I.A.U. #97 — Monday morn.

Oort. Space telescope → mem of M87 central engine?
Cells the 3C84 outer contours "jets" (not the bright blobs)
"A black hole may help to solve these problems, but other solutions also exist". (in respect of center of our Galaxy).
NGC4258 – spiral where synchrotron arms cross the spl. arms at steep angles. Sharp outer edges on synch. arms. Trail with the spiral structure. Ejection of ~ $\frac{1}{10}$ mass in NGC 1265 tails? ~10^8 yr activity? Precession of central black hole?
Jones/Stanek/Terzian "Normal" galaxies with ext. struct aligning with VLBI structure.
List of questions.

Wielebinski Large scale emission here means diffuse.
Remember projection effects [paper in Proc. Austr. AS]
NGC315 Effelsberg 2.8cm map. → no discussion.
Are spectral index gradients systematic?
DA240 ±0.1 around 0.7 no strong s.i. grad.
Exponential turnovers in mm range now? Grant observing time!

J. Baldwin What are shapes of evol. tracks of sources?
How fast traversed?
No large # of sources "missing" from 3CR Sample on basis of 151MHz 6C.
Flux-Power-Lum. diag for 3CR → ρ(R) profile similar to Xray halos

IAU 97 Baldwin (cont'd)

He likes $v/c = 0.05$ for exp. velocity

Lack of bridges across powerful doubles could be due to spectral ageing. Look for jets & bridges at lower freq. in powerful radio galaxies.

Ekers Cen A jet seen..

Asym jet / Sym "inner lobes" / Asym outer jet / Sym outer lobes.

Symmetries in U-sym jets → Variations in nuclear engine?

lobe symmetries Median sep. ratio 1.4

Media dist ratio 1.7 (BDFL)

Inversion symmetry not destroyed by projection ~

Mirror ——— is ——— C

B2 and 3CR Mirror symm ≈ Inversion symm.

B2 many more disturbed sources than 3CR

Only mirror symm in Abell clusters.

Sparke Creation of funnel by rotation @ $^2/_{10}$ Cs.

Points along $\perp^r$ rotation vector of gas infalling to central BH.

Fast rot. → wide funnel → poor collimation

Is this why spirals don't make narrow jets?

Predictions. Jets $\perp^r$ to spin axis of confining gas.

Rot. velocity vs jet width in "3C31 types"?

Birkinshaw Cyg A at 87.6 GHz 4" EW.

Central cpt breaks ro $\alpha \sim 0.65 \pm 0.15$ between 20 and 87 GHz.

No sign evidence for var... prob is spectrum.

Sf lobe α_{87}^{5} 0.94 ± 0.10 (hot spot)

α 1.40 ± 0.1 (diffuse)

Nf lobe α 0.82 ± 0.10 (HS) ~4"

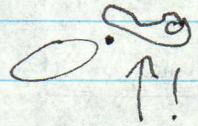
α 1.7 ± 0.2 (diffuse)

probably no breaks ~ flat spectrum

Paul Scott α gradients in ext. structure of Cyg A.

E & W cpts different spatial gradients across the lobes away from the HS

W bridge curves not back to core



P.A.G.S. Moving jets → "dentist's drill" model of cavity + HS.

[Pairs of HS]

Most recent HS usually further back?

Giant gals. like NGC6251 large: they are ejected in cavity. Dir? for some reason?

J.O. Burns 3C465 VLA @ 20cm. Where bends it?

cD gal. or cluster center!

Where's the motion for a cD? At best expect small-amplitude oscillation. Xray data → anisotropic distribution. but not (the sag) gradients steeper along the radio trails.

Larry Rudnick

One-sided jets? One side at a time?
Best fit to HS θ_1/θ_2 & θ_2/θ_1 diagrams from Gaussian distribution of intrinsic sizes (diff. on 2 sides)
How about the dip in the middle? Get that from one side at a time?
His flip-flop anticorrelation?

Guy Pooley 6C → 5km spectral work on v. large sources.
Nothing said.

Duffet-Smith I.P.S.

W. VanBreugel
T. Heckman Line emission predominantly along boundaries
Brightest near hot slightly offset from radio knots hot spots
Deposeriz. at 6cm
Pressure in radio source ≈ radio source pressure
Bulk velocities 200-300 km.s^{-1}
Velocity widths 300-500 km.s^{-1}

Bob Fosbury 3 southern radio gals with ext emission line regions.

Tim Heckman

3C305. ~ 3 kpc size inside its galaxy.
Rapidly moving.
Gas anticorrelates w. pol. %.
K.E. of gas ~ energy in red source
$L_{EUV} \sim 100 \times L_{RADIO}$

De Young — Not-very-supersonic flows in jets
→ entrainment (before the turbulence fully developed).
→ line emission filaments or (stars)? at boundary layer

$\dot{M} = 60 R_{j,kpc}^2 \delta n_0 c_8 M_\odot yr^{-1}$
$R_c = \delta R_j$
$t_c = 3 \times 10^2 T^{1.6}/n = 1.5 \times 10^6/n$ yr
$T \sim 10^1$ initially $T = 10^5$ finally
$R = 10.5 v_8 t_7$ kpc
→ star formation possible.

Massive stars → SNR's in the jet ?? 10^{41-42} erg.s^{-1} in jet?

Dan. Harris Radio and Xray from Clusters

Beware small relative displacements in FIRC maps (!)
Do tails always occur in clusters? Always goes around
Evidence of buoyancy? In low surf. brightness, maybe
high ——————, no.

No sign of xs Xray correlated with tails themselves.
Some evidence for static gas pressure confinement.
Small WAT's and "stubby" tails in hot dense regions.

Xray data on VLA 3C 15 → Some extended stuff?

B. Y. Mills Most Abell clusters contain at least 1 radio galaxy
Preferentially radio galaxies occur in clusts with much gas (from Xray data)
42 clusters below -8°
Poisson distrib. mean 1.3 rg's per cluster.
Preferred in Bautz-Morgan I.

Christine Jones Abell 1367

IPC sphere core 0.8 Mpc × 0.4 Mpc

IPC → not smooth

HRI → excess of discrete sources. (10 sources)

Significant association with the individual cluster members. Why the excess activity? Coronas common in A1367, but not in all the galaxies. Why? Ram pressure removal from higher velocity ones? It's in an early dynamical state (unrelaxed). Xray temp 2.8±1.0 keV.

She has IPC of M84. HRI → extended ~20" spherical. Velocity consistent with cluster mean.

Eric Feigelson Outer lobes not seen in Xray.

CenA Knot B just outside dust lane = Broad (A&B)

A — inside dust lane. = Narrow (A&B)

Xray outer lobe is beyond the the emission.

[redacted]

If intergalactic medium is there, pressure equilibrium with the radio jet. (The extended detection is marginal).

Marc Hot emission at edge of radio jet: brightness of the "middle" lobe. — (Similar to Cen B.)

Velocities ~ several 100 km/s (could be in stable orbits).

Terrell Cen A Vela data — brightened in 1973 3-12keV
flare lasted ~4 years, brightened by $\gtrsim \times 3$
Much substructure (weeks ~~days~~)
Possibly switches off in days (~ 10).
Source ~ few light days in size?

Kronberg. Type "A" hot spots on-axis or leading edge of lobe
Type "B" hot spots. ~ B day cusp.
Brighter than "A"
off axis
Short t synch?

Shear Vortex type of KH instability?
$\tau_{KH} \sim \frac{\lambda}{v}\sqrt{\frac{\rho_{ig}}{\rho_e}}$ Two-stream interface

Robert has counter-examples when "A" is off axis and "B" is on.

In 2-sided jets
Q. for Meier Do both sides coincide together?
Q. for Begelman Is B and transverse I correlated when do pulses look like?

Pierson VLBI of Cen A mnd. 2.3GHz.
~1×0.6 pc.

Waide AC32.69. + his other bright ones.
His $\dot{P} = \rho v^2 A$
$= \rho M^2 c_s^2 A$
$= \rho M^2 u A$ regardless of detail.
$\sqrt{\gamma}$
Gets M from Θ^{-1}.
u from equipartition
A from transverse resol.

Wilkinson MERLIN Bestiary
*get for the 200
3C295, 3C196, M87, 3C465+3*, 3C345, 1642+69
1221+809
3C309.1
3C390.3
3C245
3C454.3
3C395
+others
VLBI "jet" ± MERLIN "jet"
1853+568*, 3C418, 3C380*, 3C130.

Conway 3C273 408 MHz 0"9.
"Convergent" 200:1 down.

Davies 100 Sbc galaxies with MERLIN
40 active galaxies
NGC4151 Center-brightened 4pc. Jet? Outflow is ~200km/s.

Optical pol: ~ 8%
"Central" radio 2/de 83.5
Forbidden line region ~ 20"
Radio source in inner forbidden line region. $\tau = 150$ pc.
$t_{synch} \sim t_{esc}$ for forbidden line region.
forbidden line gas accelerated outwards by
nuclear wind with radio jets?
Jet must be misaligned with plane of galactic nuc.!

I. Browne Are we seeing normal radio QSO's end-on?
$\gamma = 5$. Fits $\log N / \log S$ for steep + flat spec radio QSOs
(Relativistic beaming models).

Ridc The 404 "calibrators"
↓
345 actually core-dominated & mapped @ 20cm
186 with z 48% contain unambiguous LSS.
Most 1 → 5". Median linear size ~ 20 kpc
Brightness ratio lobe/lobe don't look like
low velocity wide double seen end-on.
Spectral index of 2 any other unruly
steep spectrum (not "images" of primary!)

Tsien Cyg A at 81.5 IPS.
Hotspots much less prominent at low freq. & nearly disappear. (< 1.2% of total)
if 20% at 5GHz
SSA needs turnover ~150 MHz
Equipartn B would require ~ 0".2 - 0".3
Suggests its spectral differs between HS & surroundings.

DA240 HS @ 5GHz, 2.7GHz & distrib
⟹ Should we try to combine w/ Kar VLA data?

Don Becker Interstellar scattering would broaden the 81.5 MHz hot spot to ~20" !!!

Andrew Wilson "Complete" sample of Seyferts.
Mini-2 dec around accurately-determined nuclei positions.
Mark 315 - diffuse "halo" struct.
NGC4151 - the "jet".
NGC5548 - [illegible] jet?

CR & B independent of activity of nucleus? eg massive * burst?
-or- energized from nucleus?
Collimated sources energ. from nucl?
↓

① Nor disks edge-on based on the optical orient?
NGC4151 "jet" aligned with opt. pol. vectors in core

Expects her beam "stopped" in disc of Spiral
Spirals can have double-source "engines".
[bar not the double sources because they can't get out!]

No apparent relation between radio and disk nor.
axes.

Sources bent by ram pressure of intracluster gas disk?
NGC1068 bends in the wrong sense.
Modelled like Begelman et al Head-Tail model
but gravity law and rotational dynamics added.
Needs flattening of solid-body curve to slow
down the bending.
Could be gravic gradients?

Radio power correlates ⊕ with line width.
Deviations from solid body not seen in same
direction as radio jet in NGC4151.
Motions of clouds galactic nor. + acc. by beams.

P.Parma. WSRT → electrons around the jets in 0326+396 and 1321+31.
Model dep^nt: and very deep
→ energy escaping from jet ?

Bob Hjellming. SS433 **α = 0.6** shows up v. commonly.

<10% deviation from $v = 0.26$ along jets.
Exponential decay of blobs in brightness
50 → 90 days.

Kinematic model works ∴ jets dominated by bulk ke. (**not** instabilities etc).

P.Shapiro SS433 ~ 10^6 × more opt/radio than EGRS.
Flow accelerate with v_j shifts continuum beyond Ly α
cutoff → $v_j = 0.28c$!
Can't work in EGRS !!

Sanders Bending of jet in NGC4258 by ram pressure
and static pressure gradient.

Martin Rees

Problems with pressure confinement, e.g. 4C32.69
How to confine them?

① Unconfined narrow jets

Cold jets with shocks → shocked material in blobs
Regions making radio emission need not be confined.

② β $B_{\perp} \to B_{\parallel}$ confines if jet carries net current.

Core overpressured might be all we see as $B_{\perp}$.

Beam material cold clouds embedded in hotter plasma. Entrainment → clouds?
Why not c?

Velocities? Berjets ⇏ ΔI (van Gorkom et al.)
Kinematic models (B. & I. ?)
Depol. → subrel. to keep energy and momentum fluxes reasonable

VLBI → superluminal.

Stability? Linear theory → vulnerable to a zoo of instabilities.
Do radio obs → jet params?

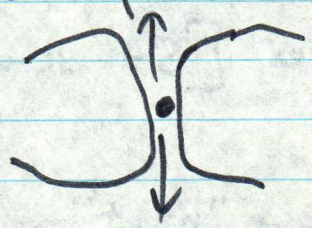
MJR cont'd.

If collim. occurs so close to BH then Lense-Thirring effect constrains accretion disk to have aligned with BH rot^n. Whatever the orig. $\vec{J}$ mtm.

Suppose accretion onto normal obj at low $\dot{M}$.

Inward drift time < Thermal cooling time
Electron-ion coupling time.

→ rotating cloud supported by ion pressure



If $\vec{B}$ twisted hole → extract energy from BH itself, not just from accretion. $10^9 M_\odot$ BH with max $\vec{J}$ mtm → 10^{45} erg.s^{-1} for H_0^{-1} !!!!
(Power radio sources by primordial $\vec{J}$ mtm stored up in BH.)

Cen A lin scales $10^8 : 1$.
Must be cascade of scales and possible collimation - recollim.
Large scale "meteorology"?
Small scale, relativistic plasma physics?

Segelman

Assume $p_{min} \sim p$

Viscous Dissipation in Jets.

Ohs → get heat up as they wide.

$P \sim \rho^{\gamma}$ with $\gamma < 1$ (now just $< 4/3$!)

→ Dissipation determines effective eq. of state.

Assume ripping bulk ke. by viscous stresses.

Dp → adiabatic acceleration

Entrainment, loss of momentum (sideways)

$\nabla \cdot S \sim \frac{S}{\delta R}$ decelerates jet per [S = stress]

→ heat.

V. thin jet, large shear, more "heat"

Increase per entropy.

High stress → pressure can exponentiate.

Ratio of viscous stress to pressure ~ can easily determines whether or not balance is kept.

Dissipation per meets $S \sim Dp$.

Entrainment in supersonic jet cannot make $\dot{M} \to 2\dot{M}$ & remain it's supersonic (?)

Once subsonic, entrain all you want.

Smarr.

① MHD near BH $\sim 10^{-5}$ pc
② Twin-exhaust nozzle
③ Large scale deflections.

Wilson (1972) → flow into Kerr BH
Updated.

Impossible to develop de Laval nozzle unless entraining knots from cavity wall into flow.

If central luminosity is not high enough for a given cloud rep → "bubbles".
If too high, nozzle goes R-T unstable.

In jet, internal shocks are periodic → knot formation. Essential.

Rieke. IRxs's are dust heated by starburst.
1413+135 – monoenergetic electron synch
power law with steep cutoff.
radio → IR but X-ray xs

F. Pacini Central Sources
Equipartition → $E \geq 10^{60}$ ergs
CR physics → $E_p/E_e \sim 10^2$
but $E_p/E_e \simeq 1$ in Crab Nebula
(dynamic IV expel too fast)

Lifetimes $\sim 10^8$ yrs
L to 10^{47} erg.s^{-1} $E = LT \rightarrow 10^{62}$ ergs. (up to)
$\sim 10^8 M_\odot c^2$

Conservation on grav. energy?
Two model types
(a) many *-mass objects
(b) supermassive objects ← $10^8 M_\odot$ stars, magnetoids, black holes

Outburst phenomena $\gg E_{SNR}$ or even $1 M_\odot c^2$
hence (a) unfashionable.

$\frac{Gm^2}{R} \sim 10^{62}$

$R \sim R_{Swartz} \Rightarrow M \sim 10^8 M_\odot$.

Dynamics won't distinguish BH from something 3 or 4 x bigger than BH.

BH more stable than spinars, magnetoids.
→ BH most favorable theoretically?

Conversion Mech?
Accretion $L \sim 10^{47} \frac{\dot{M}(yr^{-1})}{M_\odot}$ ergs/s

Electrodyn. outflow $\sim B^2 c R^2$

$$L \sim 10^{47} \left(\frac{B}{100 gauss}\right)^2 \left(\frac{R}{10^6 cm}\right)^2$$

Accretion models stimulated: work for gal. Xray s's.
Classical accretion is too cold.
SM objects, mix it with $\underline{B}$ fields.

Electrodynamic outflow works for BH's and spinars.
- works in Crab Nebula

Phys. parms
VLBI → 10^{19} cm $B \sim 10^{-2}$ gauss
optical lines 10^{17-18} cm $B \sim 10$ gauss
variability
opt, Xray continuum $< 10^{16}$ cm $B \geq 10^2$ gauss

2 constraints:- Very few thermal particles $\leq \frac{kT^2}{\sigma_T} << N_\odot$
Very short particle lifetimes
Need accel^n ($10^{13} \rightarrow 10^{18}$ cm).

Corollary: Diffuse acc^n, not injection of new electrons.
(too many compton depolarize).

Pacini/Salvati 1978

B 10^2-10^3
R 10^{15}-16 cm
γ 10^2-10^3

→ strong X-ray (C^{-1}).

Cavaliere/Morrison 1980.
Rel. Teachi limits $\gamma_{maximum} \frac{3\times10^7}{\sqrt{B}}$

→ SM collapsed obj 10^8-10^9 $M_\odot$ required.
Whether BH or SM* hard to distinguish

Reeo: spinar must be held up by pressure, radiation or Eddington limit.
- short-lived precursor stage to BH or beor.

K. Thorne
Rel. gravity round BH.
Double-BH must precess (Geodetic precession)
Make 1 of them a radio source.
No other way to make a BH precess!

Begelman: If accretion disk has more than mass of BH, then jet could precess around normal for axis? Thorne: not sure.

1.7 sq.deg. Braccesi field — Tananbaum

MMT.

Braccesi UV xs objects more *'s than expected in 18-19^m. Xrays better judge of real QSO's.

Confirmed QSO's fit $L(z) = L(0)\exp\left[8\frac{z}{1+z}\right]$ Hess. OK

Some are "extended images", not real or higher-quality imaging (Véron)

α_{ox} 1.09 → 1.58 for 10 QSOs in field $B<19.2$

$\bar{\alpha}_{ox}$ 1.37 ± 0.10

QSO's ~ 10% ± 5% of X-ray background (18^m-19^m contrib.)

Repeats from a Complete sample S4, S5 > 1.3 Jy $\delta > 35°$ — Readhead

Hybrid mapping. Continuous 12^h

≥4 telescopes. + closure phases.

~50 objects mapped, up to 6 epochs. 6 freq.

Many core-dominated asymmetric structures ← called "jets"!

Conv. flat-spect. Asymm. structures steep-spect

Some "genuine" equal 2ples. ~ $50'' \times 10^{-3}$

Spectra ⌒ tend to be associated with these rather than — or ⌣. Therefore believe that it's double around "quiet" center, early stage of evolution of a large-scale double?

Reeder cont'd

3084 # of compact bright emitting regions in diffuse-spect halo.

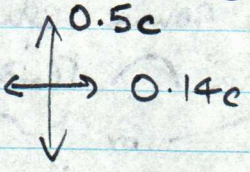
~70% of resolved mapped objects (not "complete sample") core-jet.
~15% "equal double"
5% "complex"
~10% double or core-jet.

35% of all mapped are only slightly resolved

Small-large scale alignments ie 3C111, 236, 774, 3923, Cyg A, NGC315, NGC6251.

He uses as evidence for relativistic beaming.
(need v. high velocities for cases like NGC315, NGC6251 which are ~~close to limit~~ already so large they must presumably be in plane of sky, or for ones like Cyg A which have dust lane almost edge-on so must also be close to plane of sky).

Romney HOGFACE NGC1275 VLBI of core 2.8cm



M. Reid M87 and VLBI

Jet ∥ to large-scale jet (base) and on same side

Unresolved transverse ($< 3\times10^{-3}$ ")

Looked for cpts in knots.

Compact $< 4\times10^{-3}$" in inner 2 knots < 20 mJy.

No evidence for internal structure in knot.

VLA limit $< 300\times10^{-3}$ "

VLB $> 100\times10^{-3}$ " → 0".2 ± 0".1 !! (Knot "D")

for unresolved VLA jet knot

Possible "Wiggles" in jet. N/a similar to Kerr VLA jet.

E. Schreier M87 X-ray. new data on jet.

Overall spectrum $\alpha_{R-O} = 0.6$

$\alpha_{O-X} = 1.3$

→ synchrotron extrapolation ?

Thermal gas pressure ~ 10× too low to confine inner jet

~ 20" out can confine.

HS X-ray object → definite assn. 

like Korayi nebula. Hence C^{-1} ?

Consistent with Bes in the radio halo.

X-ray enhancement around jet similar to Ford/Butcher filament

Similar pressure to

Cotton VLBI pol'n of 3C454.3 few %.
Quasi-circular jet primarily Li-γ particles with well-ordered B∥ outside the probable opt-thick region.
Knot with disordered B
Little thermal plasma in front of jet
(RM ~ -33 rad/m².)

Robert - 3C286 B_1 to NB jet? (RM small).

KJ²

Spangler Flat spectra. Superposition requires conspiracy.
Sharply-peaked synch spectrum is really power-law. Relativistic Maxwellian helps much
So does inhomogeneous source.

Sherwood All optically discovered emission line Q80's in Osmer/Smith sample are sources at 300GHz. Only 6 are radio sources.

ParCrane Abs. line FWHM 480 km/s
SgrA τ ~ 0.4%
v_{cent} 5320 km/s
4×10^{18} cm^{-2}K^{-1}

Linda Dressel

Is Correl. bet nuclear activity and HI content?

No.

"Good" correl. bet. HI detection and $\lambda 3727$ emission

Mike Davis

0235+16 BLLac. Abs at $z = 0.524$ (Radio)

Variable HI abs. in amplit.

Possible variable in V.

R. Fanti Low freq var. (408 MHz)

30-40% of flat-spectrum sources var at ~10% level

"flat-spectrum" means around the freq. at which the variability is found.

~1 mex every ~ yr. (Sinclair vs cm $\lambda\lambda$.)

T_b problem $\tau_{var} = (1+z)^{-1}\left(\frac{d\ln S}{dt}\right)^{-1}$

$\rightarrow T_b \sim 10^{14}$ K

Show structure few milliseconds on VLBI ✓

R. Moore Most QSO's pol. < 2% (optical)

few > 4% → 20%. ⇒ Two types?

Highly pol'd QSO's are OVV.

all radio-loud. (~15% radio loud are HPQ)

frequent low-freq variables.

Moore cont'd

No differences in z

em. line widths

optical luminosity.

HPQs are "similar to BL Lacs".

likes std. beaming model for HPQs, except they don't have weaker emission lines so go into "enhanced" continuum.

M. Cohen >C Sources.

3C120, 273, 279, 345, 179, NRAO 140, [redacted]

He claims these cores are not moving (can ID'd cores by s. index, although per beam do not separate.

3C120 MTRLI → "jet." (Get from Wilkinson).
~10", curved.

3C273 0.76 mas/yr.
3C120 1.8 mas/yr
3C345 0.36 mas/yr
NRAO140 0.13 mas/yr
3C279 ~0.5 mas/yr
3C179 ~0.1 mas/yr

Maischer

NRAO140.

Has now observed 3 - 10c expansion if $\begin{cases} H=100\ q=1 \\ \downarrow \\ H=50\ q=0 \end{cases}$

Porcas 3C179 QSO $z = 0.843$

Double radio lobes LAS 14"

Apparent transverse $v = 7.6c \pm 1c$ ($H=55$)

→ problem for Scheuer/Readhead ?

Konigl Prediction of the SIR model

→ unbeamed outer lobes should be seen as low surface-brightness steep-spectrum halos around strong compact cores. He says Perley data confirm.

[redacted]

Shaffer $\log N / \log S$ for radio selection in PG QSO sample does not favor preferential selection of rel. beamed cores.

Osterbrock

Donna Weistrop

1) Are all BL Lac in galactic nuclei?
2) z_{gal} for BL Lac. $z_{gal} = z_{BL}$?

CCD imaging.

5 BL Lac's obs. 3 are extended prsonne + giant E gal
For 2 objects opt flux predicts Xray flux
Point sources in 2 regions. opt + Xray can be synchrotron
Absolute magnitudes of underlying galaxies $M_V \sim -22^m$

Maarten Schmidt

Density Evol. $= f(L_{opt})$
Quasars 360 Gpc^{-3} $\rightarrow$ 36000 Gpc^{-3}
$z \sim 0$ $z = 3$
Slope of QSO counts 15^m–18^m (B) $\frac{d \log N}{d \log S} = -2.3 \pm 0.15$

"Copernican" unless redshifts large, in which case the look-back time gives you a reason for geocentrism!

Predict ≥ 20 QSOs $z = 3.7 - 4.7$
$B < 20.5$ in 5 sq. deg

But Osmer found none.
Thus either QSO turn-on or $z \sim 3.5$
or dust assoc. with gal. formn. important.

Jais Wall

① Strong cosmic evolution for steep-spect ex r. sources
e.g. Cyg A. Only most luminous sources

② Similar evolution for flat-spect compact sources
e.g. 3C273

5C12 33% ids to 21^m
no bluing of radio galaxies, (unlike Kargent)

2.7 GHz N Hemisphere catalog 168 sources >1.5 Jy
$\langle V/V_{max} \rangle = 0.68$ for flat-spect QSOs

Source counts two-dpt — flat-spect
steep-spect

Peacock Opt-selected QSO's could be lensed by *'s
Pseudo QSOs near galaxies? (Arp)

Double QSO (Burke)

0957+561 — is double image imaged by gal + cluster mass distrib. ≠ light distrib.

Porcas et al. Box radio QSO's one-jet is dense pa

Triple QSO <40 μJy at 6cm

P. Moore 3rd image should have jet ther merges with jet from S QSO image.

Shklovsky SS433 low Xray, radio lum rel optical compared with typical QSO.

10^{-4} Xray/opt ratio
10^{5} radio/opt ratio
] ⇒ ≠ Scalable