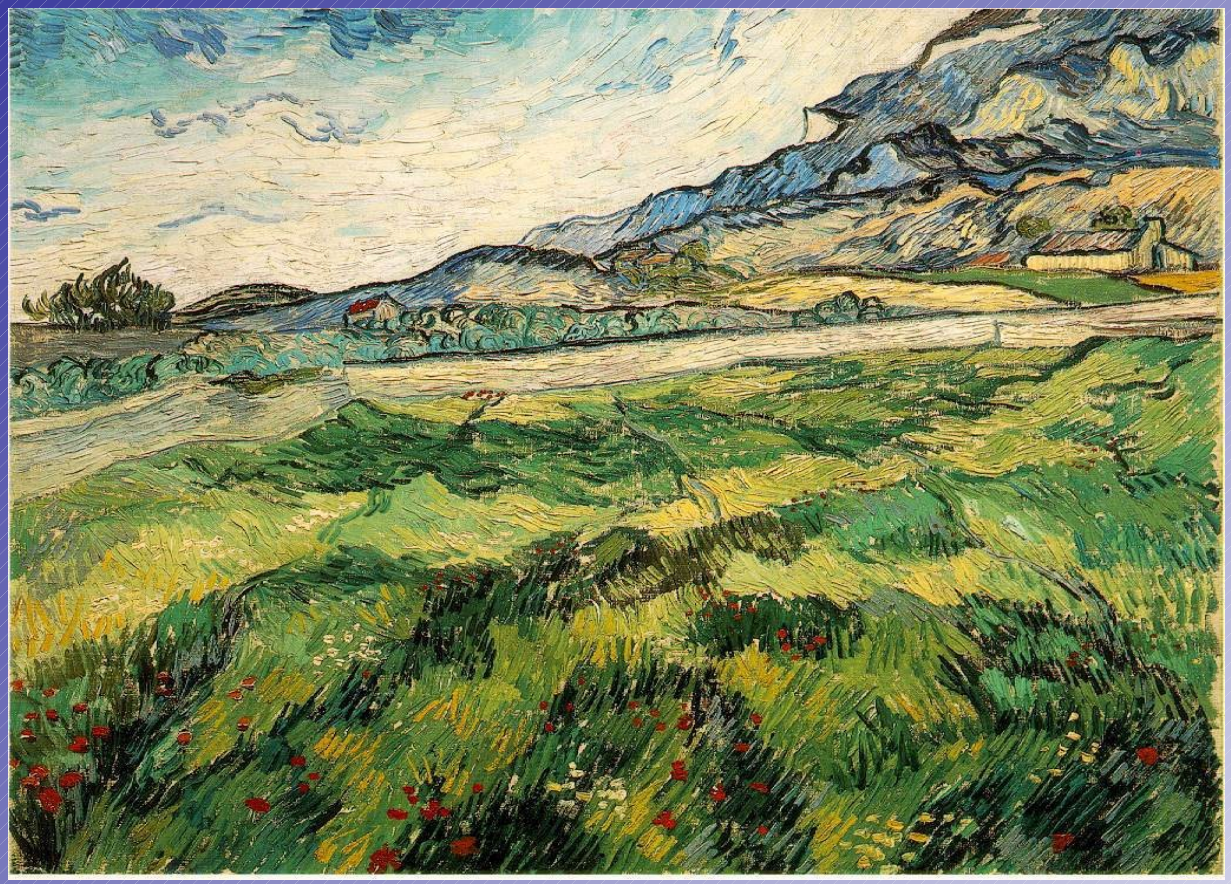
BAL QSOs: status of the field

- Radio papers -

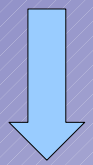


BAL QSOs meeting
24-26/06/09
Bologna

The Compact Structure of Radio-Loud Broad Absorption Line Quasars

Y. Liu [1,3⋆], D. R. Jiang[1,3], T. G. Wang[2,3], F. G. Xie[1,3,4]

- EVN + MERLIN observations of 8 BALs @ 1.6 Ghz
- 4 LoBals + 4 HiBALs, either steep or flat VLA spectra
- Only J1122+3124 shows two sided structure ~ 2 kpc
- 7 sources with unresolved or core-jet structure < 300 pc
- Polarization < 10%, synchrotron emission
- No apparent difference between HiBALs and LoBALs radio-morphology nor between flat and steep spectrum sources

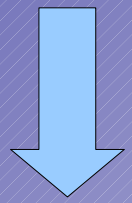


BALs are probably young radio sources

Polarization of Quasars: Rotated and Funnel-shaped Outflow

Hui-Yuan Wang, Ting-Gui Wang and Jun-Xian Wang

- Polarization as a probe to investigate geometries and dynamics of BAL outflows
- Monte-Carlo simulations to reproduce polarization produced by resonant and electron scattering in BALR (observed by Ogle et al. 1999)

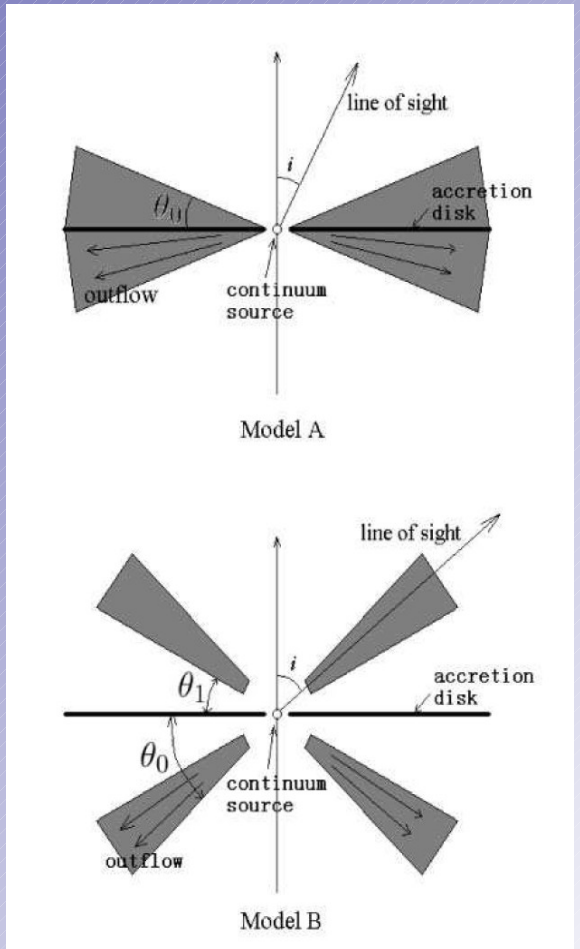


- A rotated and funnel-shaped outflow is preferred to explain many observed polarization features
- The resonant scattering can contribute a significant part of NV emission line in some QSOs

Polarization of Quasars: Resonant Line Scattering in the Broad Absorption Line Region

Hui-Yuan Wang, Ting-Gui Wang and Jun-Xian Wang

- Monte-Carlo simulations of electron and resonance scattering process in the BALRs
- Both singlet and doublet transitions are considered for radial outflows of two different geometries: equatorial outflows and hollow-conical outflows with and without rotational velocities
- PA rotation in the absorption trough can be produced only when the outflow carries angular momentum
- subtending angle of the outflow should be larger than 25°
- They show that the resonantly scattered light will contribute a significant part of NV in some QSOs and can give rise to anomalous strong NV lines in these QSOs



A sensitive submillimetre survey of Broad Absorption Line quasars

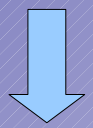
Robert S. Priddey[1⋆], S.C. Gallagher[2], K.G. Isaak[3], R.G. Sharp[4], R.G. McMahon[5] H.M. Butner[6]

- SCUBA submillimetre survey of 15 radio-quiet BALs from the Large Bright Quasar Survey (LBQS: Hewett et al. 1995), identified by Weymann et al. (1991)

- 2 goals:

  1) test the null hypothesis H0: BALQs and non-BAL quasars have identical submm properties

  2) determine the 850μm flux distribution, the submm (850 + 450μm) contribution to the SEDs, and the relation between submm and other properties of a well-selected, well-studied sample of BALs



- submm properties of the BAL and non-BAL samples appear to be similar

- "typical" 850μm flux density of an optically luminous, z=2 BALQ is 2–3mJy

- tentative evidence for a dependence of submm flux on the equivalent width of the C IV broad absorption line

THE SUB-MILLIMETER PROPERTIES OF BROAD ABSORPTION LINE QUASARS

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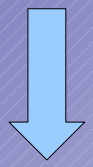
Draft version February 5, 2008

- 30 BALs drawn from a homogeneously selected sample from the SDSS at redshifts $2 < z < 2.6$ observed with the SCUBA array at the JCMT
- There is no correlation of sub-millimeter flux with either the strength of the broad absorption feature or with absolute magnitude
- BAL quasars do not have higher sub-millimeter luminosities than non-BALs



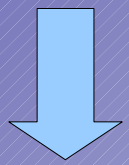
consistent with the hypothesis that all quasars would contain a BAL if viewed along a certain line-of-sight

Polar Outflows in Six Broad Absorption Line Quasars

Hongyan Zhou[1], Tinggui Wang[1], Huiyuan Wang[1], Junxian Wang[1], Weimin Yuan[2], and Yu Lu[1]

• Using the radio observations by FIRST and NVSS, they build a sample of 151 radio variable quasars selected from the SDSS DR3

• 6 (+2) are classified as BAL QSOs, with radio flux variations of a few 10 percent within 1.5-5 years



• large amplitudes of the variations imply brightness temperatures much higher than the inverse Compton limits (1012 K) suggesting the presence of relativistic jets beaming toward the observer

• the angle between the outflow and the jet is constrained to be less than ~ 20°

Multi-frequency radio observations of BAL quasar 1045+352

Magdalena Kunert-Bajraszewska Andrzej Marecki

- Multi-frequency 1.7, 5 and 8.4-GHz VLBA observations of a radio-loud BAL 1045+352
- young compact steep spectrum (CSS) object
- asymmetric, two-sided morphology on a scale of several hundred parsecs, extending in two different directions, may suggest intermittent activity
- young age and unusual morphology of 1045+352 are arguments in favour of an evolutionary scenario for BAL quasars

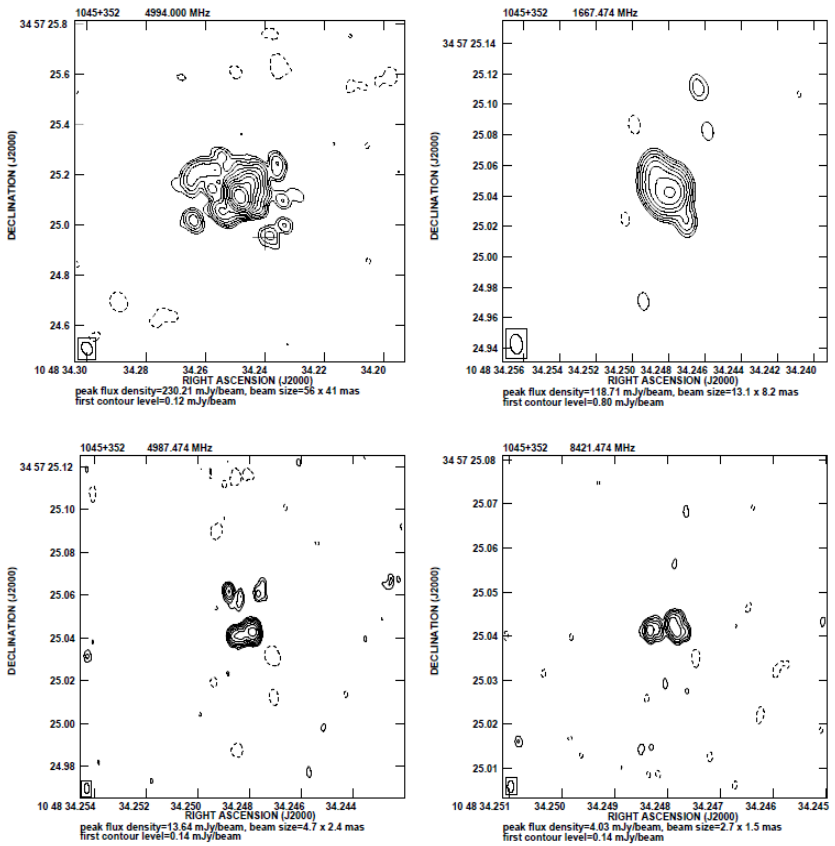


Figure 1: The MERLIN 5-GHz (upper left) and VLBA 1.7, 5 and 8.4-GHz maps of 1045+352. Contours increase by a factor 2 and the first contour level corresponds to $\approx 3\sigma$. Cross indicates the position of an optical object found using the SDSS/DR5.

Inner radio structure of compact BAL quasar 1045+352

Magdalena Kunert-Bajraszewska Marcin P. Gawroński

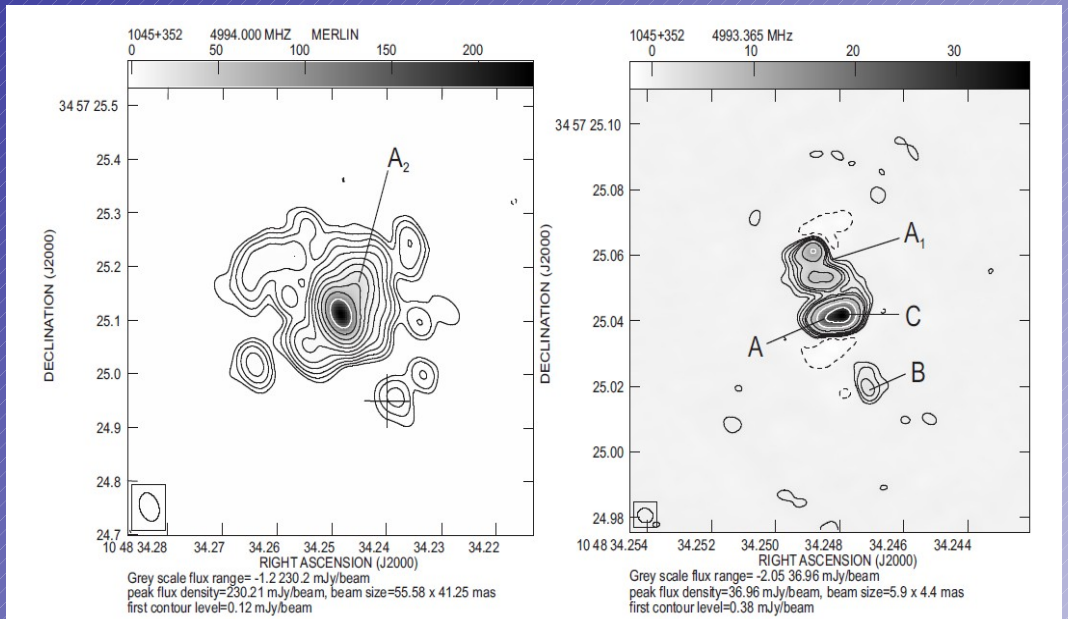


Figure 1: The 5 GHz MERLIN image from [5] and the new 5 GHz EVN image of 1045+352. Contours increase by a factor 2 and the first contour level corresponds to $\approx 3\sigma$. A cross indicates the position of an optical object found using the SDSS.

- new full-track radio observations of 1045+352 made with the EVN+MERLIN at 5 Ghz
- presence of strong interactions between the jet and the medium of the host galaxy
- strong jet-cloud interactions present in that source and changing the jet path

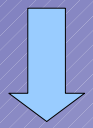
Evidence that FeLoBALs may signify the transition between an ultraluminous infrared galaxy and a quasar

D. Farrah[1] M. Lacy[2] R. Priddey[3] C. Borys[4] J. Afonso[5]

• mid/far-infrared photometry of nine FeLoBAL QSOs, taken using the Spitzer space telescope

• all nine objects are extremely bright in the infrared, with rest-frame 1-1000 μm luminosities comparable to those of ULIRGs

• possibly all of the sample is likely to arise from star formation



• FeLoBALs mark galaxies and QSOs in which an extremely luminous starburst is approaching its end

• rapidly accreting supermassive black hole in the last stages of casting off its dust cocoon

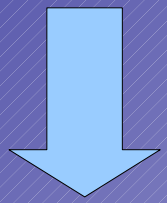
• FeLoBAL signatures in high redshift QSOs and galaxies may thus be an efficient way of selecting sources at a critical point in their evolution

DEPENDENCE OF THE BROAD ABSORPTION LINE QUASAR FRACTION ON RADIO LUMINOSITY

Francesco Shankar,[1] Xinyu Dai,[1] and Gregory R. Sivakoff[1]

- the fraction of classical BALs among the FIRST radio sources in the SDSS DR3 is:
  - $20.5^{+7.3}_{-5.9}$% at the faintest radio powers detected ($L_{1.4}$ [GHz] ~ 10^{32} [erg/s])
  - rapidly drops to ≤ 8% at $L_{1.4}$ [GHz] ~ 3×10^{33} [erg/s]
- adopting the broader absorption index (AI) definition of Trump et al.:
  - the fraction of radio BALs reduces from $44^{+8.1}_{-7.8}$% to $23.1^{+7.3}_{-6.1}$% at high luminosities
- the trend is independent of the redshift range, the optical and radio flux selection limits, or the exact definition of a radio match
- quasars identified as AI-BALQSOs but not under the classical definition do not show a significant drop in their fraction as a function of radio power
- balnicity index and mean maximum wind velocity are roughly constant at all radio powers

They discuss several plausible physical models which may explain the observed fast drop in the fraction of the classical BALQSOs with increasing radio power

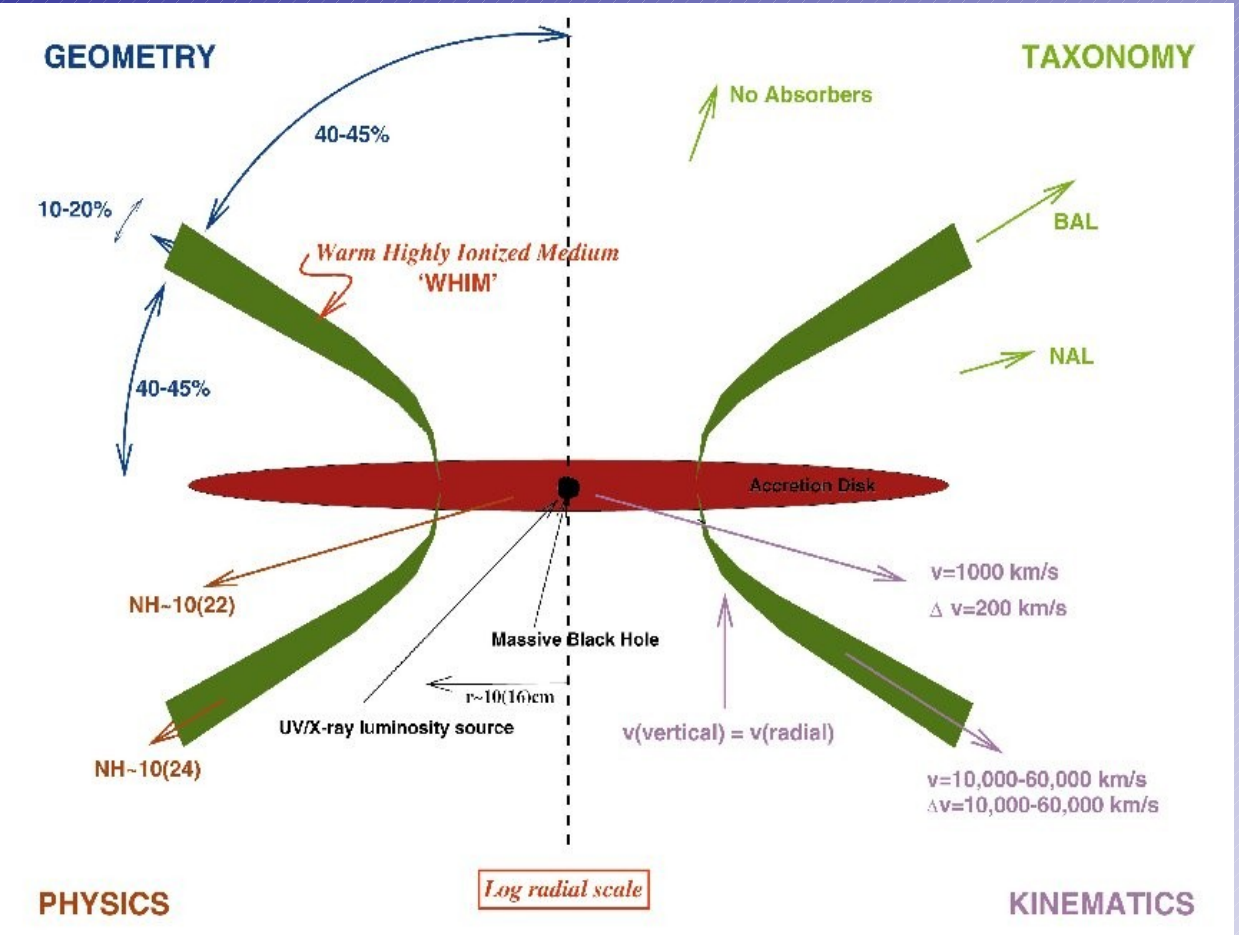


- a strictly evolutionary model for the BALQSO and radio emission phases requires a strong fine-tuning to work

- a simple geometric model, although still not capable of explaining polar BALs and the paucity of FRII BALs, is statistically successful in matching the data

Explanations for the BAL phenomenon

Orientation Scenario:



Martin Elvis (2000)

Explanations for the BAL phenomenon

Orientation Scenario:

PRO:

- Naturally explains why BAL/non-BAL QSOs are so similar
- Explains higher reddening/obscuration in BAL QSOs
- Explains higher polarisation via resonant scattering and other polarization features (Wang et al. 2007)

CONTRA:

- Variety of radio spectral indices (Becker et al. 2000, Montenegro-Montes et al. 2008)
- Found both edge-on (FR II) and polar (strongly beamed) BAL QSOs (e.g., Gregg et al. 2006, Zhou et al. 2006)

Explanations for the BAL phenomenon

Evolutionary Scenario: Young or recently refueled quasars

(Becker et al. 2000; Gregg et al. 2000, 2006;
Kunert-Bajraszewska & Marecki, 2007)

Explanations for the BAL phenomenon

Evolutionary Scenario:

PRO:

- Anticorrelation for FR II BAL QSOs between R* and BI (Gregg et al. 2006)
- Radio BAL QSOs are compact sources “like” CSS/GPS (Montenegro-Montes et al. 2008, Liu et al. 2008)
- young age and unusual morphology of 1045+352 (Kunert et al. 2009)
- BALs as transition objects between ULIRGs and QSOs (Farrah et al. 2007)

CONTRA:

- Same cold and warm dust properties of BAL/non-BAL QSOs (Priddey et al. 2007, Willot et al. 2007)

Thank you!