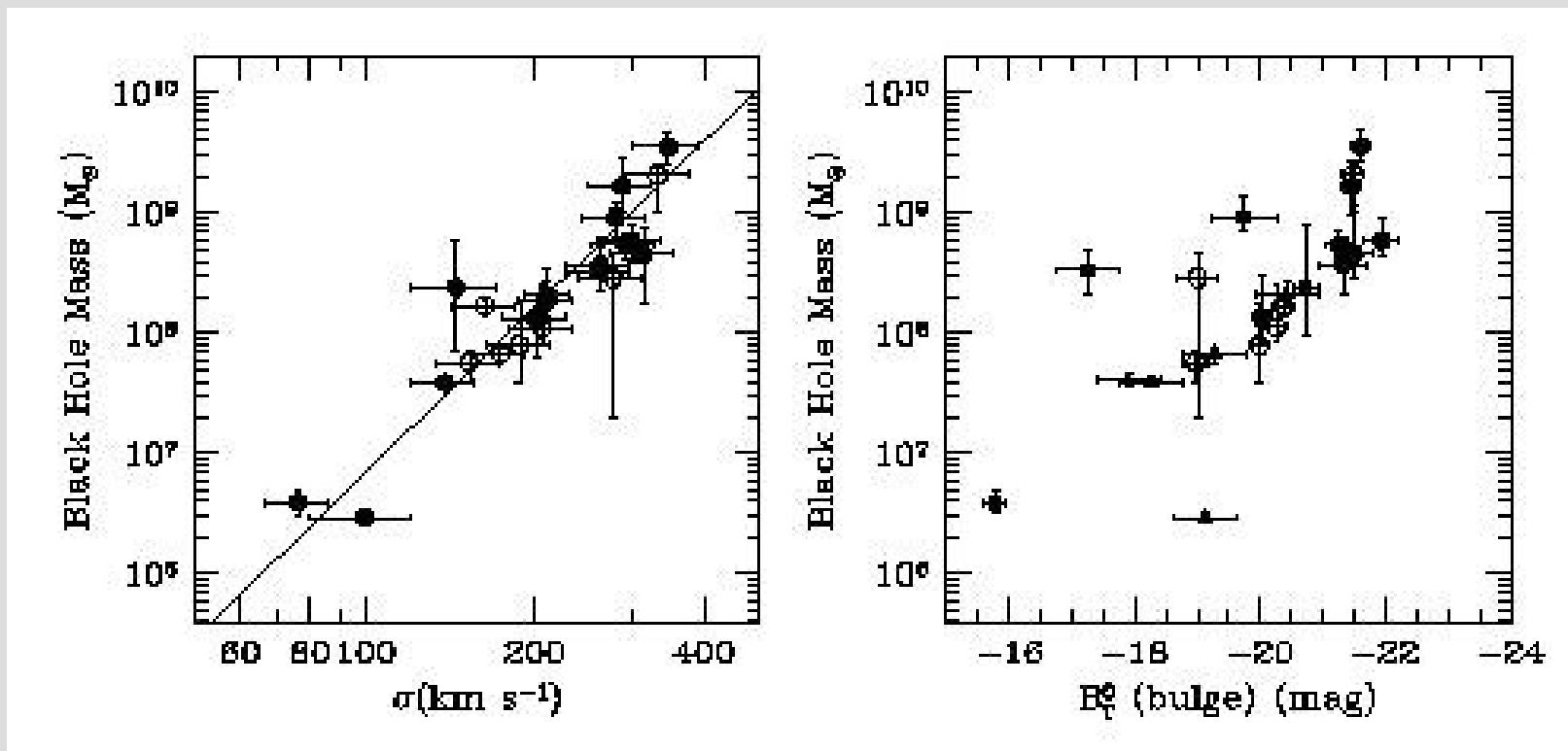
Q 2215-037

S?



PG 1309+355

# Relation between BHs and Host Galaxies: Mass & Fuelling



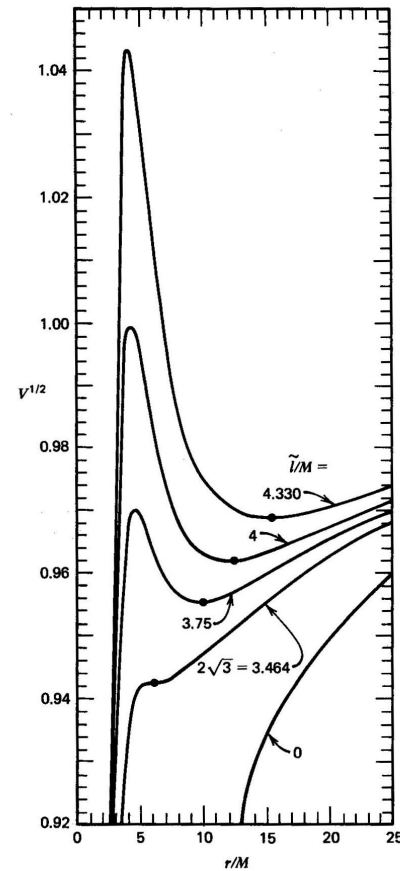
# Lecture -4-

- AGN Global Energetics  
(BB Notes)

# Lecture -5-

- Evidence for BHs in AGN (theory/observations)
- Eddington luminosity
- Accretion efficiency ([non]rotating BHs)

# BH Physics & Accretion Efficiency



**Figure 12.3** The effective potential profile for *nonzero* rest-mass particles of various angular momenta  $\tilde{l}$  orbiting a Schwarzschild black hole of mass  $M$ . The dots at local minima locate radii of stable circular orbits. Such orbits exist only for  $\tilde{l} > 2\sqrt{3}M$ . [From *Gravitation* by Charles W. Misner, Kip S. Thorne, and John Archibald Wheeler, W. H. Freeman and Company. Copyright © 1973.]

# Evidence for SMBHs in Galaxies

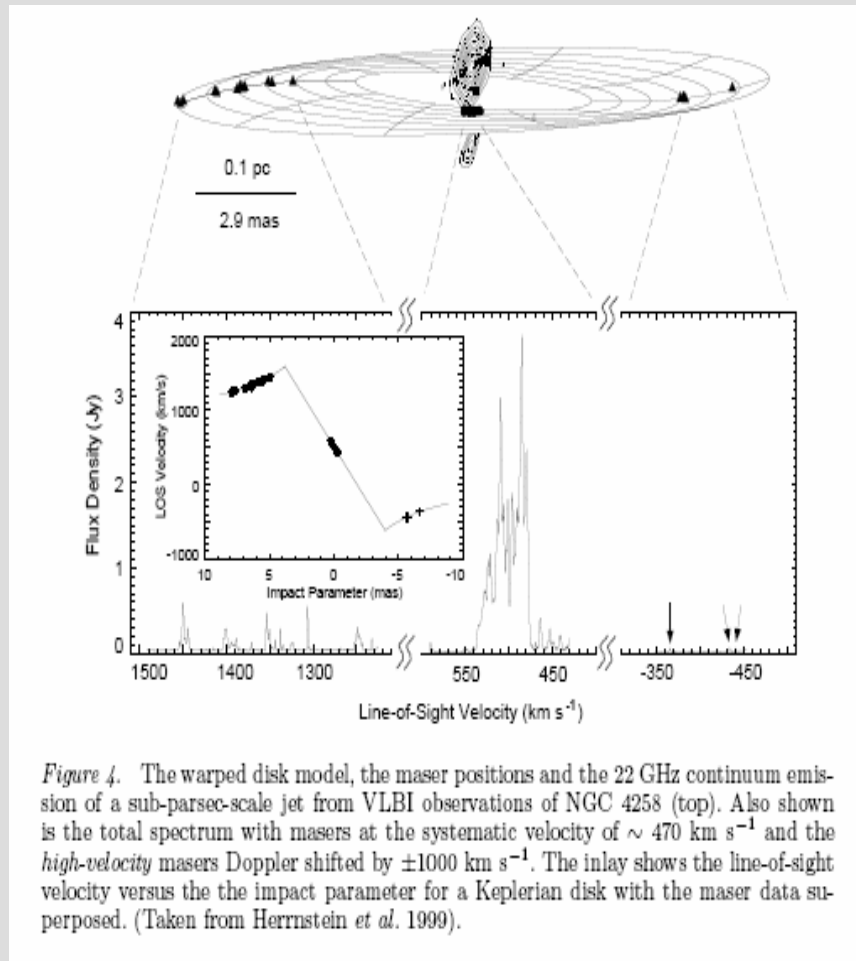
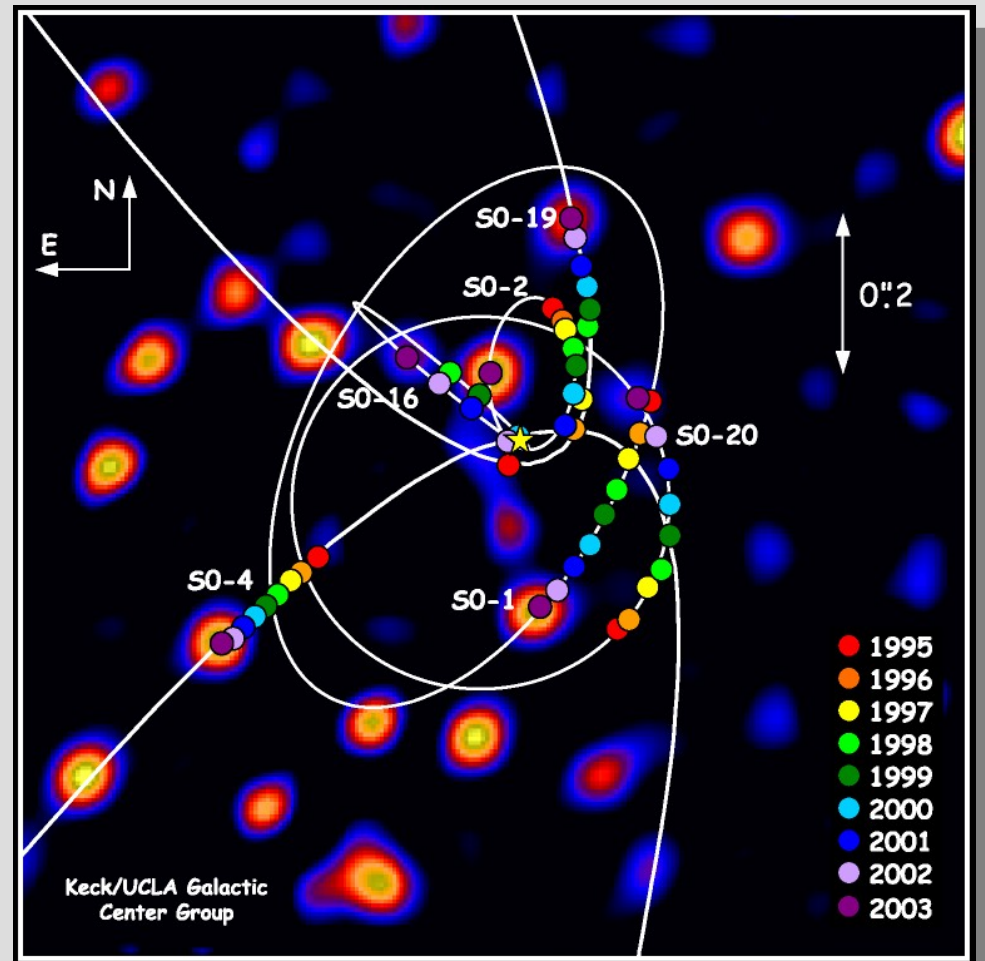


Figure 4. The warped disk model, the maser positions and the 22 GHz continuum emission of a sub-parsec-scale jet from VLBI observations of NGC 4258 (top). Also shown is the total spectrum with masers at the systematic velocity of  $\sim 470 \text{ km s}^{-1}$  and the *high-velocity* masers Doppler shifted by  $\pm 1000 \text{ km s}^{-1}$ . The inlay shows the line-of-sight velocity versus the the impact parameter for a Keplerian disk with the maser data superposed. (Taken from Herrnstein *et al.* 1999).

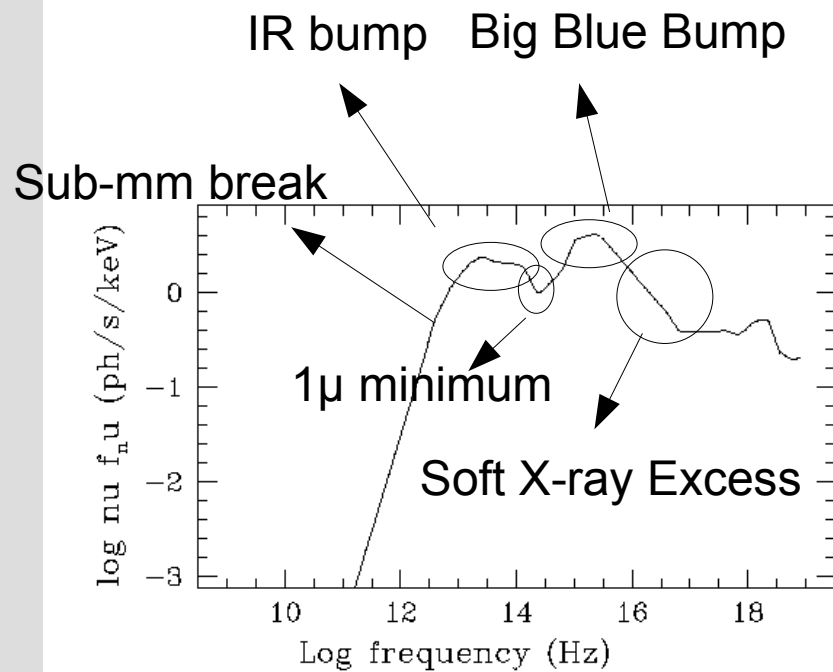


# Lecture -6-

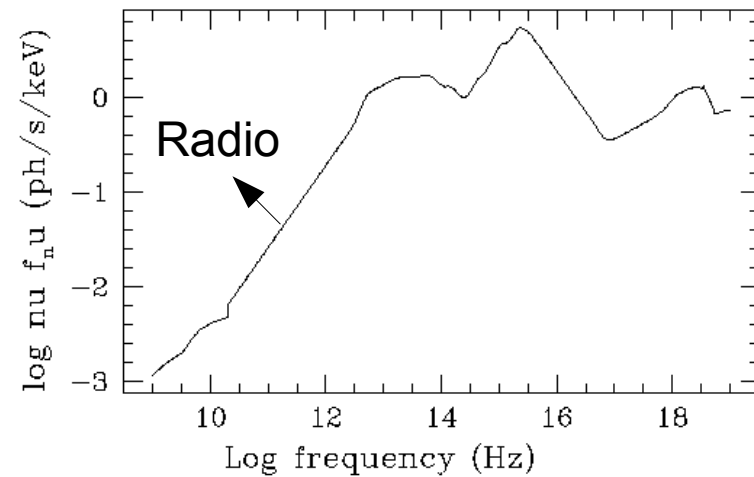
- Explain AGN SED in detail (bumps, etc)
- What causes the bumps (IR, UV, ...)
- Explain X-ray emission of AGN (jet/Accretion disk)

# General Features of SED and their Origin

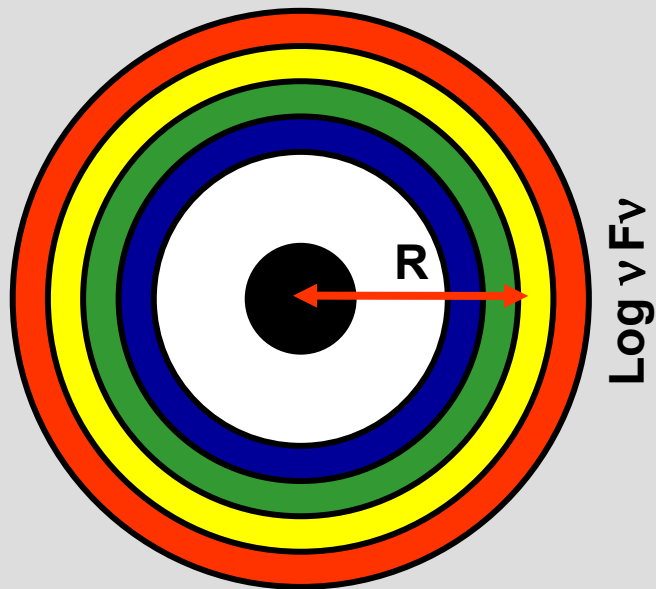
## Radio Quiet Quasars



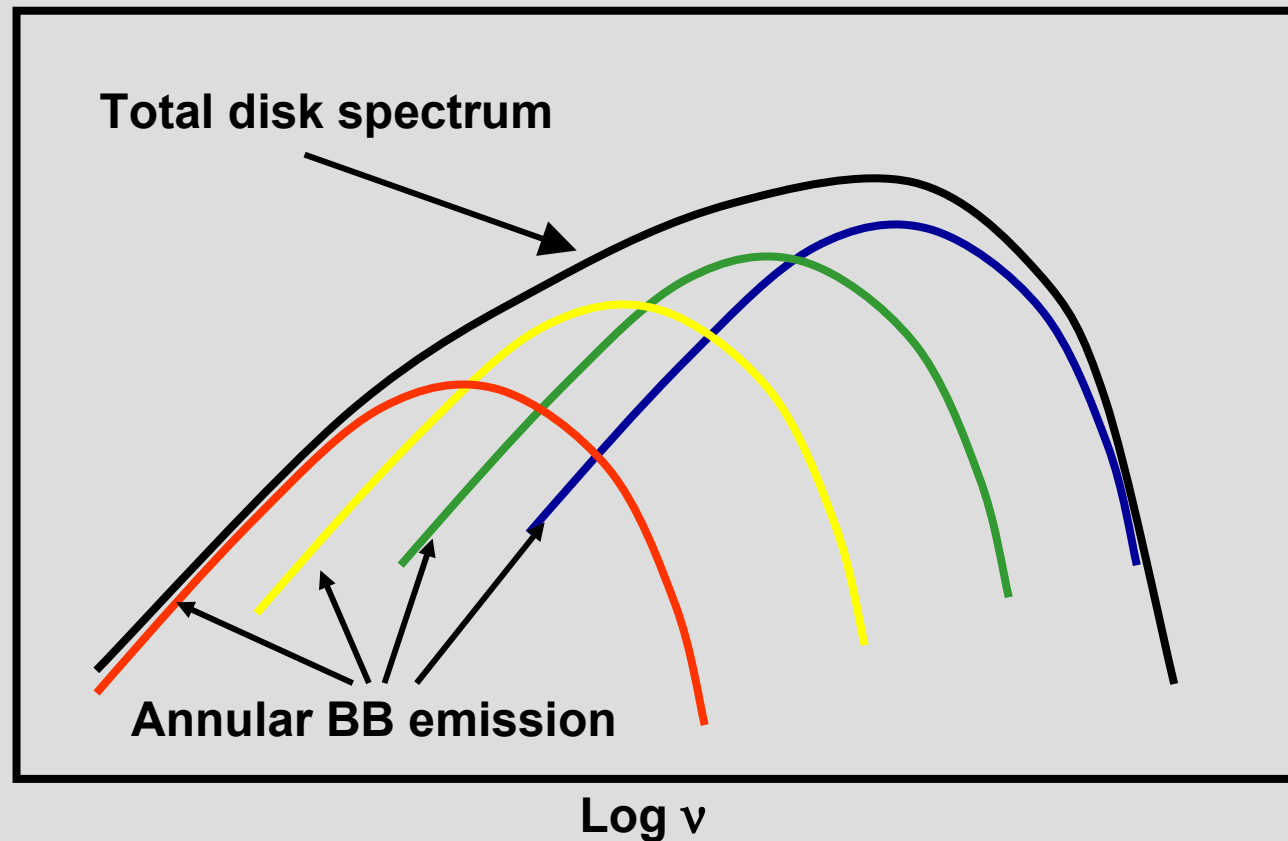
## Radio-Loud Quasars



# Accretion Disk Physics and Emerging Spectra



Log  $\nu F_\nu$



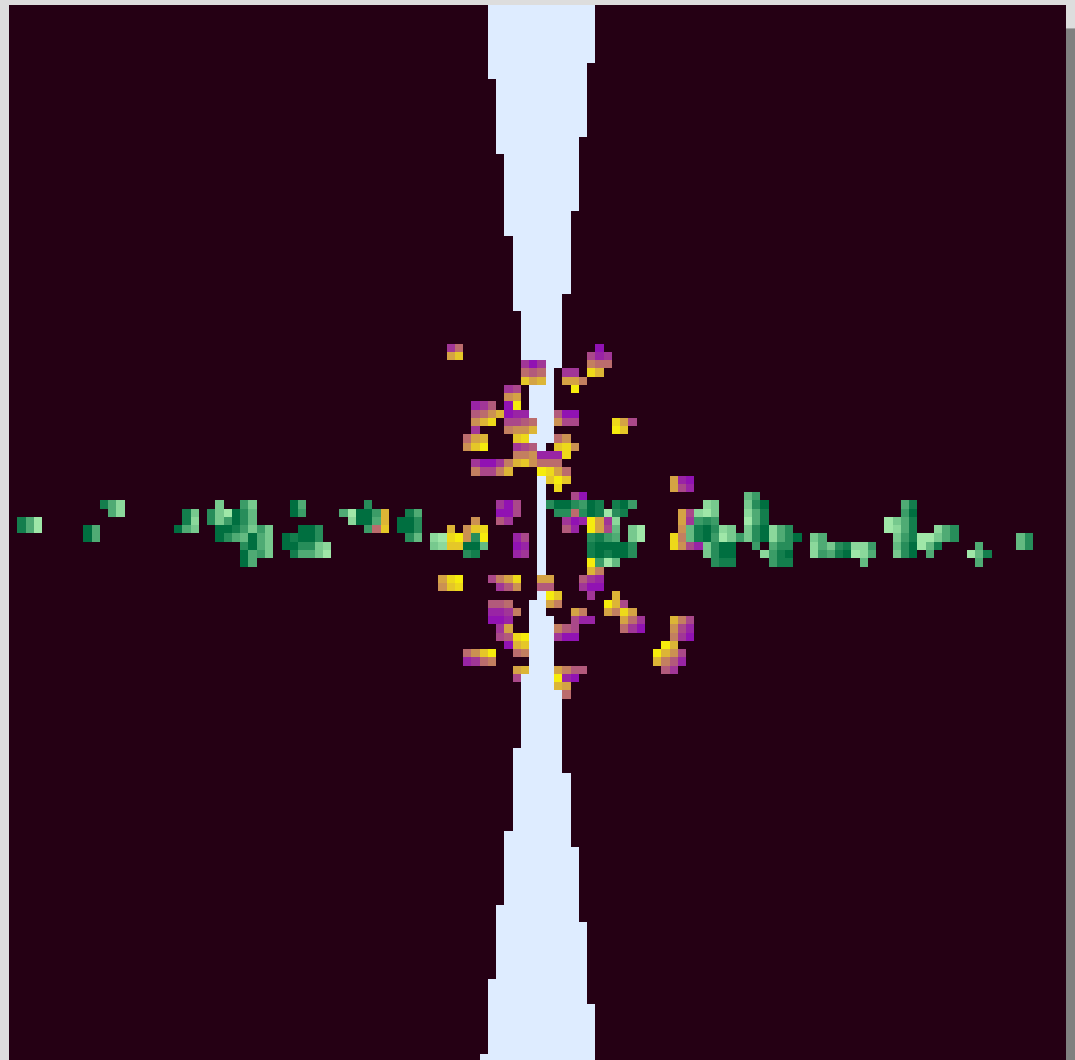
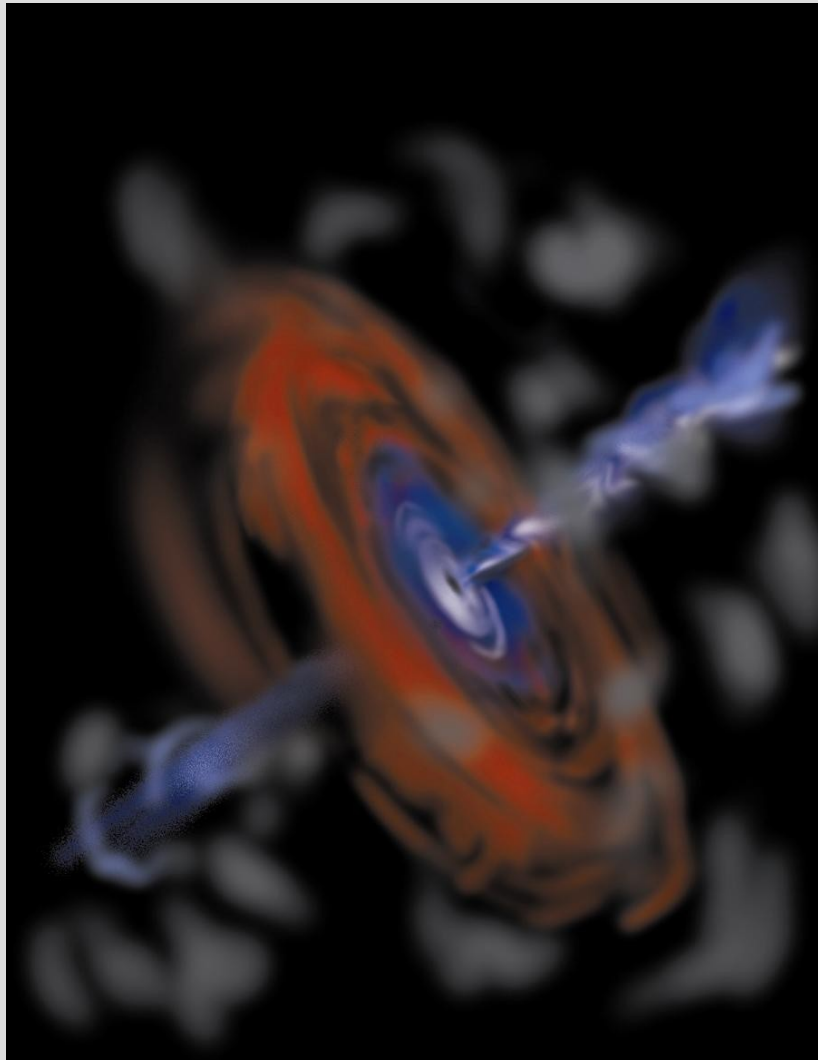
# Lecture -7-

- Accretion disk physics  
(BB Notes)

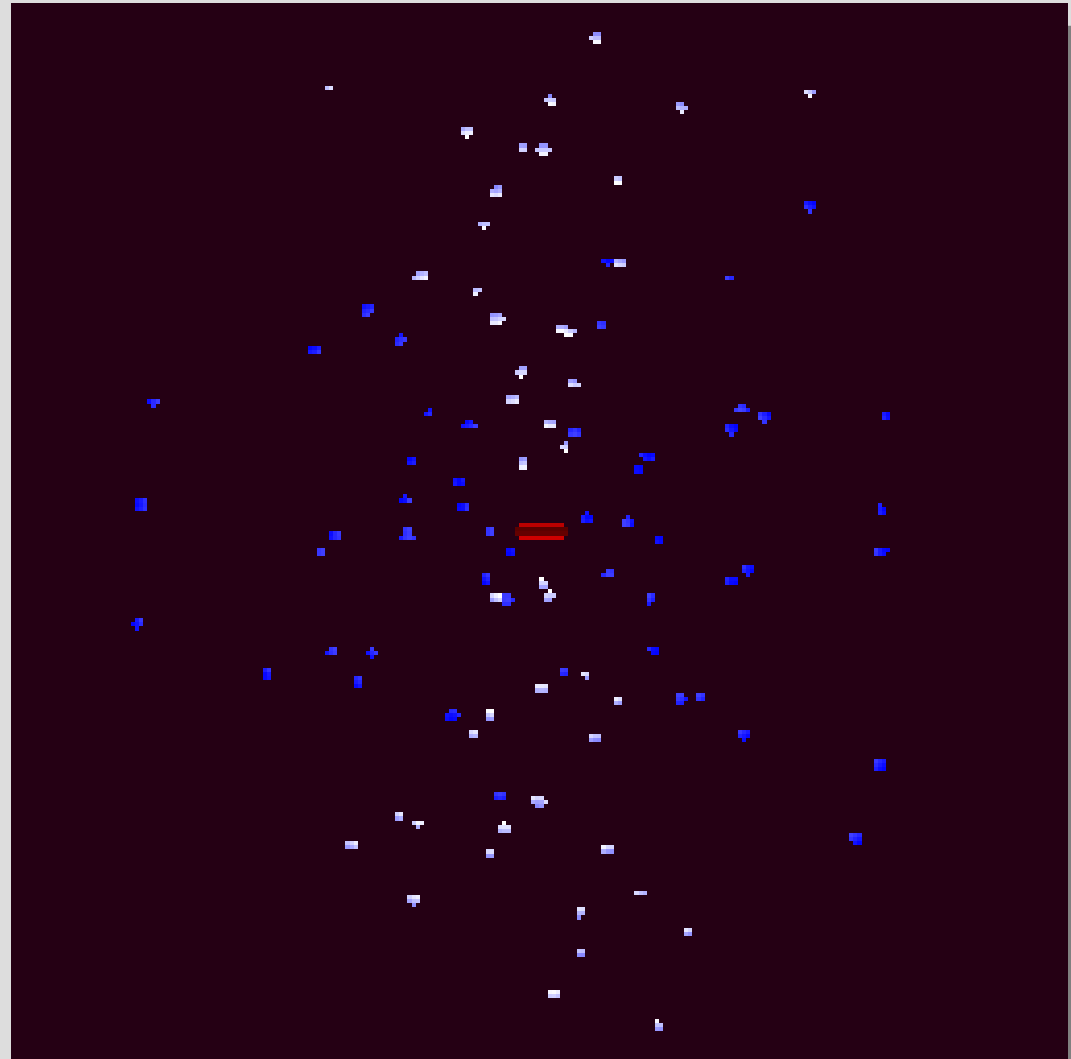
# Lecture -8-

- Where do the B/NLR originate and what are their general features (e.g. size, density, etc)
- Difference in spectra between different AGN types
- BLR clouds versus wind model
- Variability/reverberation

# BLR: General Features (disk/wind?)



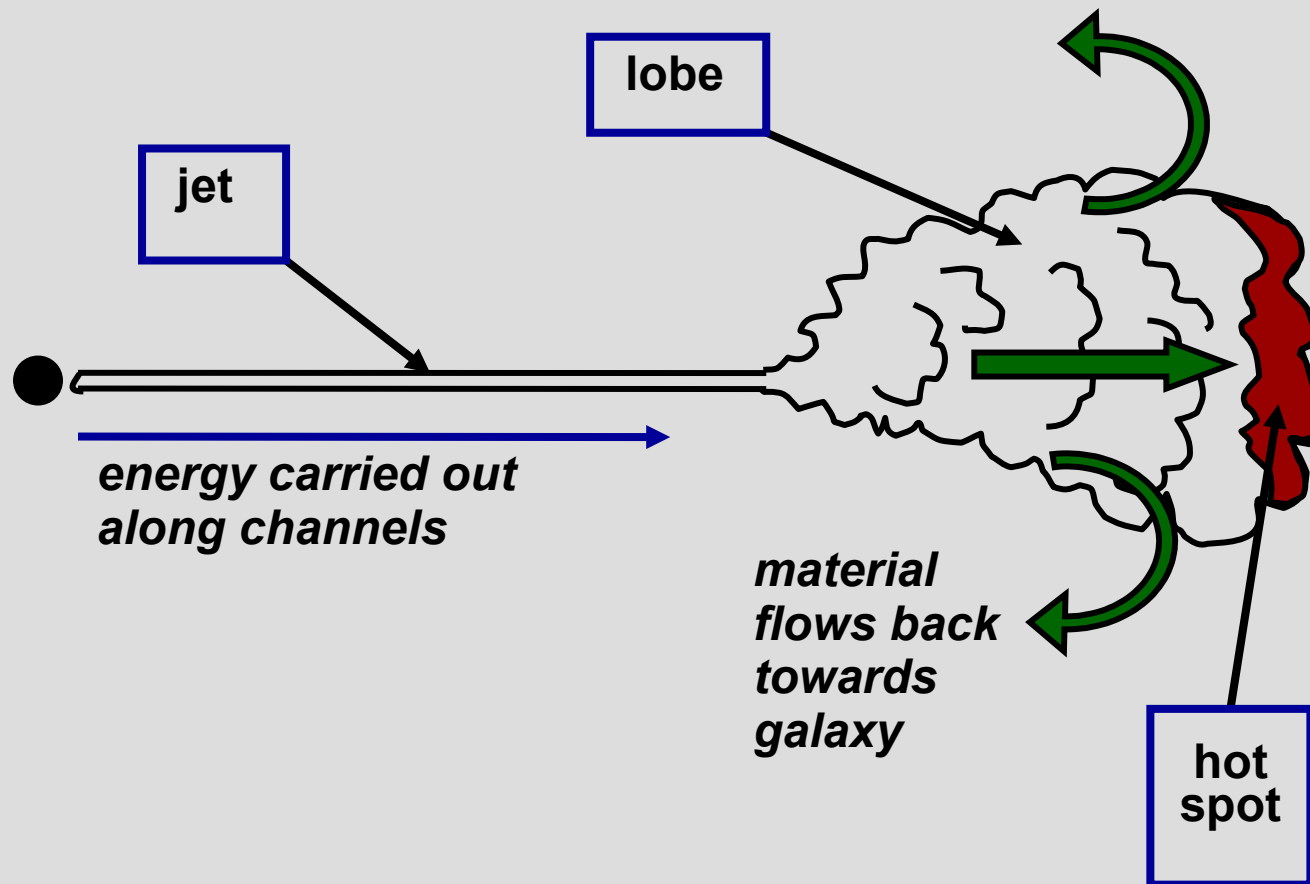
# NLR: General Features



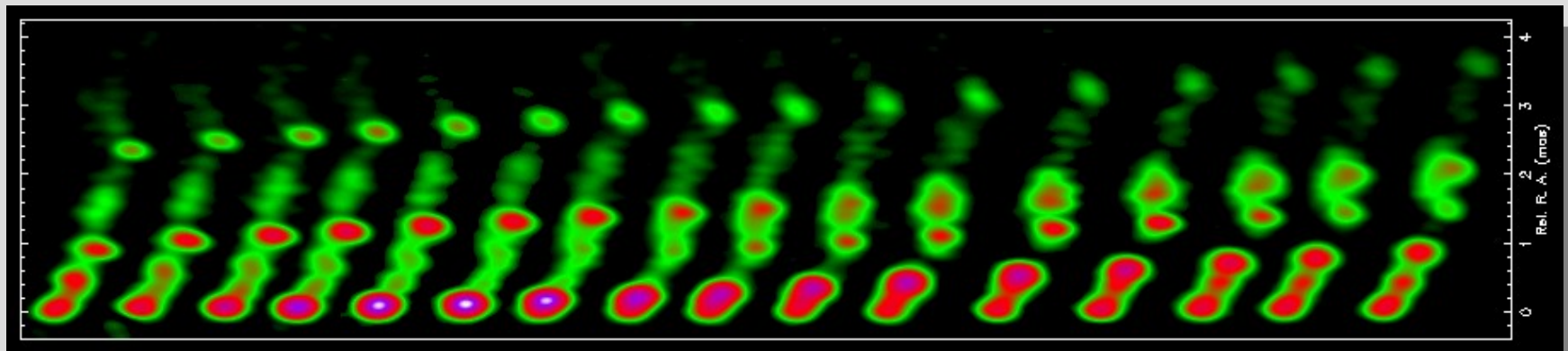
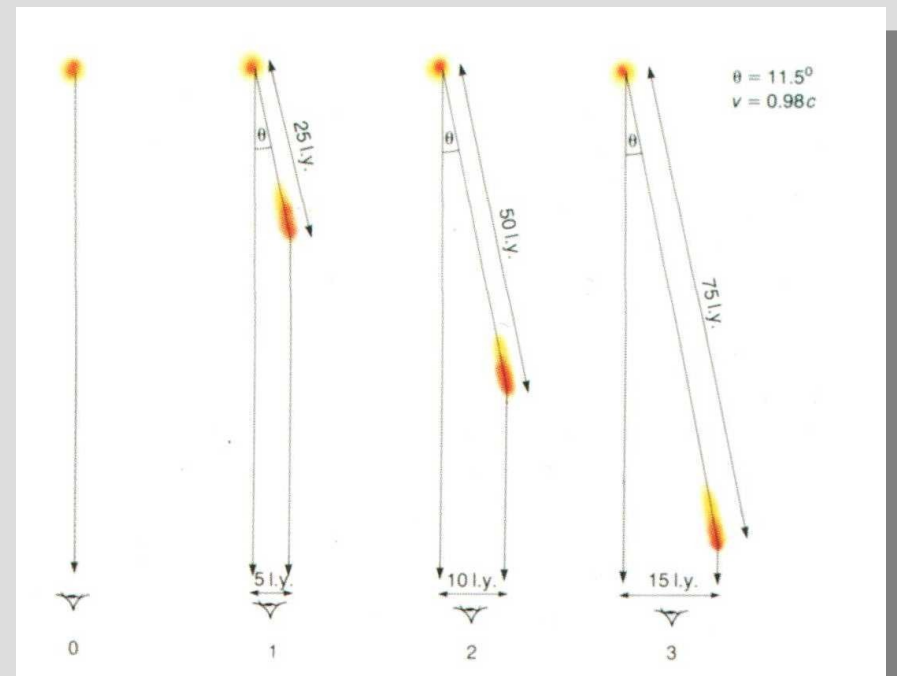
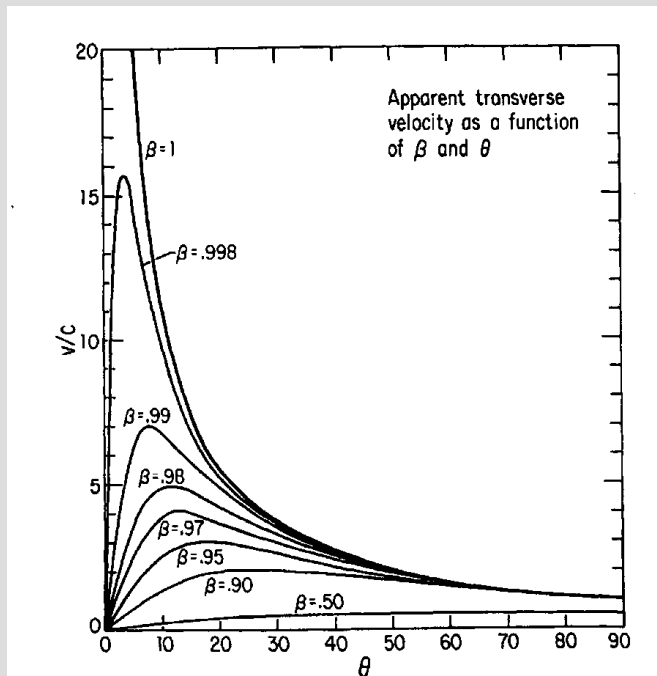
# Lecture -9-

- Radio galaxy types & differences
- Jets and Super-Luminal motion
- Radio surveys
- Evolution of radio spectra
- Synch. Self absorption
- Polarisation
- Faraday Rotation
- Jet (sub/supersonic) in FR-I/IIs

# Radio-Galaxy Properties & Physics



# Superluminal Motion



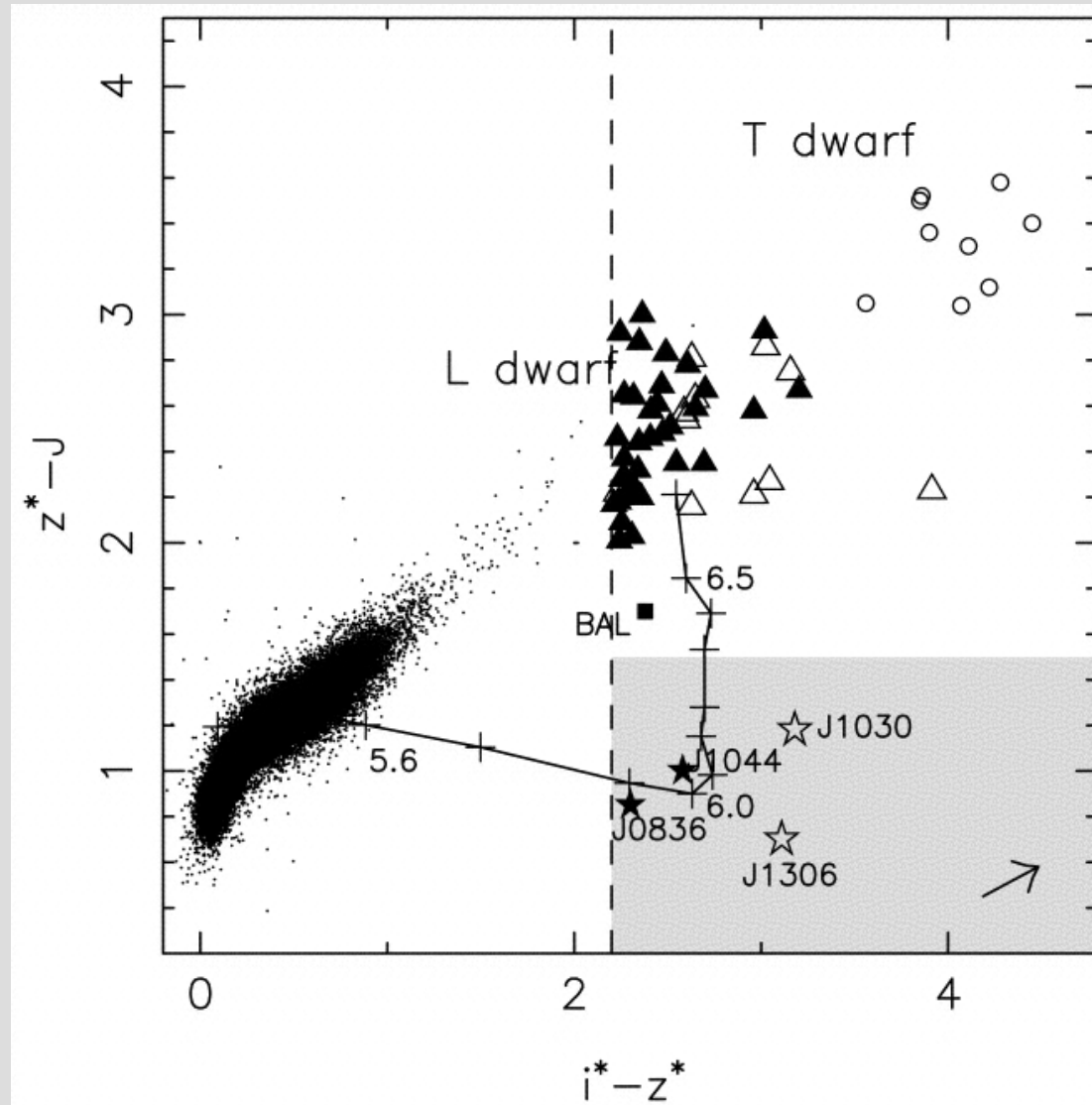
# Lecture -10-

- Superluminal Motion and Jet Physics (BB Notes)

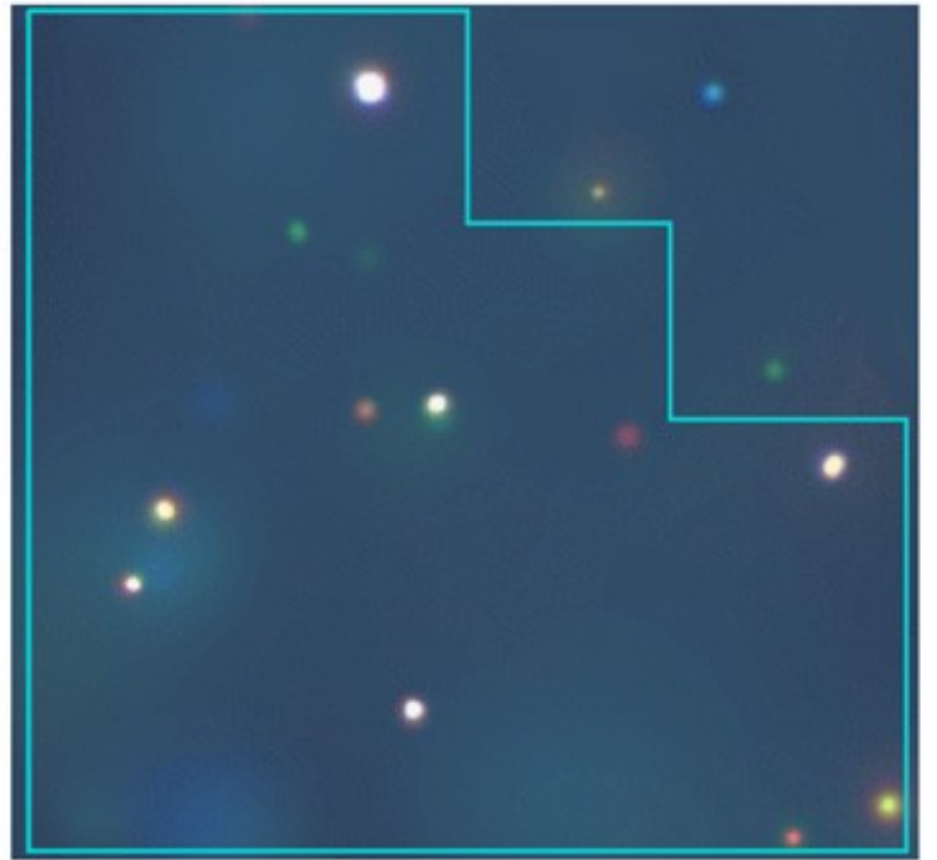
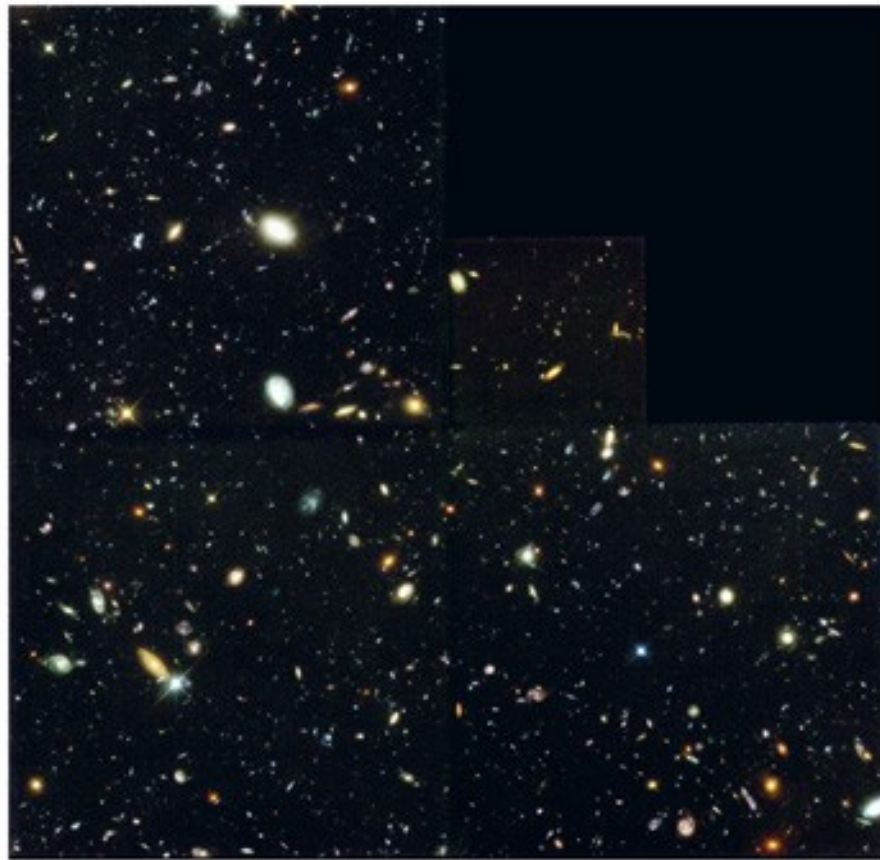
# Lecture -11-

- Quasar Surveys
- How to find quasars (spectra/colors)
- Biases in quasar surveys
- QSO density/LF
- Importance of different types of surveys (eg X-ray)
- Relation  $\star$ -formation versus AGN activity
- Growth of SMBH

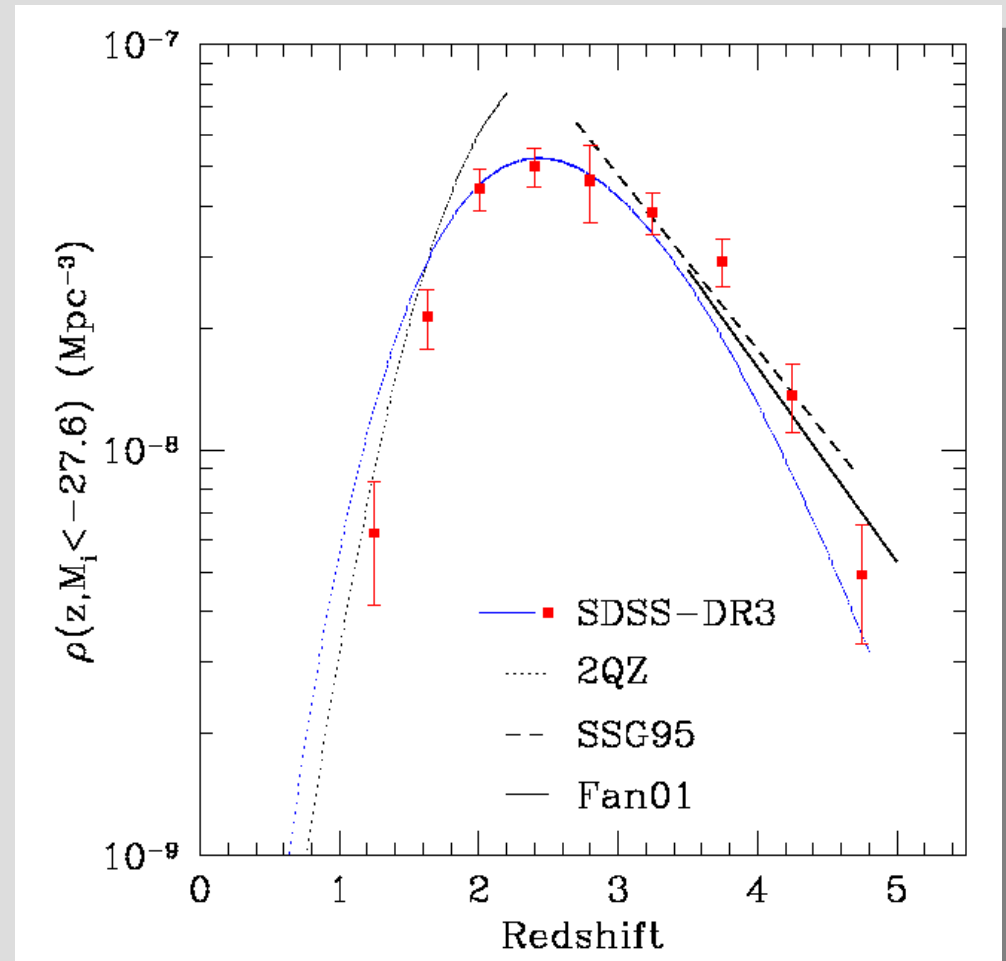
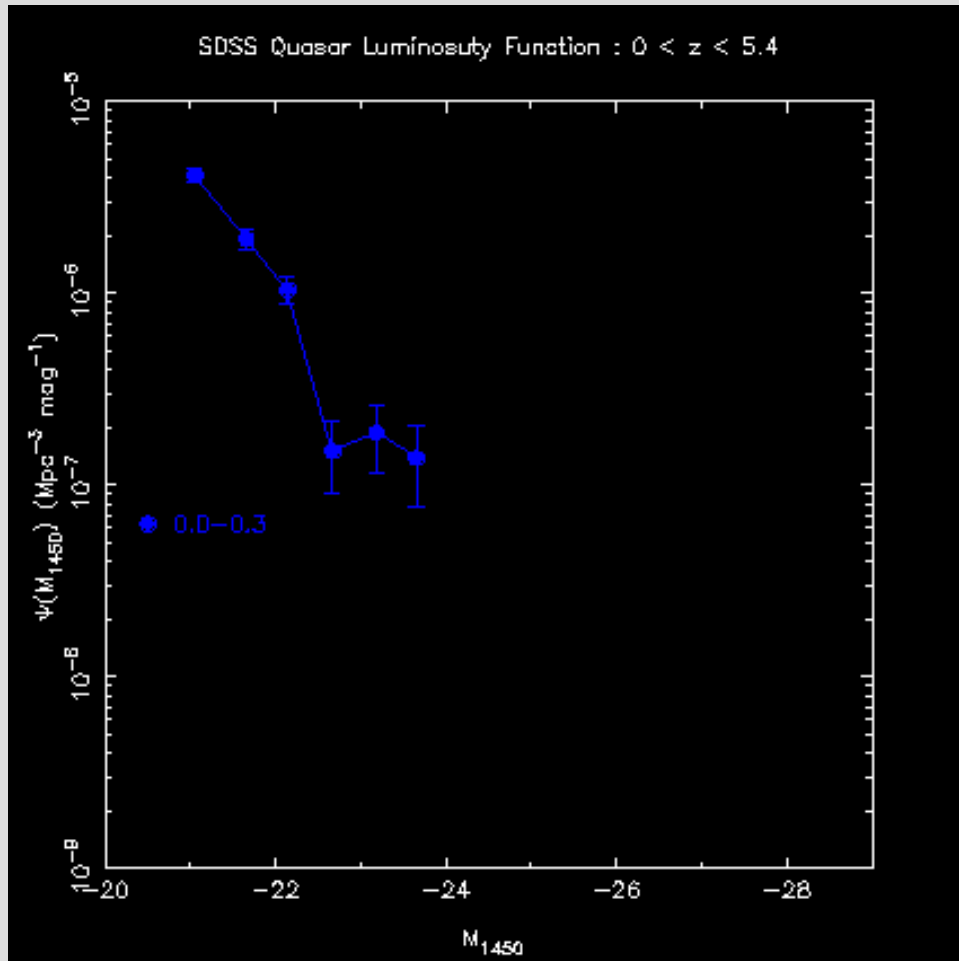
# Quasar Surveys & Survey Methods/Biases



# Surveys at different wavelengths



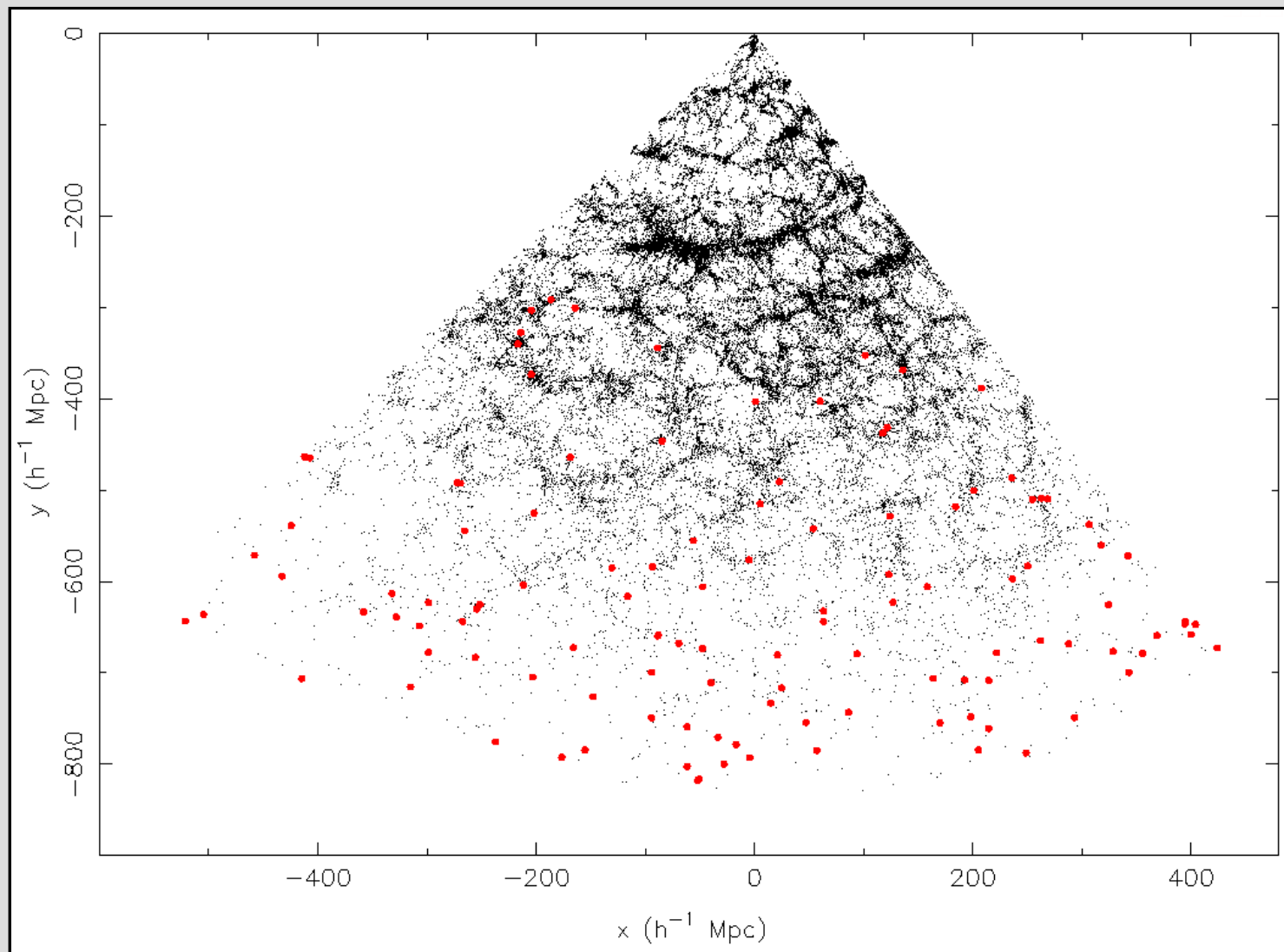
# Quasar LFs and Space Density



# Lecture -12-

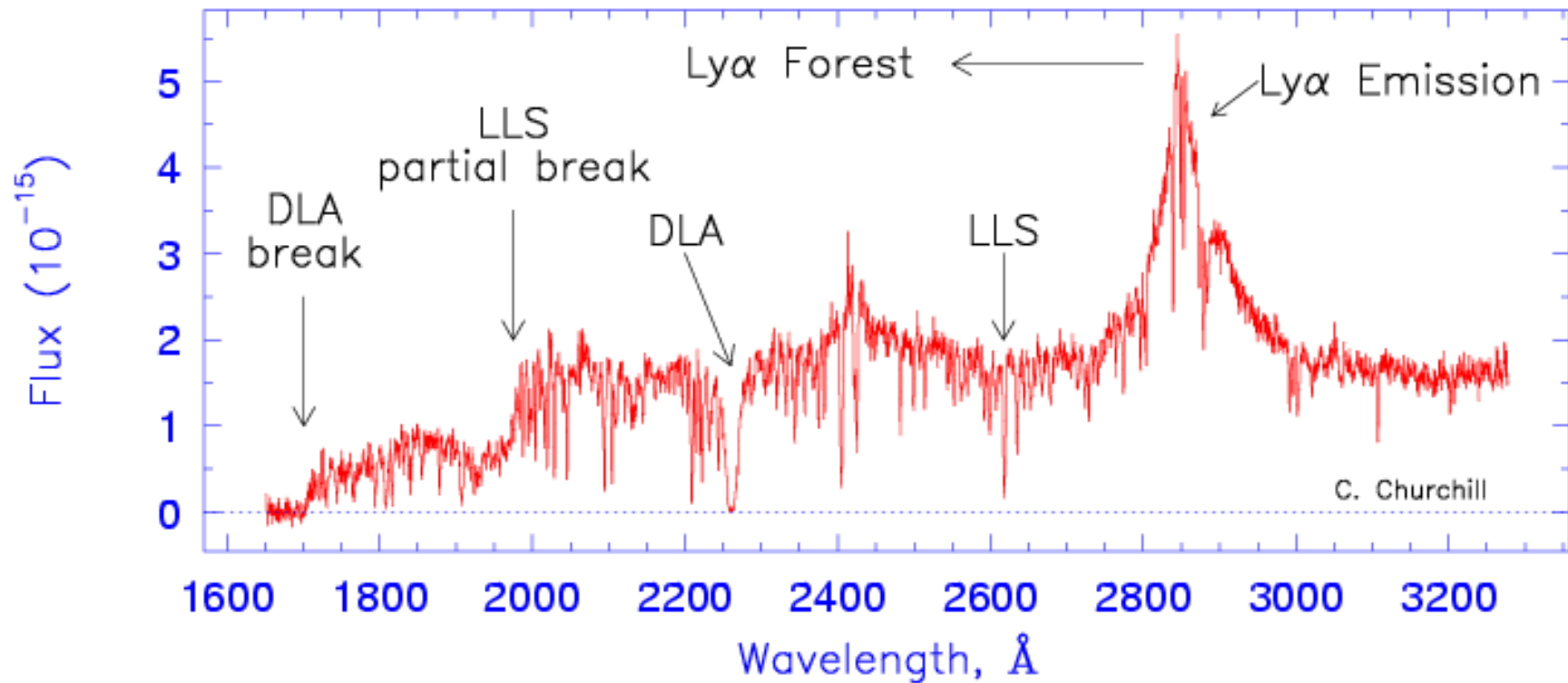
- What makes QSOs useful as cosmological probes in LSS/Cosm. Parameters
- QSO spectra as probes of the IGM
- Gunn-Peterson effect & EoR
- Ly-a forest/Metal-lines

# Quasar as Probes of LSS/Cosmology

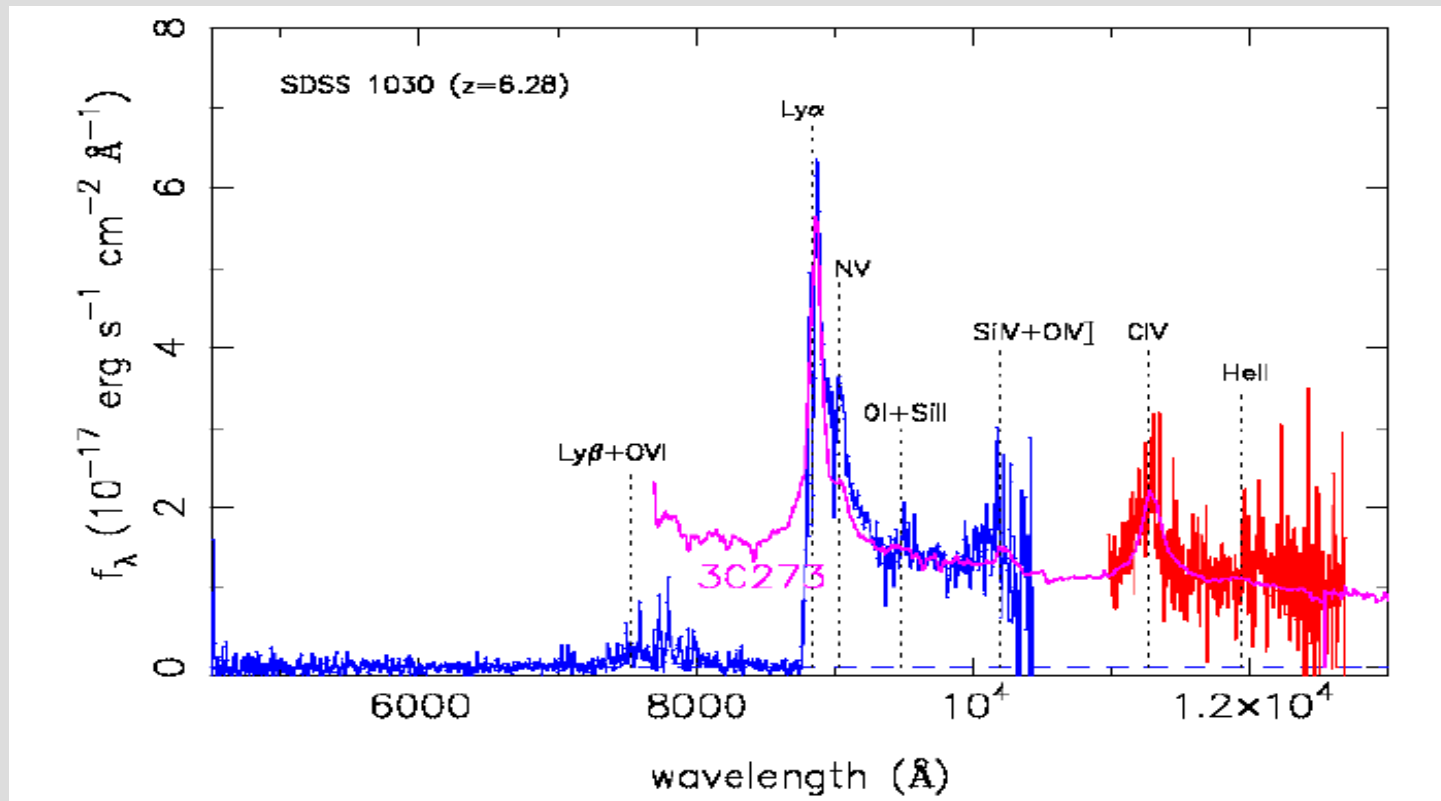


# Quasars as Probes of the IGM

PKS 0454+039  $z=1.34$



# The Gunn-Peterson Effect & Probing Reionization



# Type of exam questions

Emphasis will not be on calculations (although I might ask some derivations), but on understanding and having a broad overview over the subject of AGN and their properties and physics.

Some questions will be to derive of some simple equations and their application, and some will be general broad knowledge & understanding questions