

# Quasars & Active Galactic Nuclei

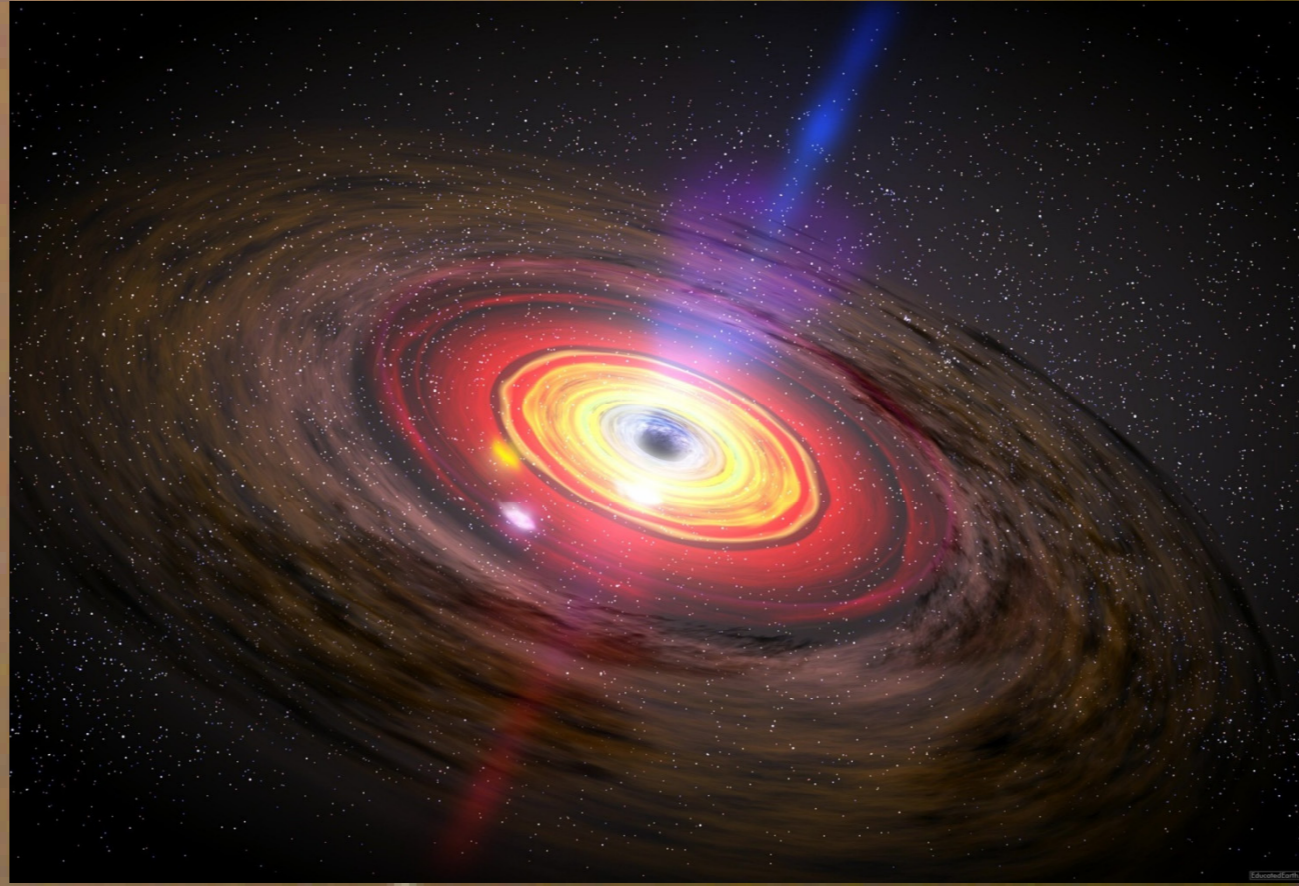
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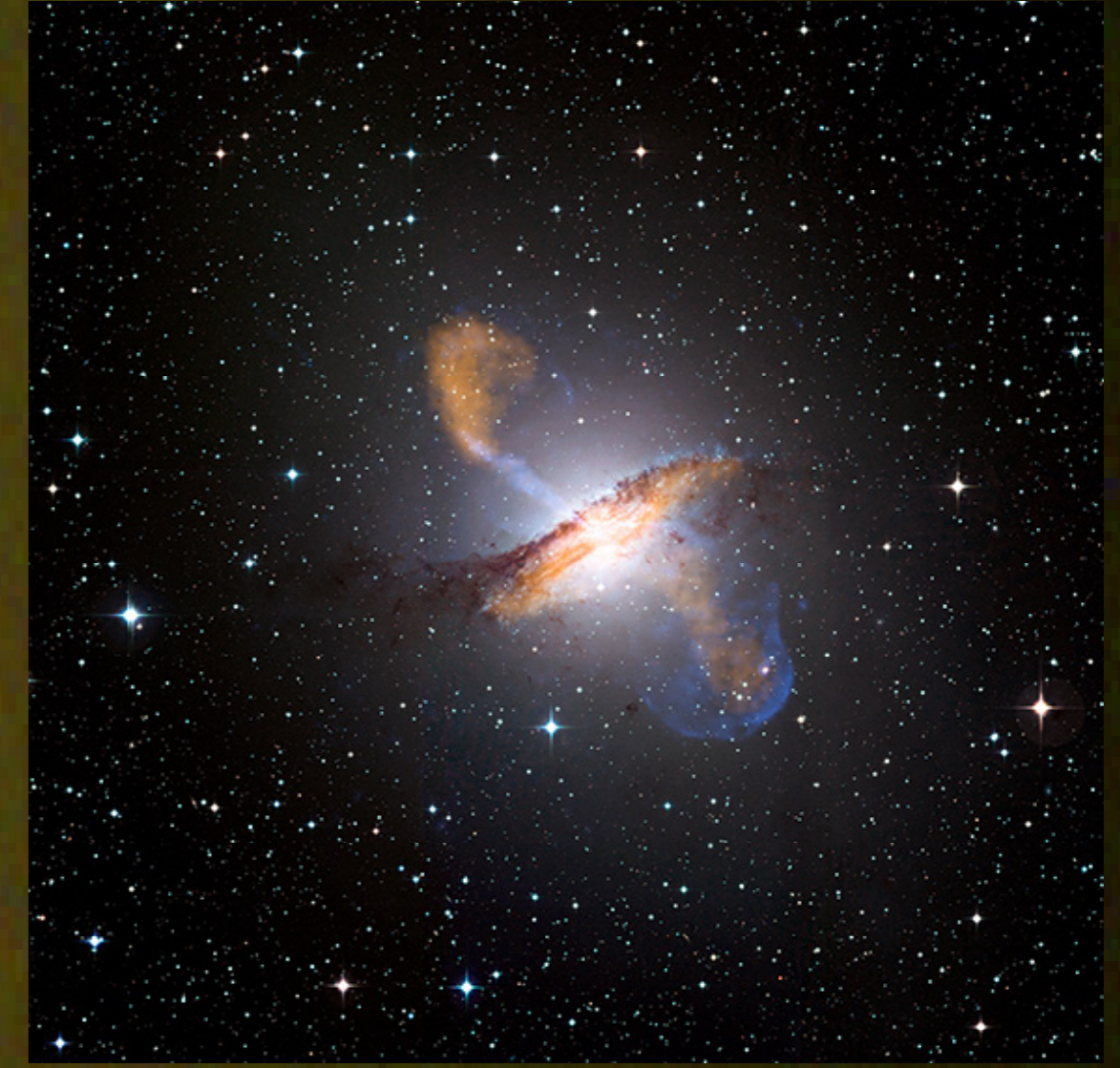
An **Active Galactic Nucleus (AGN)** is a compact and highly luminous region with a non-thermal spectrum at the centre of a host galaxy.

## Quasars

- Most luminous subclass of AGNs identified as star-like objects in radio regime.
- Nuclear source is brighter than all stars of the host galaxy by a factor of  $\geq 100$ .
- Large UV, X ray and sometimes radio flux
- Broad emission lines
- Large redshifts
- Time variable continuum flux



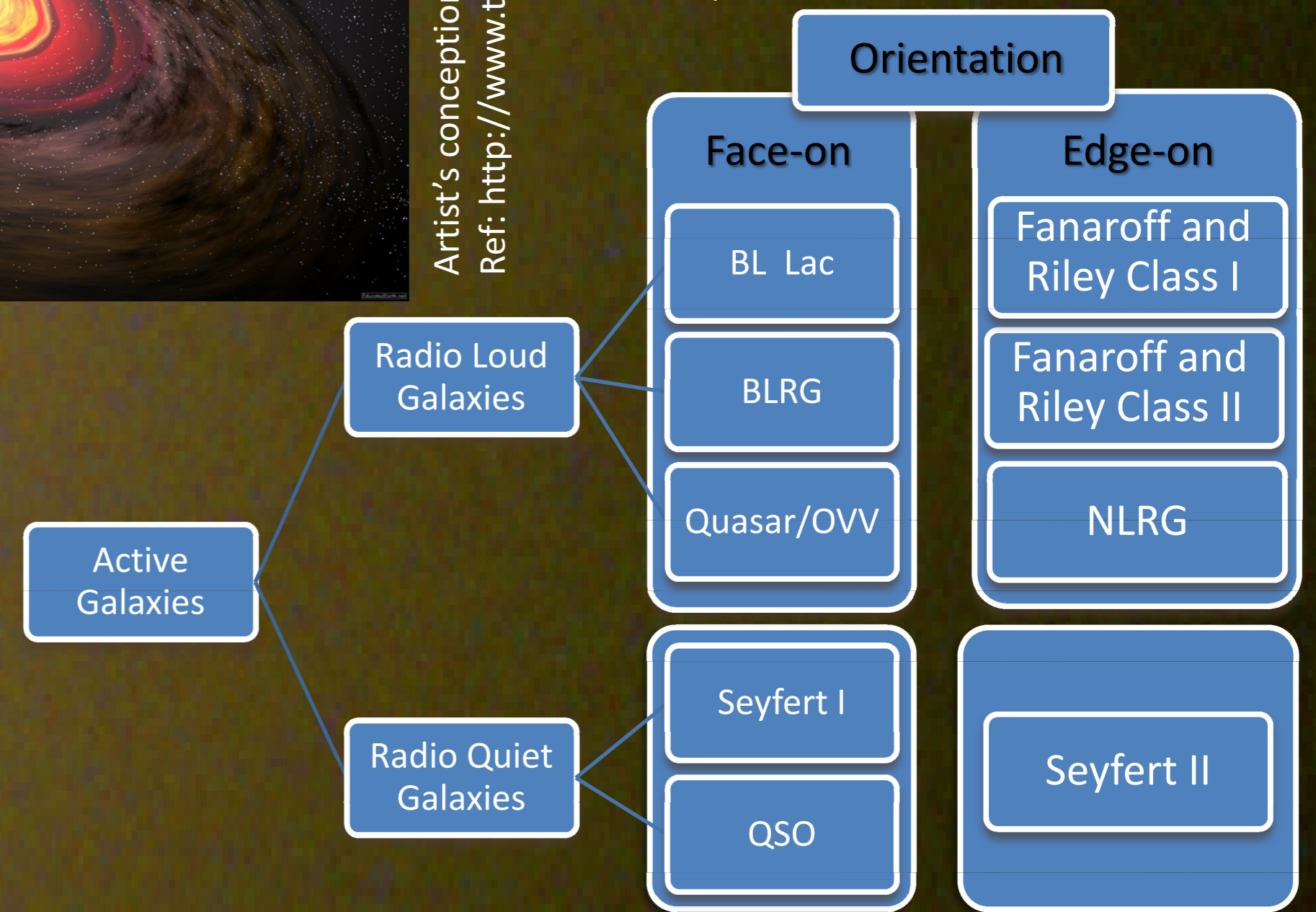
Artist's conception of a black hole.  
Ref: <http://www.twasul.info>



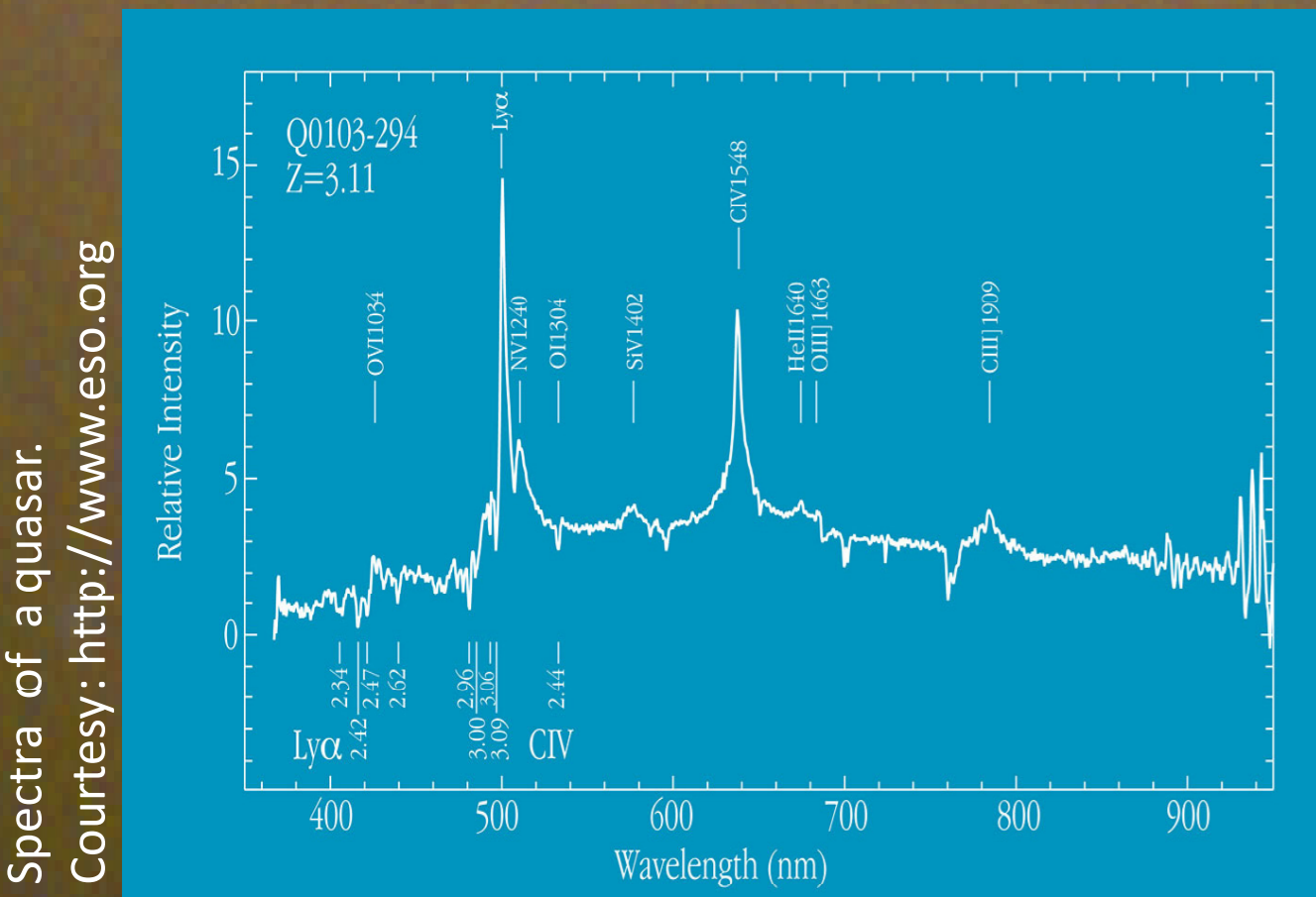
Merging X-ray data (blue) with microwave (orange) and visible images reveals the jets and radio-emitting lobes emanating from Centaurus A's central black hole.  
Ref: <http://www.sott.net/articles/show/228985>

## Energetics of AGN

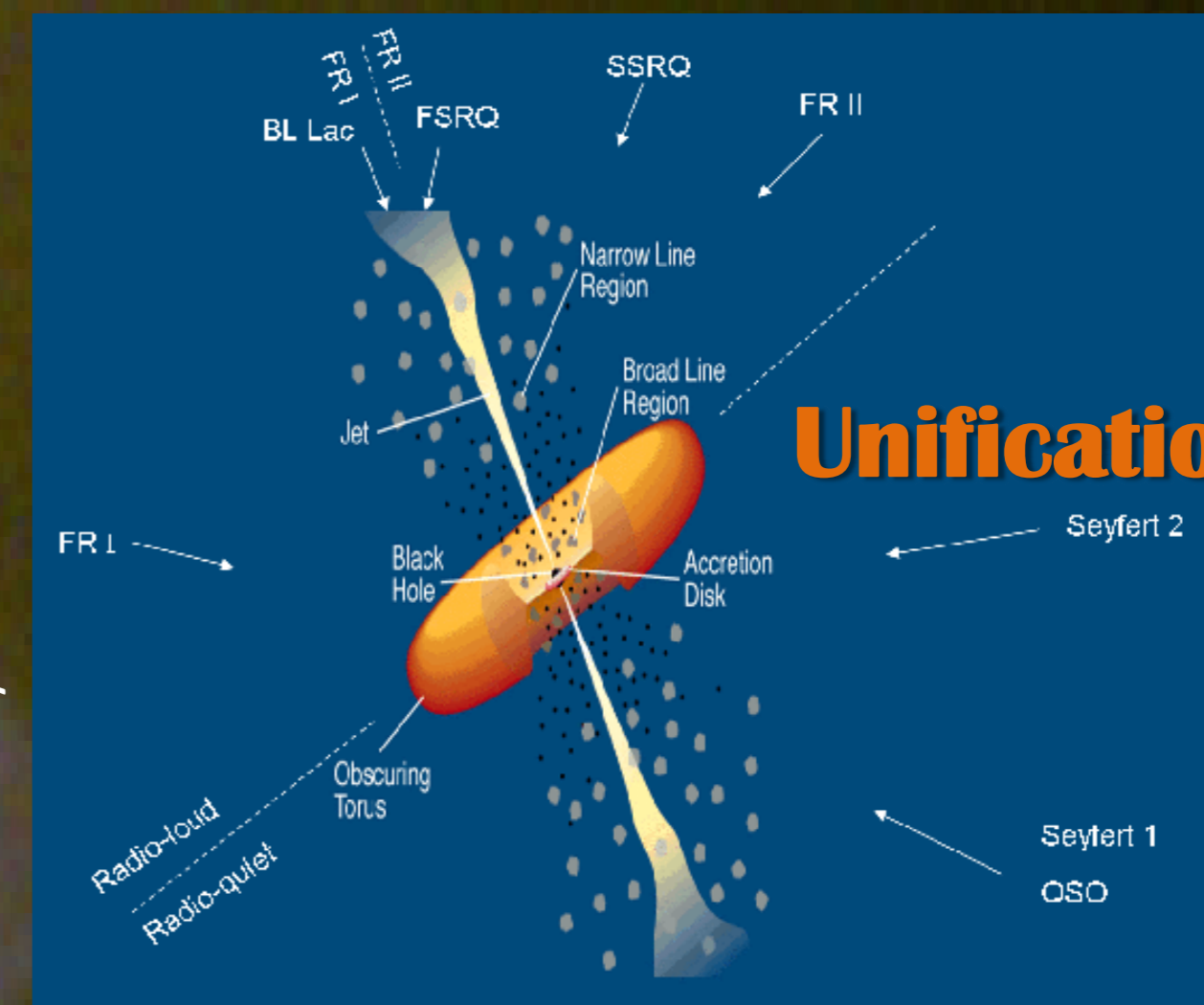
- Variations in the light observed from an AGN limits size of the nucleus to typically about less than few light days.
- An AGN's luminosity exceeds (by a factor of  $\sim 10-1000$ ) the rest of the galaxy's luminosity ( $10^{44}$  ergs/sec).
- The spectrum is non-thermal
- Possible energy production mechanism: Accretion onto a super massive ( $\sim 10^8-10^{10} M_{\text{solar}}$ ) black hole



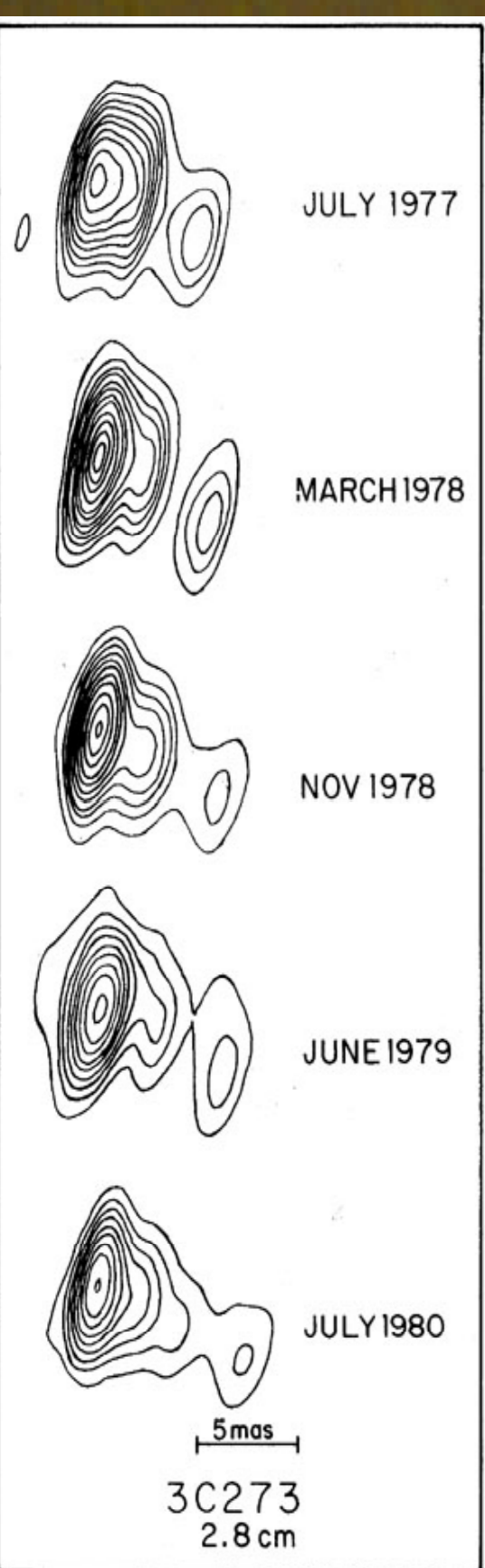
Ref: B. M. Peterson, An Introduction to Active Galactic Nuclei



Quasar PG 0052+251  
Ref: [spacetelescope.org](http://spacetelescope.org)



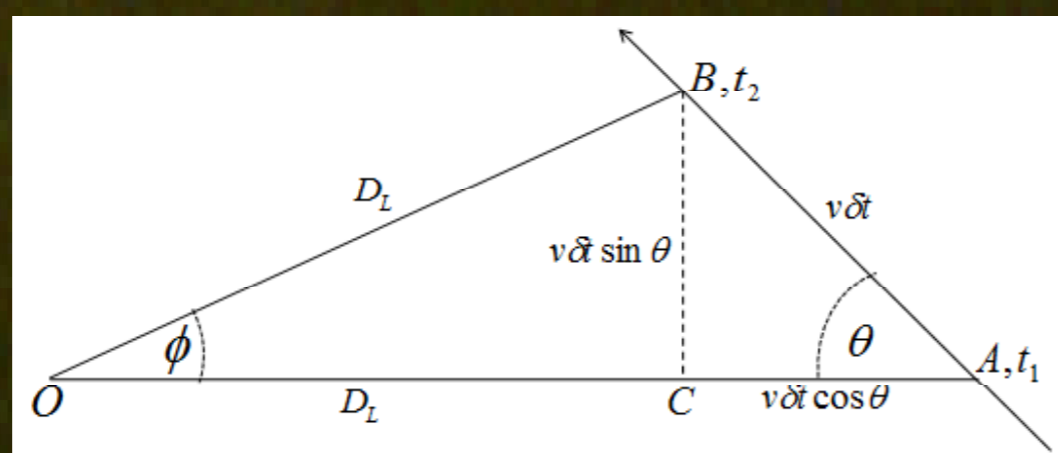
## Unification Model



## Superluminal Motion

- Some compact radio sources are made up of components that separate at apparent speeds exceeding the speed of light
- Occurs due to highly relativistic motion of the source close to the line of sight
- This also leads to rapid variability and flux amplification hence one sided jets

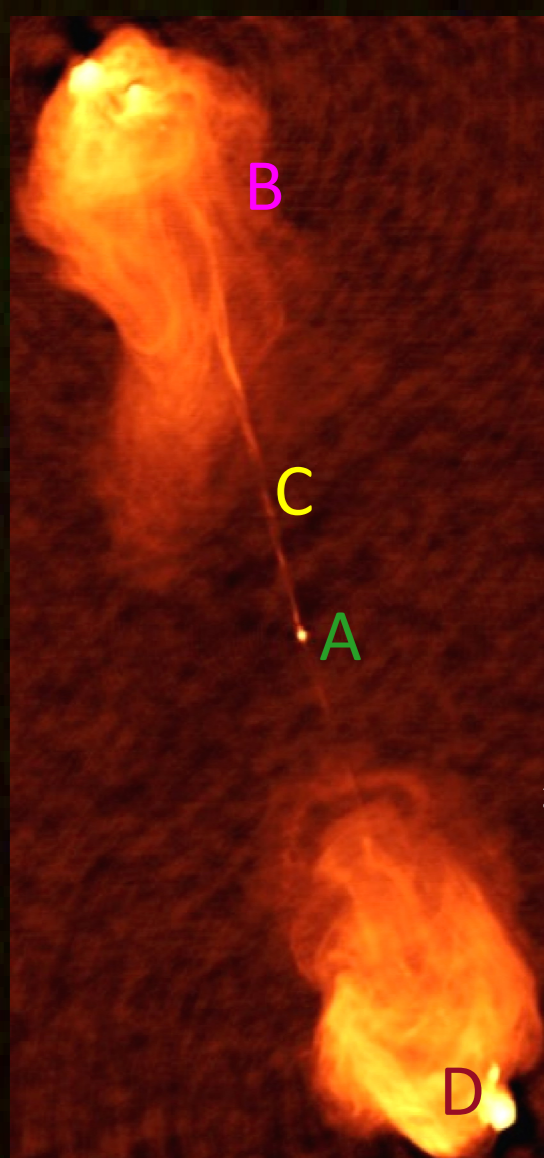
$$\beta_T = \frac{v_T}{c} = \frac{\beta \sin \theta}{1 - \beta \cos \theta}$$



Geometry assumed to explain apparent superluminal expansion of radio sources.

## Radio Morphology

- A. Cores**
  - compact components
  - unresolved when observed with angular resolution greater than 0.1 arcsec
- B. Lobes**
  - mechanism for radio emission from the lobes have earmarks of synchrotron radiation
  - brightest radio emitting objects in the universe
- C. Jets**
  - Highly collimated
  - carriers of energy from the AGN to the extended region
- D. Hotspots**
  - intensity maxima located towards the outer extremities of the lobes of highly luminous sources



Cygnus A. <http://www.tandfonline.com>

## References :

- B. M. Peterson, Introduction to Active Galactic Nuclei
- Frank H. Shu, The Physical Universe
- Kembhavi and Narlikar, Quasars and Active Galactic Nuclei