## ASTR 5590 - Jets & AGN

Jets are common when you have an accretion disk around a compact object ☆ Slide

- → Newborn stars (T Tauri stars) have accretion disks & ⊥ jets
- → Some XRBs: microquasars
- → Collapsing stars → SNe (collapsar model of GRBs)
- → AGN: Active Galactic Nuclei

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AGN have a huge # of names/types, which depend on $\lambda$ & history

There is consensus of a "unification model" for AGN, which describes these different classes in terms of orientation to the observer.

☆ Slide on Unification Model

<u>Quasars</u> – radio point sources often
associated w/point-like objects (star-like
in the optical @ ↑ z

Type I → BLR, no forbidden lines

Type II → NLR, forbidden lines

↳ QSOs w/out radio emission also
found, typically via UV excesses

Underlying galaxy <u>difficult to see</u>, but there

<u>Seyfert galaxies</u> (selected for → bright (1943)
– fainter than quasars, but w/ nucle
– mostly spiral galaxies

<u>Markarian galaxies</u> (Byurakan Obs./Armenia) ['60s]
– survey of gal. w/strong B & U emiss.
– mostly star-forming, but ~10% have
same property as Seyferts

<u>Radio galaxies</u>
– '70s, optical spectra revealed
BLR + NLR also similar to Seyf.

## Blazars (~'70's)

BL Lacertae – variable "star" w/assoc. variable radio emission: BL Lac obj.

OVVs – optically violently variables

- exhibited super-luminal motion in high res. VLBA images
- all $\gamma$-ray sources that are persistent & extragalactic are blazars

## ULIRGs (~'80s)

$L_{IR} \gtrsim 10^{12} L_\odot$

>50% have lines like Seyferts, but some IR due to star formation

## X-ray

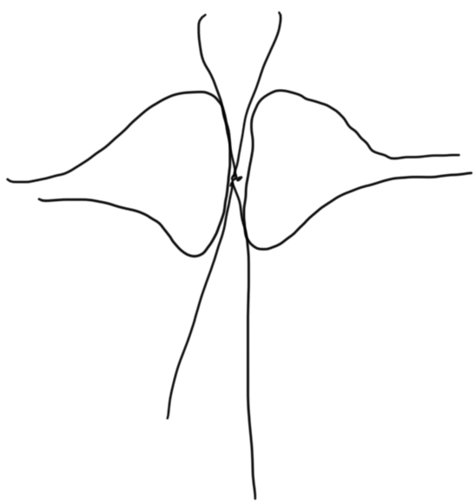
- first UHURU (70s), ROSAT (90s)
- all of the above types (can) have X-ray point source coincident w/nucle
- most 0.5-2keV AGN are unobscured w/photon indices $\Gamma \sim 1.8$, steeper than CXB @ E>2keV (1.4), need a f... ...d AGN (& column

pop. of obscured AGN (column densities) up to $N_H \gtrsim 10^{24}\,cm^{-2}$, when Compton scattering (by $e^-$) becomes important: Compton thick

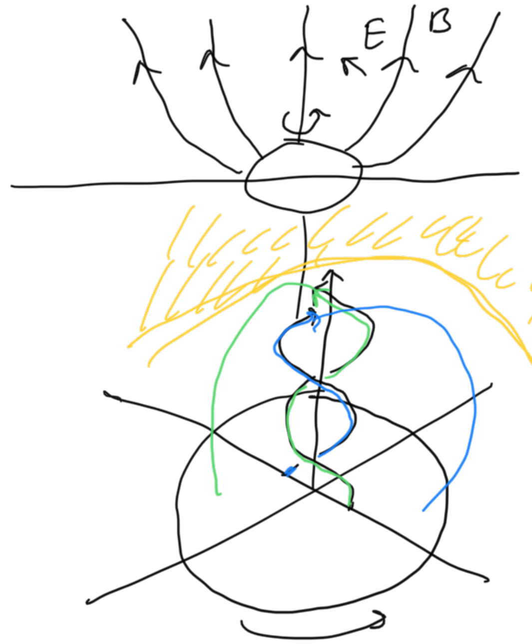
## Jets

How are they formed? We don't know

Thick disks?



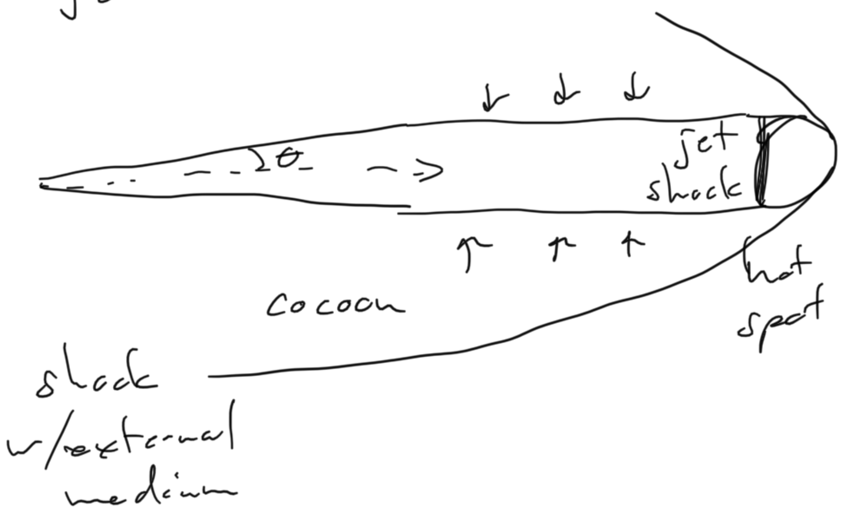
Winds + E/B fields




How do they stay collimated over such large distances?

- hit ISM/IGM/ICM, form shock called a hotspot where particle accel occurs
- particles create a cocoon that

– rel. particles [illegible]
provides ram pressure that confines the jet → self-collimation




Cygnus A prototype of source
→ called FR II radio galaxies

★ Cyg A slide

FR I sources fainter in radio, typically in galaxy clusters
→ inflate bubbles that rise buoyantly in the hot gas

★ Virgo A (M87) slide

↳ discuss imaging of disk around BH, must be face on b/c clumps in jet appear to move faster than light

↳ next slide on supraluminal motion

Get relativistic boosting effects that blueshift
& narrow rad. beam

## γ-ray bursts

- discovered by Vela surveillance satellites, published 6yr after 1st seen to make sure really of astronomical origin

2 types: short & long
(<2 s) (> 2 s)

peak: 0.5 s 40 s

Release huge amounts of E → $10^{46}$ J ($10^{53}$ erg)

if emitting isotropically

Accounting for beaming in a jet, long bursts have $E \sim 10^{51}$ erg, typical of SNe

## Collapsar Model

core forms BH & accretion disk

develop jet & cocoon

... breaks out of inner atmosphere

jet breaks
of star, see as γ-ray burst
see an afterglow once jet plows
thru rest of star and picks up
enough material to decelerate it
→ thought to be Wolf-Rayet stars
(in binaries where mass transfer
has taken place & sig. rotation)

Short-bursts → NS-NS mergers ?!
→ GW170817 : short gamma ray
burst coincident in time, but
localization poor
→ optical SN found w/in positional
uncertainties

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STAR-X

New Proposed mission to study
AGN pop., galaxy clusters, &
follow up GW sources & detect
SN breakout & tidal disruption
events (TDEs)