Vera Genten

AGN
(Active Galactic Nuclei)

Topics

1) General properties
2) Model
3) Different AGN-types
   - I. Quasars
   - II. Seyfert-galaxies
   - III. Radio galaxies
   - IV. young radio-loud AGN (GPS, CSS and CFS)
   - V. Blazars
   - VI. LINER galaxies

1. General properties

- AGN is the short form of "active galactic nucleus"
- They have nearly a stellar shape on photographic plates.
- The visible emitting area is nearly as big as our solar system.

Broad band emission: i.e. from radiowaves, microwaves-infrared, visual ,ultraviolet- and x-ray to gamma radiation

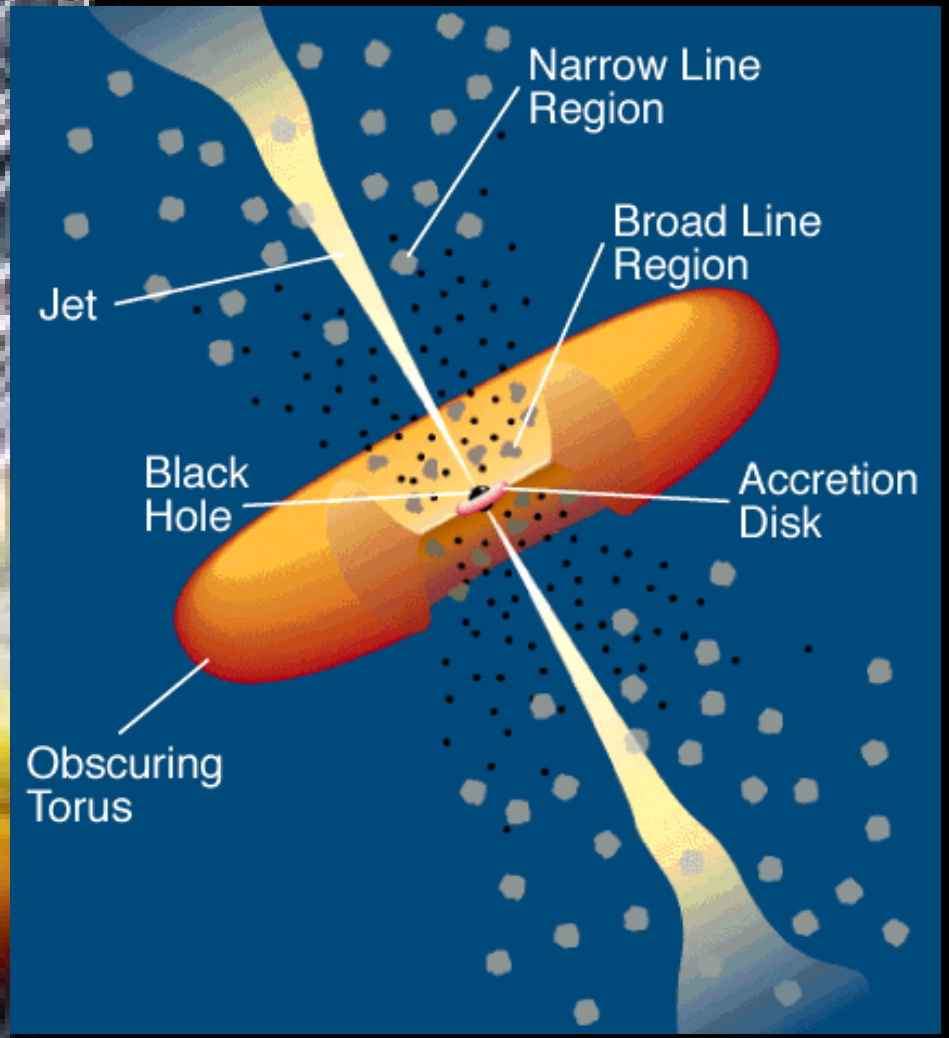
Assumption of the energy source for the extraordinary luminosity

- AGNs are the most luminous objects in the universe
- Assumption: a Black hole accretes gas and dust
  - Dissipative processes in the accretion disc transport matter inwards and angular momentum outwards, while causing the accretion disc to heat up
    - The resulting energy reaches nearly mc^2

Common galaxies gleam due to their stars in opposite to active galaxies- they gleam due to their AGNs

2. Model

- A super massive, rotating – or not 'rotating – 'black hole' with a mass up to $10^{8\text{-}10}$ solar masses
- An accretion disk, surrounding the black hole
- Two Jets emerging from the center
- Broad-Line- and Narrow-Line regions
- Obscuring torus surrounds the accretion disk



2.1 Regions

Broad-Line region (BLR)

- Above the accretion disk
- heavy ionized clouds
  - Become noticable with very broad lines

Movement 1.000-10.000 km/s

Narrow-Line region (NLR)

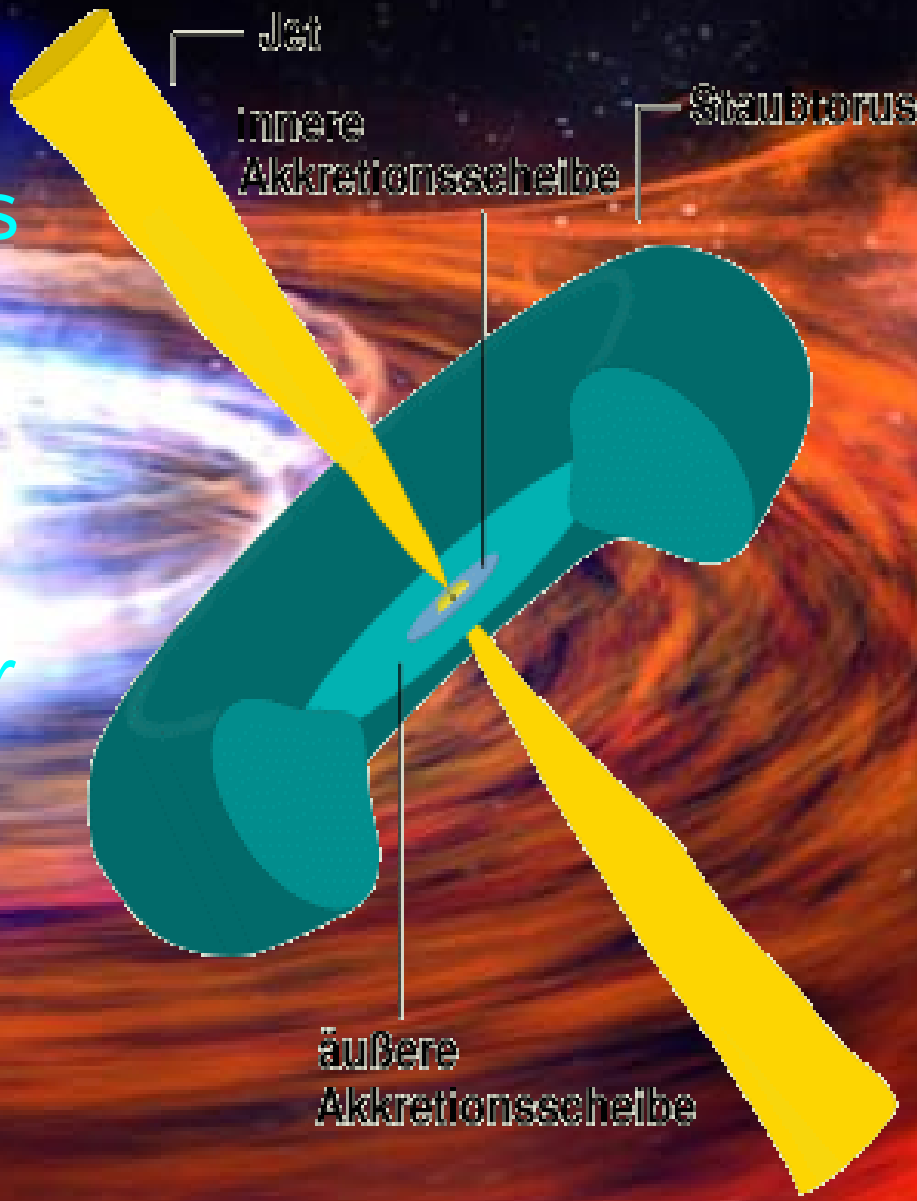
- Beyond the BLR
- heavy ionized clouds

-Emissionlines in the spectrum less intensely dispread

Slower movement (ca. 100 km/s)

2.2 Accretion disk

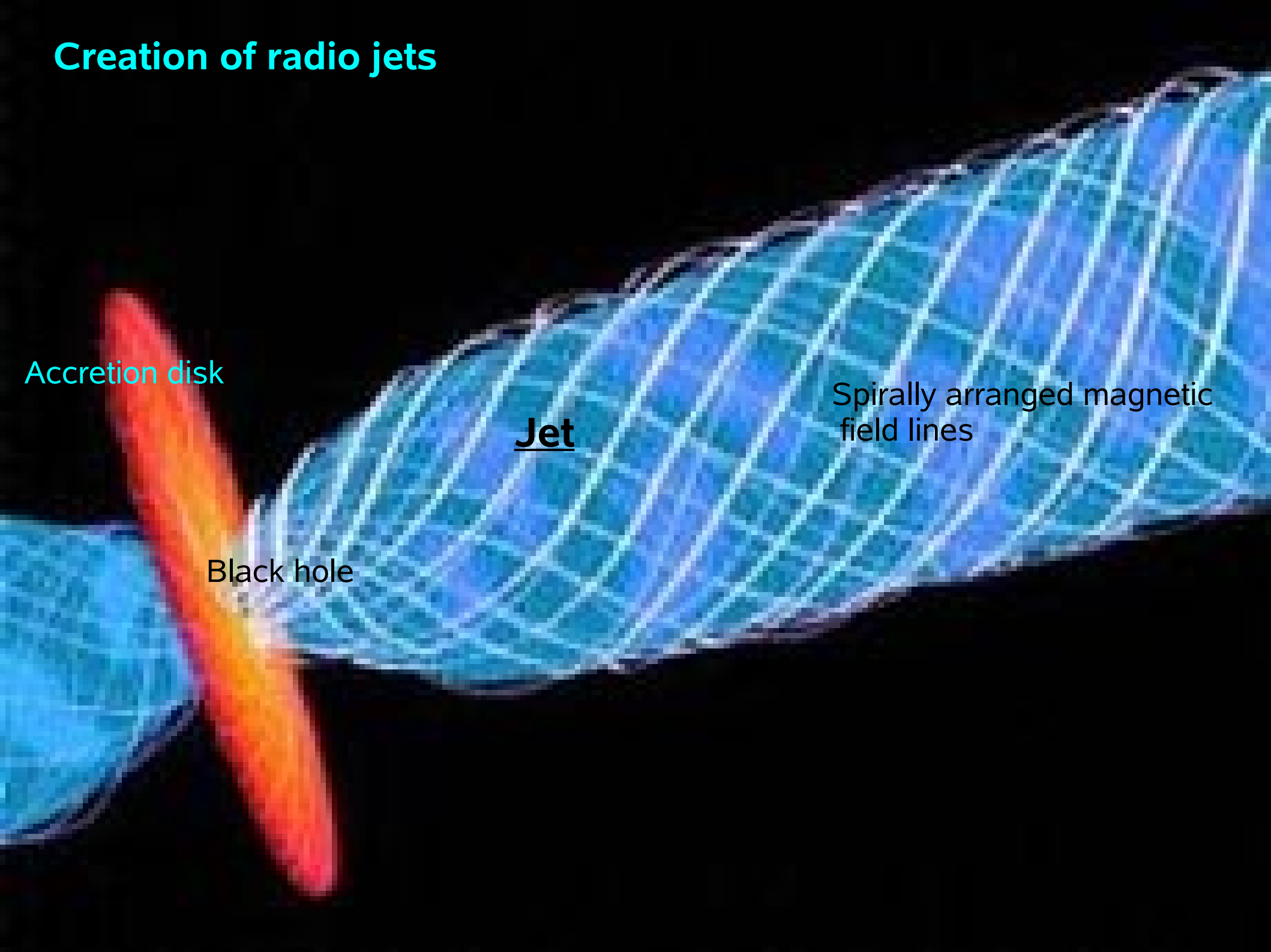
- A disk, rotating around the black hole, transports matter in the center
  - Active galaxies differ thereby from common galaxies
- consists of normal gas or dust, or of ionized gas (->plasma)



2.3 Radio-jets

- Consist of particles accelerated at nearly the speed of light (i.e. relativistic matter)
- Magnetic field lines are coiled (->by Frame-dragging in the ergosphere)
  - Arising a high magnetic pressure
  - The matter is ejected but remains confined by the magnetic field

Creation of radio jets



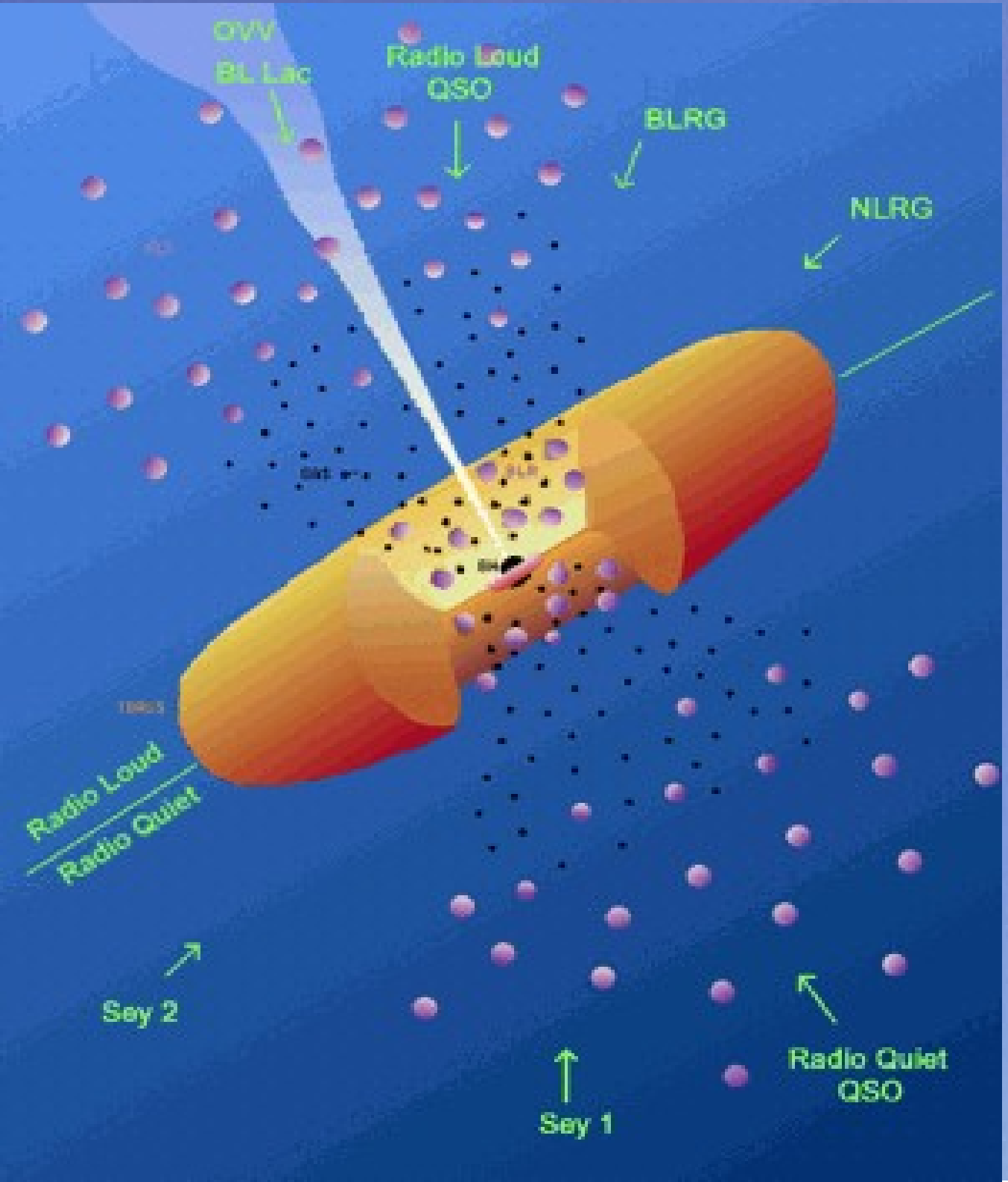
3. AGN- types

Which member you are observing depends on...

a) the angle between the observer and the object

b) the mass of the object

c) how much mass the black hole accretes



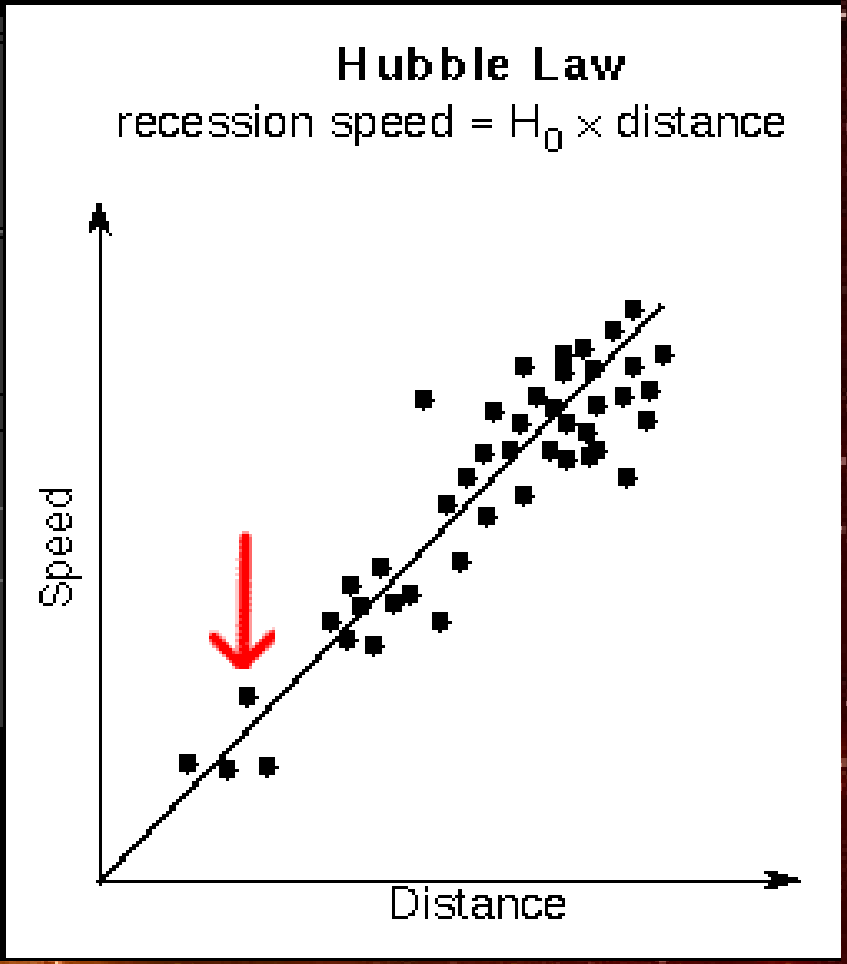
Type dependent on observing **angle**

3.1 Quasars

- among the most remote objects of the universe
  - i.e. „SDSS 1030 + 0524“ is 14x10^9 lightyears away from the earth
- Distance meassured with redshift (->Appendix 1)
- Discovered by radio emission
- More information see Hendrik Gross
  - > ***http://www.mpifr-bonn.mpg.de/public/massi/hendrikgross.pdf***

Appendix 1

Redshift

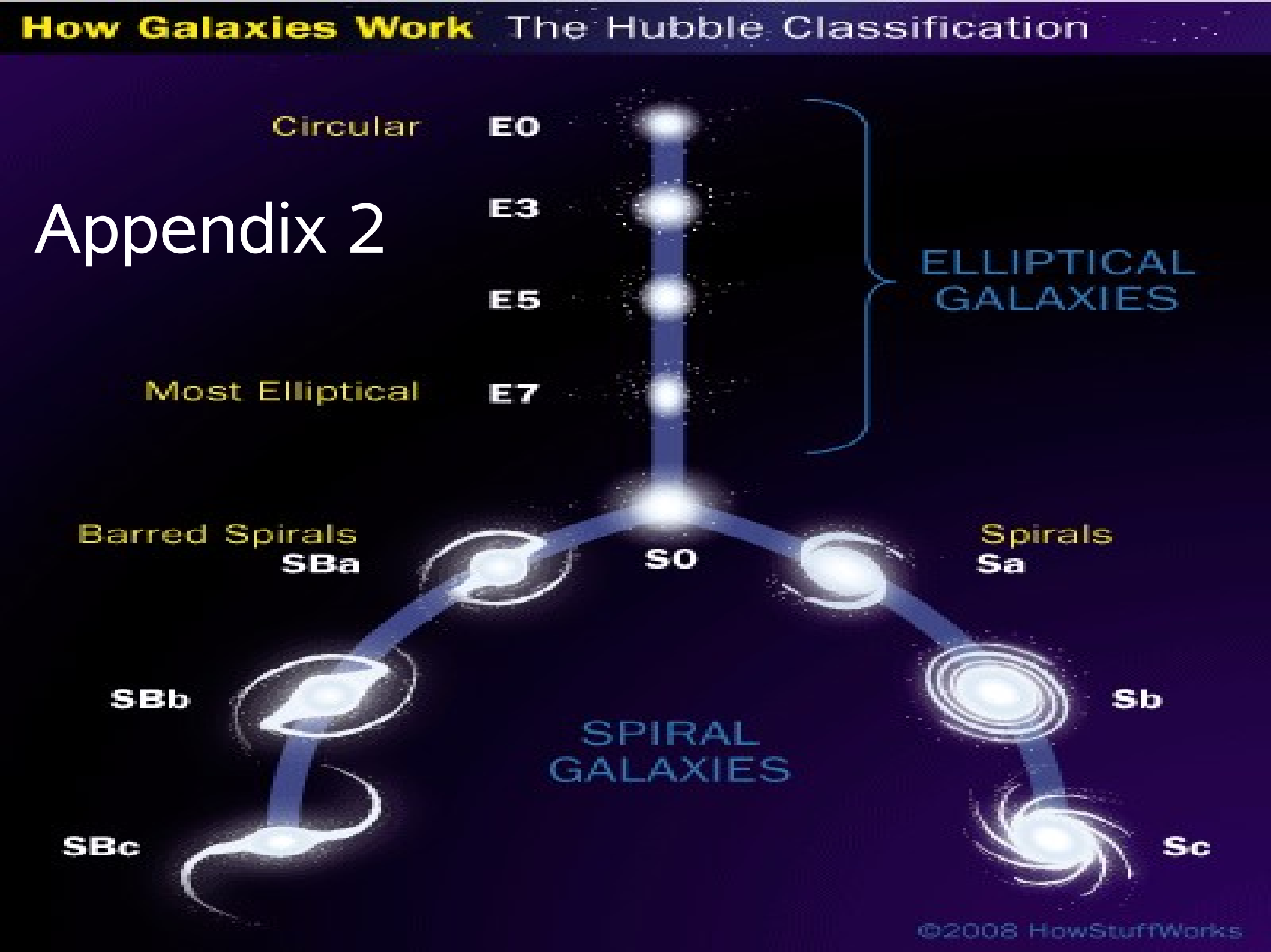


Hubble's law says, that the more distant an object is, the faster it is moving away from us.
The diagram shows the proportion velocity/distance
The velocity of objects can be determined measuring their redshift,

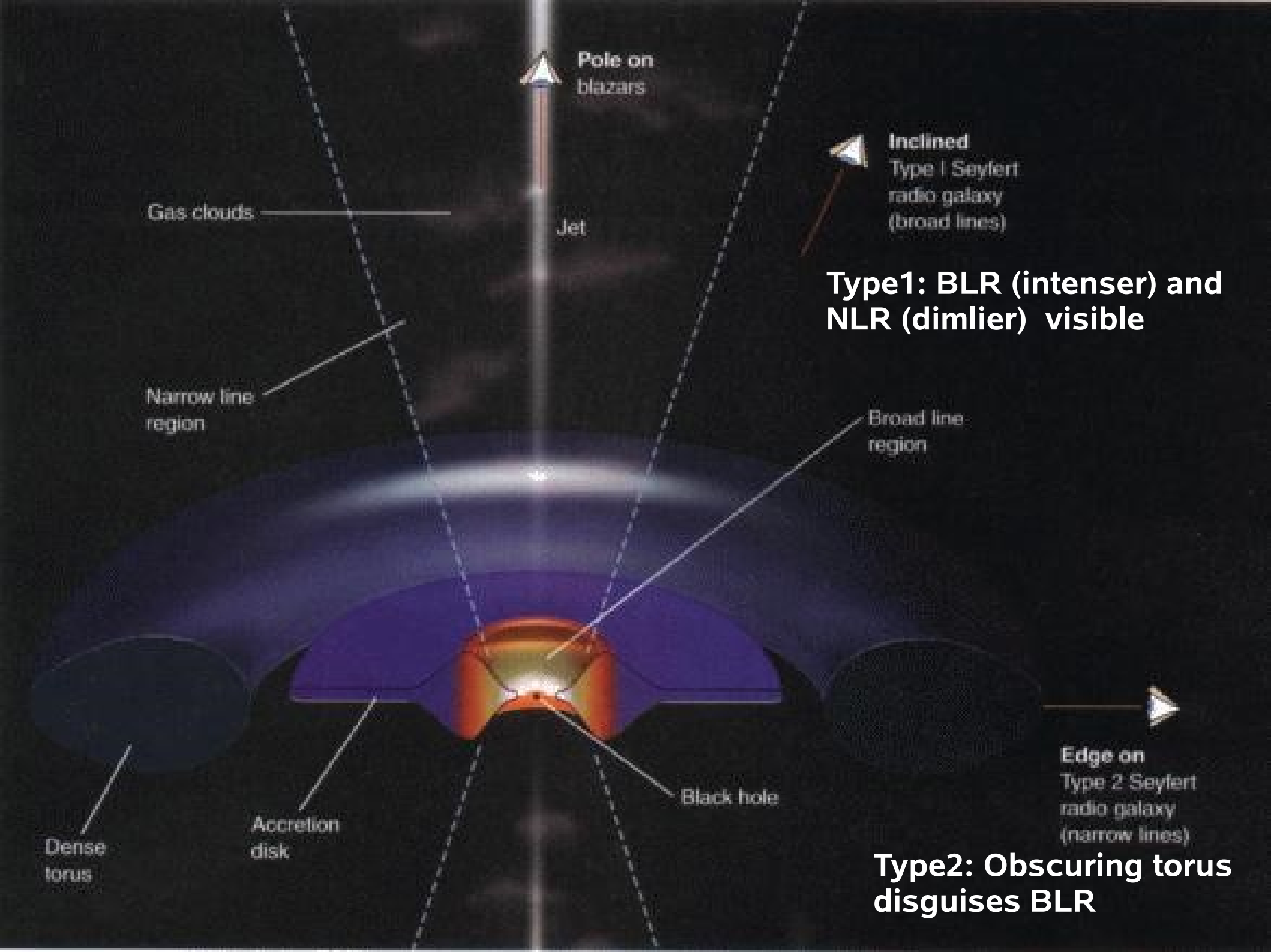
3.2 Seyfert-galaxies

- named by the astronom Carl Keenan Seyfert
- Spiral- or irregular galaxies (->App. 2) with very luminous galactic nucleus (they can also emit gamma-rays).
- Seyfert-galaxies are of two types (Seyfert I and Seyfert II)
  - They are AGN, as Quasars, but with a less massive black hole at the center

Appendix 2


How Galaxies Work
The Hubble Classification
Circular
E0
E3
E5
Most Elliptical
E7
ELLIPTICAL GALAXIES
Barred Spirals
SBa
S0
Spirals
Sa
SBb
Sb
SPIRAL GALAXIES
SBc
Sc
©2008 HowStuffWorks

- 2 different types:
  - Seyfert 1-galaxies:'broad' line component (see 2.1)
  - Seyfert 2-galaxies: just Narrow-Line region apparent



Type1: BLR (intenser) and NLR (dimlier) visible

Type2: Obscuring torus disguises BLR

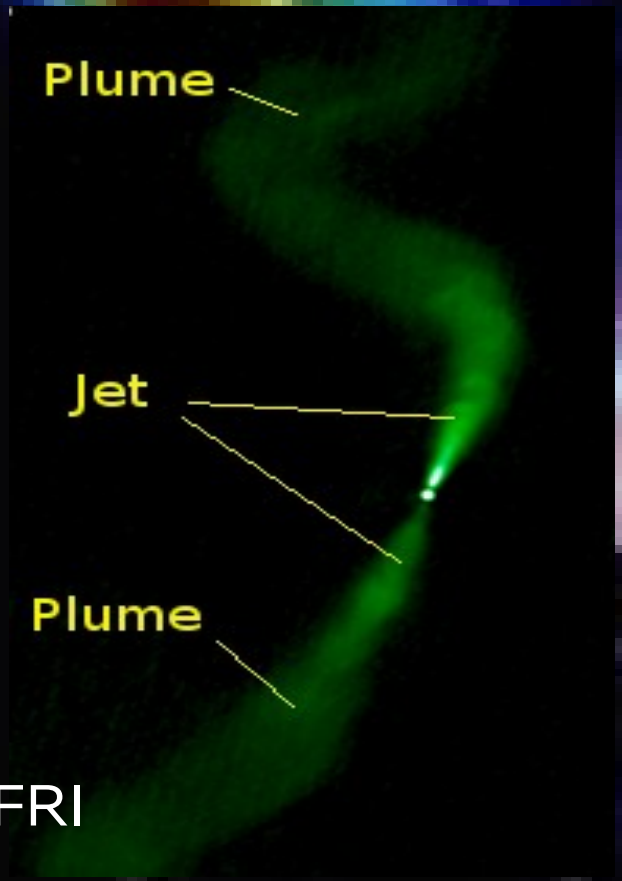
3.2 Radio galaxies

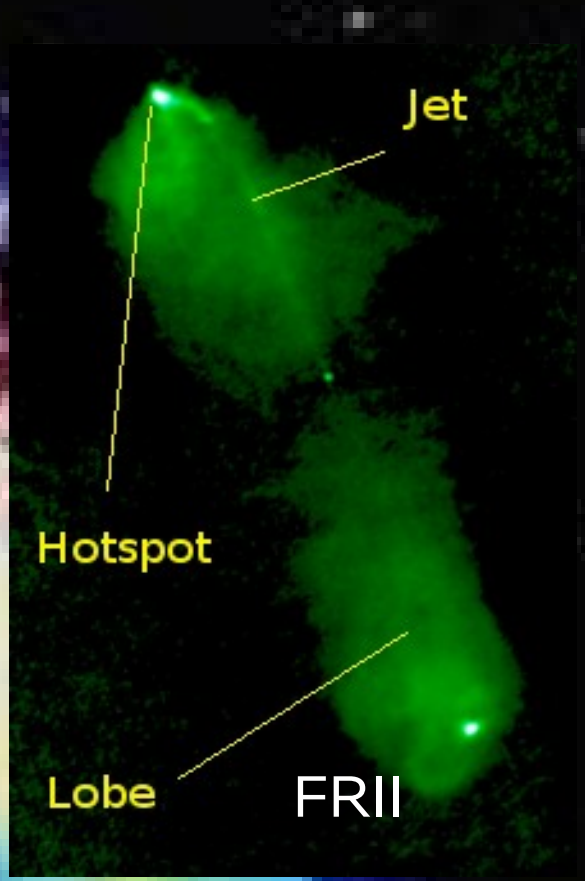
- associated to Elliptical galaxie (-> App. 2)
- Radiation power in radio area exceed the radiation power in the visual spectral area

- They could be identified among other dimly objects in the visible light, because...
  - The galaxy in the visible light is not outshined by its core
-

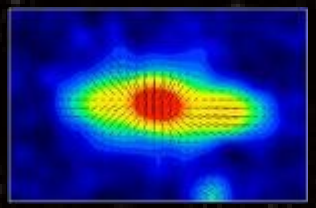
nearest radio galaxy: Centaurus A (NGC 5128)

In 1974, radio sources were divided by Fanaroff and Riley into two classes, now known as Fanaroff and Riley Class I (FRI), and Class II (FRII).



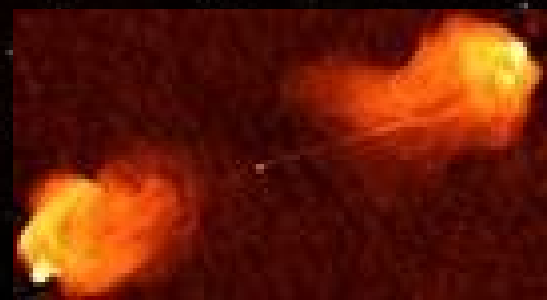


3.3.1 Radio radiation



- The radio emission is synchroton radiation (emitted from electrons gyrating along magnetic field lines)

- The most common large-scale structures are called **lobes**: these are double, often fairly symmetrical structures placed on either side of the active nucleus.



3.4 GPS

- Gigahertz peaked spectrum sources (=GPS)
  - Spectrum with convex form, peaks at ca. 1 Ghz
  - High frequency peakers (HFP)
    - Like GPS, peak at >5 Ghz
- GPS galaxies are young radio sources (~100-1000 years old)

CSS

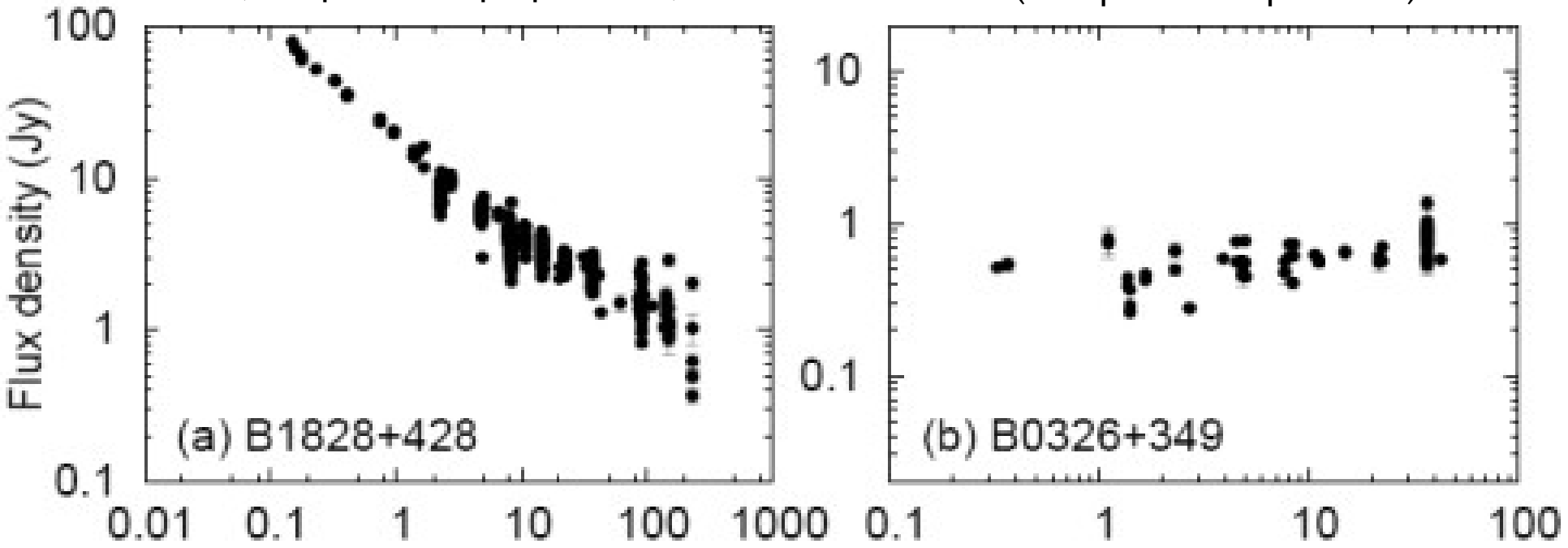
- Compact steep spectrum sources (=CSS)
  - ≤1“ in size, steep spectrum (->App.3), peak at ca. ≤100 MHz – not visible
  - CSS sources are 10000-100.000 years old

CFS

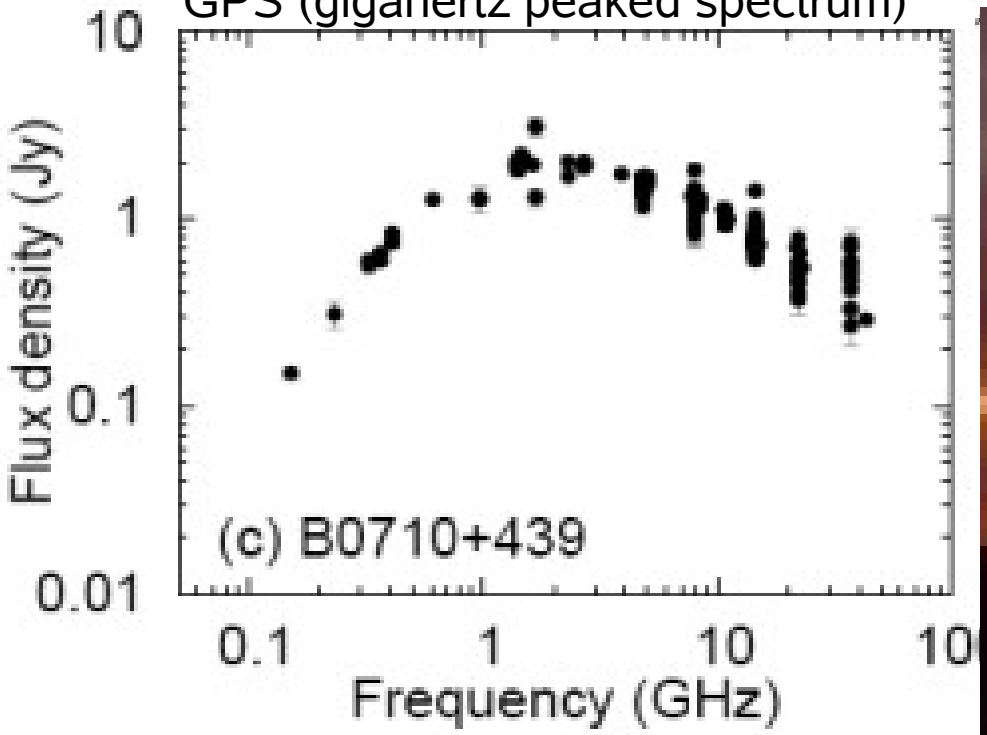
- Compact flat spectrum (=CFS)

CSS (compact steep spectrum)

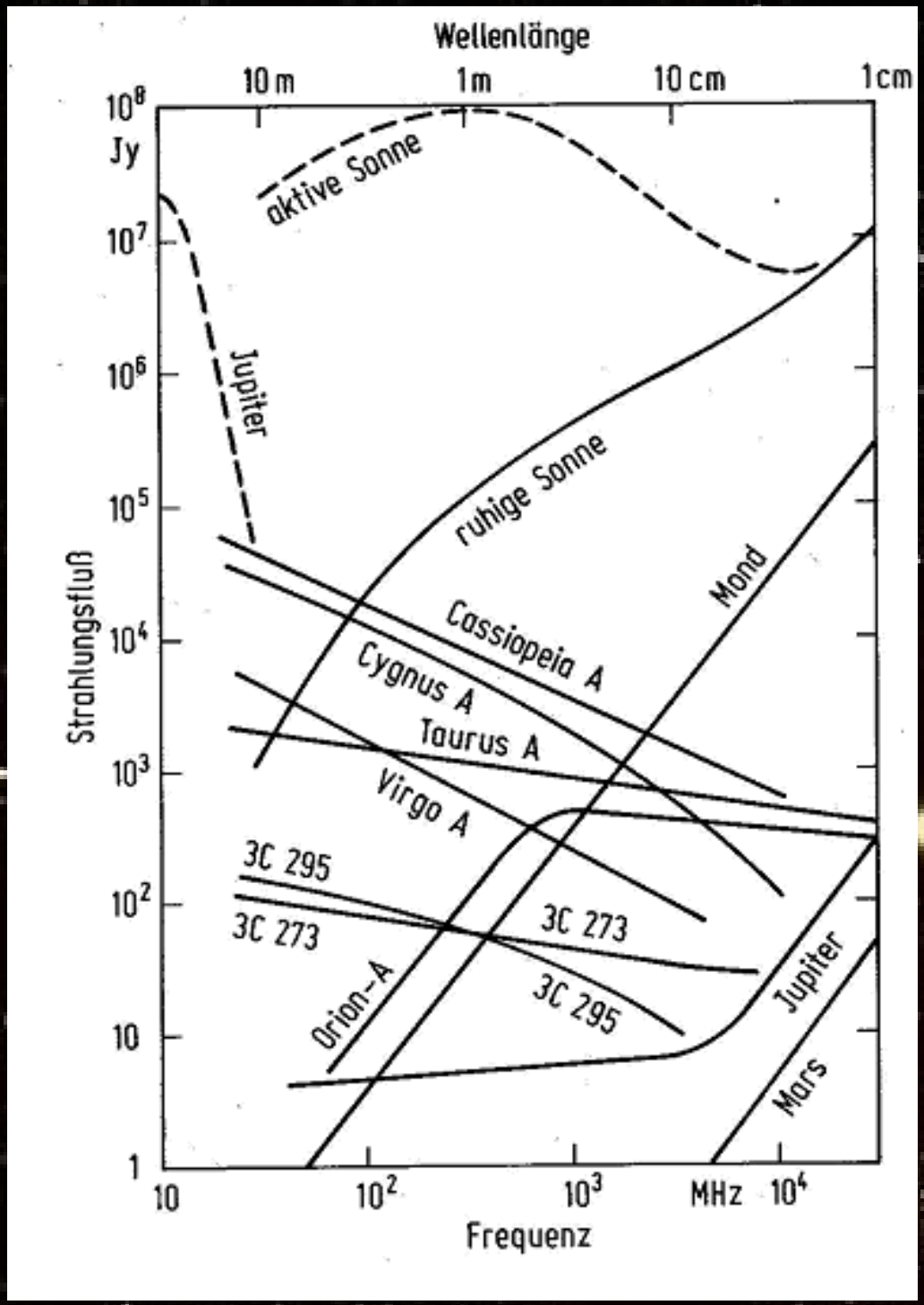
CFS (compact flat spectrum)



GPS (gigahertz peaked spectrum)



Appendix 3



intense radio sources

Spectrum: radiation flux in dependence of radiation frequency

3.5 Blazars

Blazars are a subset of AGN

They are divided into two groups:

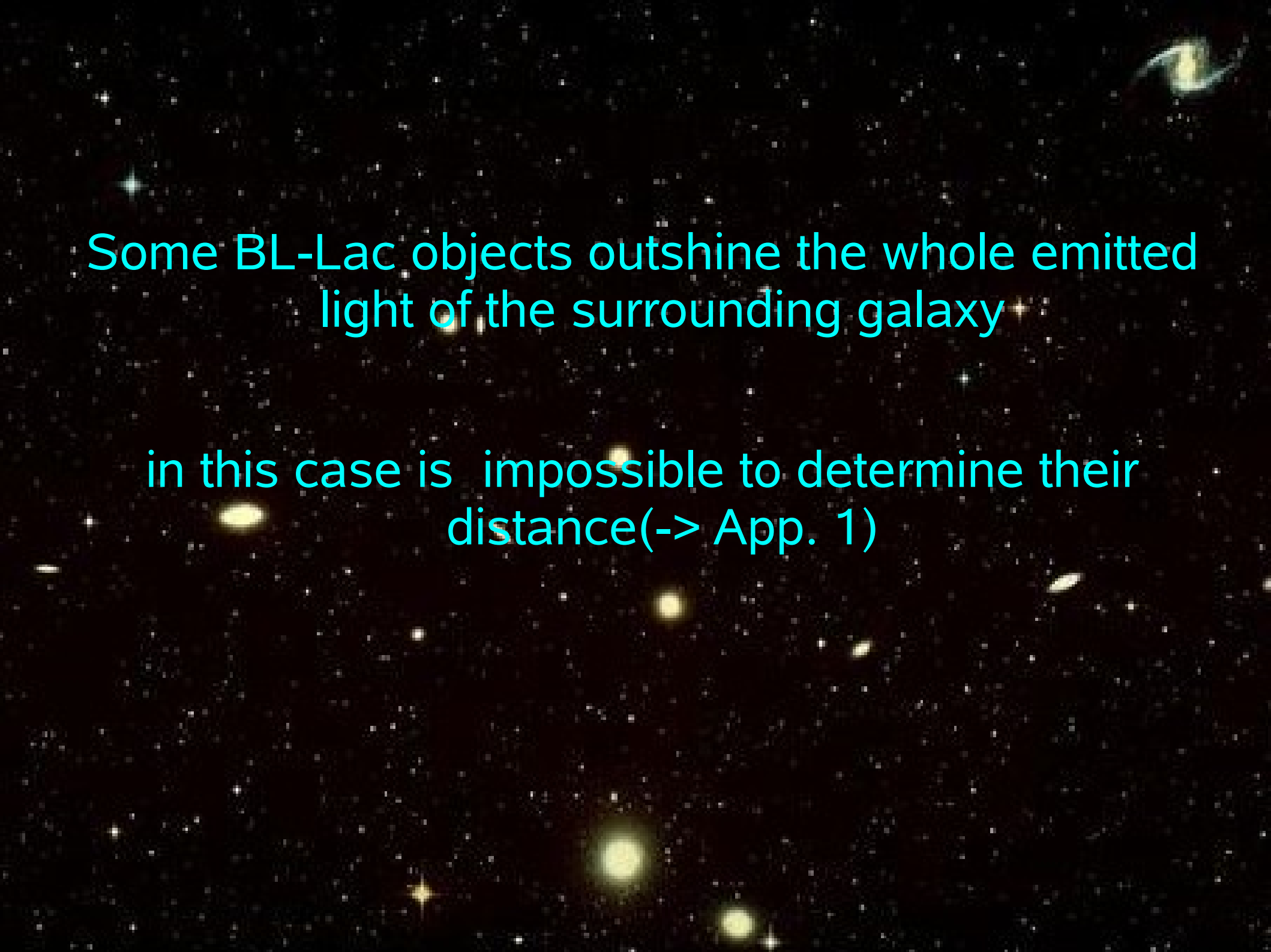
optically violent variable quasars (OVV), and BL Lacertae (BL Lac) type objects,

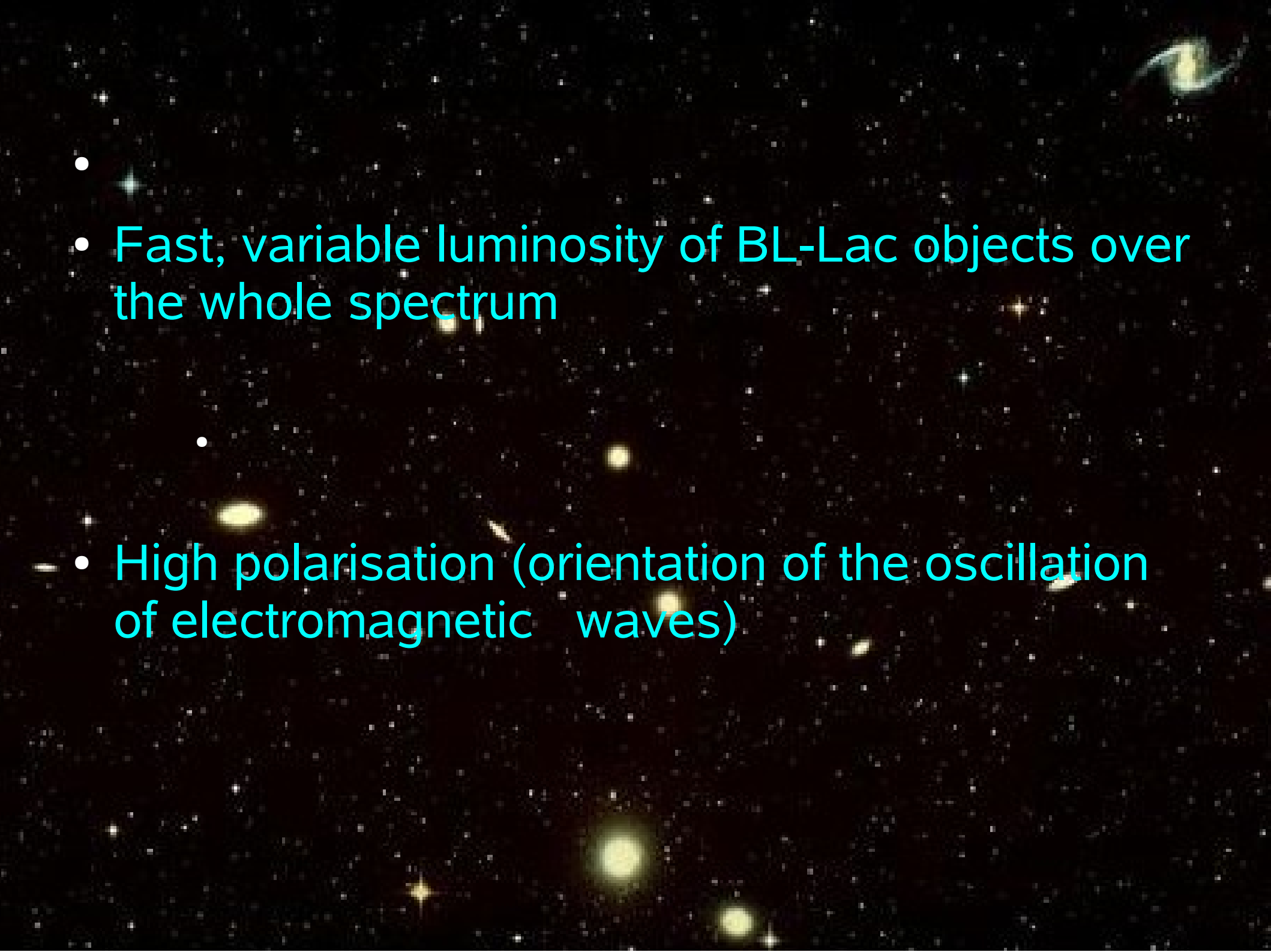
which display extremely intense, broad and rapidly varying electromagnetic emission, from radio to gamma-rays in some case

Angle between line of sight and jet axes of few degrees

BL-Lac objects

- Firstly detected by Cuno Hoffmeister in 1929
- 1968: detected as strong radio source
- Angle between jet axes and observing direction is very humble (direct view into the jet)
- Continuous spectrum without absorption- and emissionlines
- Strong emission in gamma-rays


Some BL-Lac objects outshine the whole emitted light of the surrounding galaxy
in this case is impossible to determine their distance(-> App. 1)



- Fast, variable luminosity of BL-Lac objects over the whole spectrum
- High polarisation (orientation of the oscillation of electromagnetic waves)

3.7 LINER galaxies

- Connector of active and non-active galaxies
- Optical emissionline-spectrum -> low level of ionization