On the Origin of the BL Lac Phenomenon

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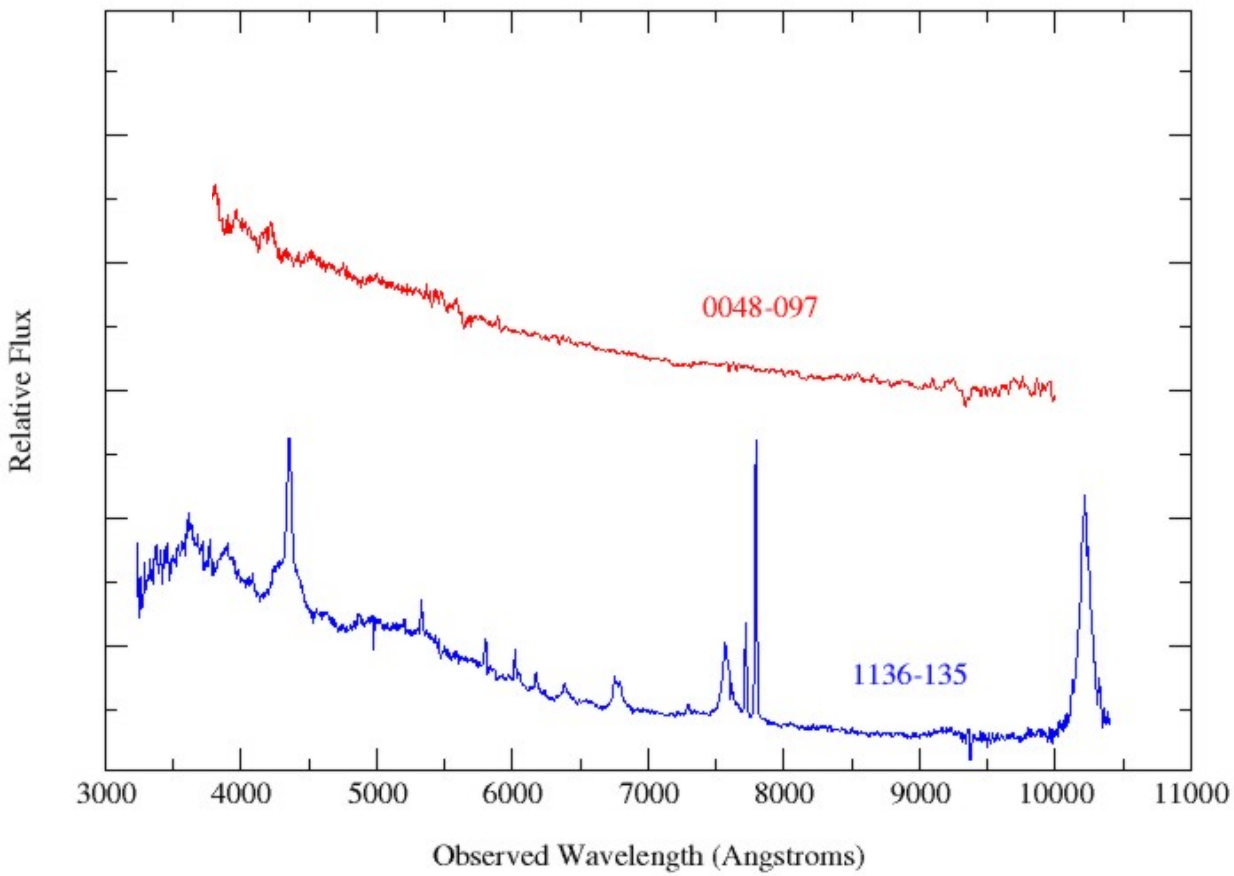
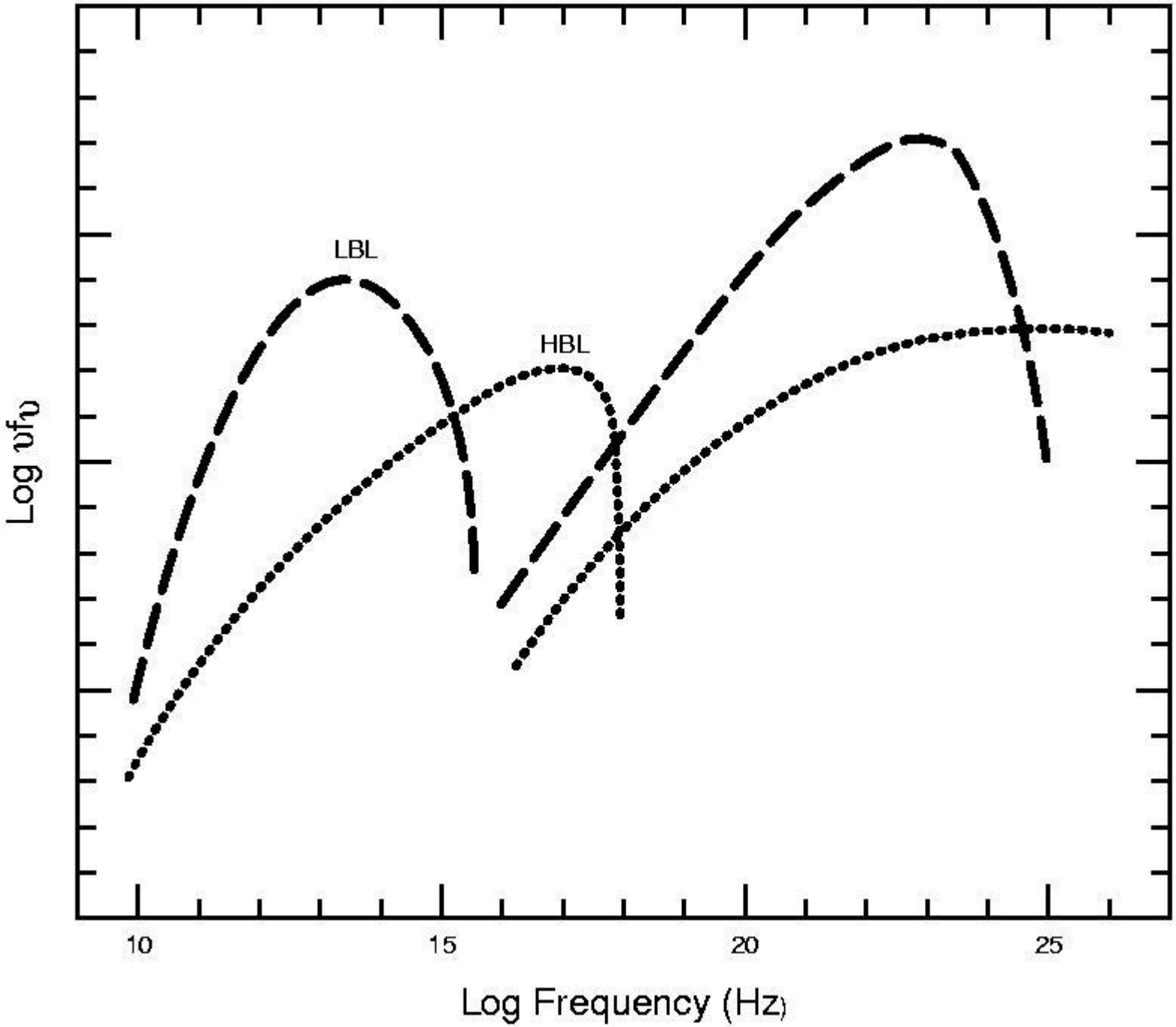
BL Lacs vs. Quasars



Dominant paradigm

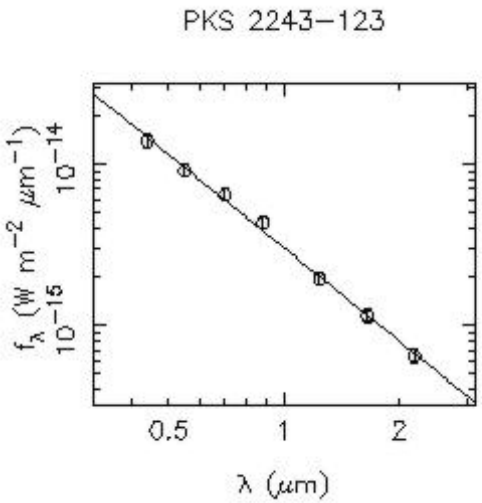
- Commonly attributed to conference paper by Blandford & Rees (1978).
- BL Lacs are viewed close to axis of a relativistic jet.
- Jet emission is strongly beamed, and swamps any emission line radiation.
- Unification models (Urry & Padovani 1995) describe BL Lacs as beamed FR I radio galaxies (the lower luminosity versions).
- Broadband spectra dominated by non-thermal continuum. Classify according to location of synchrotron and inverse-Compton peaks → LBLs,HBLs


LBL
HBL
Log υf_υ
10
15
20
25
Log Frequency (Hz)

Flat-spectrum radio sources

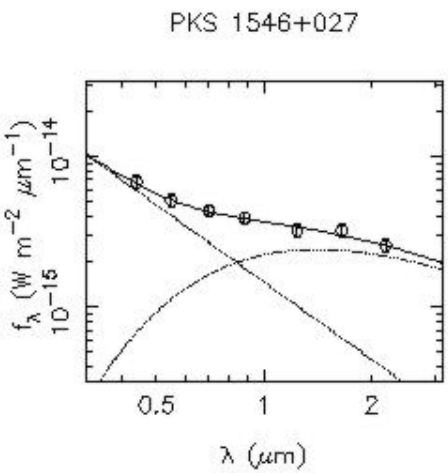
- Look at optical/NIR properties of ‘stellar’ sources from Parkes Half-Jansky Flat-spectrum Sample (PHFS, Drinkwater et al 1997).
- Fit models to BVRIJHK photometry from Francis, Whiting & Webster (2000).
- Models include power law from accretion disc, synchrotron from relativistic jet.
- Able to gauge relative strengths of disc and jet according to the fitted models.
- Results published in Whiting, Webster & Francis (2001), MN 323, 718.

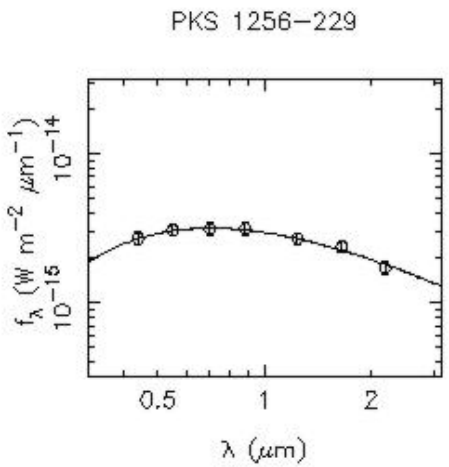
Example fits



Power law

Power law + Synchrotron





Synchrotron

Results of modelling

- Approximately one third of sources dominated by blue ‘accretion disc’ power law. These sources do have synchrotron emission present, but at much longer wavelengths.
  - These are the classical radio quasars, similar to 3C 273: blue optical continuum + broad emission lines.
- Similar number show good evidence for synchrotron emission in the optical.
  - In many cases the synchrotron component dominates the continuum (eg. 1256-229) and no accretion disc can be seen.
- BL Lacs are in this group, but are not the entire group. There are sources with dominant synchrotron that also show strong emission lines.
  - Not just the synchrotron strength that determines “BL Lac-ness” – emission lines are a separate consideration.

Clues From Other Surveys

- UV spectroscopy
  - (eg. Kinney et al 1991)
  - BL Lacs show weak/no lines at UV.
- High-peaking FSRQs:
  - (Perlman et al 98, Padovani et al 2003)
  - From DXRBS, RGB: similar SEDs to HBLs
- 2QZ BL Lac sample:
  - Londish et al (2002)
  - Optically selected. Appear to be different to “normal” BL Lacs.
- “Naked AGN”
  - Hawkins (2004)
  - Apparent type-1 AGN with no broad lines.

How do you make a BL Lac?

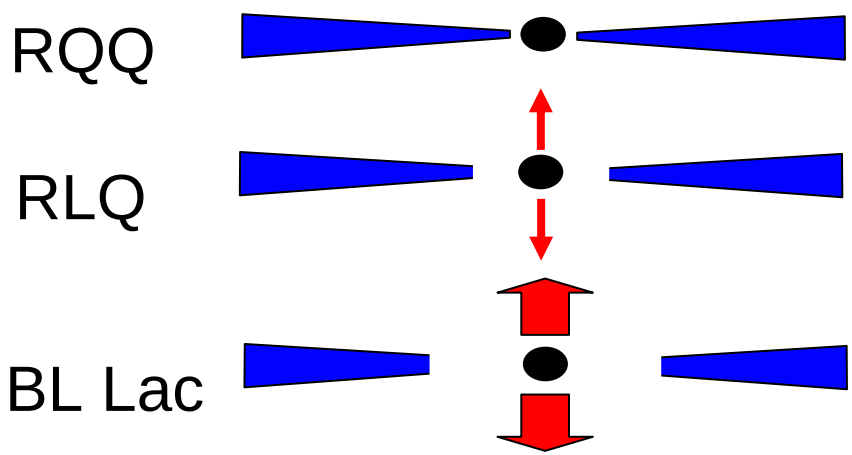
- Lack of lines due to lack of line-emitting gas (either no gas or gas not sufficiently ionised).
- Continuum is dominating more by default, rather than being excessively strong.
- Implies a weak broad line region, or (for radio-loud BL Lacs) a weak accretion disc.
- Weak AD → few ionising photons → weak BLR.
- Or, if BLR originates in a wind (as in Elvis model), naturally get weak AD → weak BLR.
- Still require a strong jet to provide the synchrotron emission in the optical.

Weak Accretion Discs – I

- One accretion scenario is that a “normal” quasar-like disc does not form in BL Lacs.
- Instead, accretion proceeds via a low radiative efficiency process such as an ADAF.
  - Similar to the accretion in the Milky Way BH.
- Still need to form a jet, but this can come about naturally through ADAF-type solutions.
- Consistent with FR I radio galaxies (the suggested parent population of BL Lacs).
- Problem with generating enough extended radio emission?

Weak Accretion Discs – II

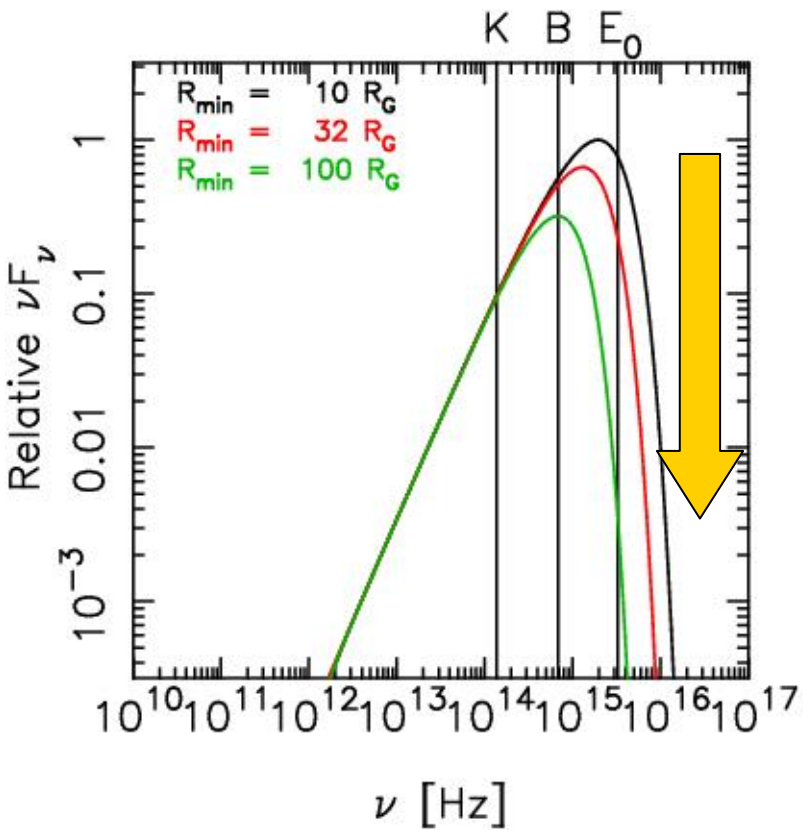
- The accretion process is similar to radio-loud and radio-quiet quasars, but with a greater amount of outflow.
- This means more of the disc is disrupted by the outflow, reducing the net emission.

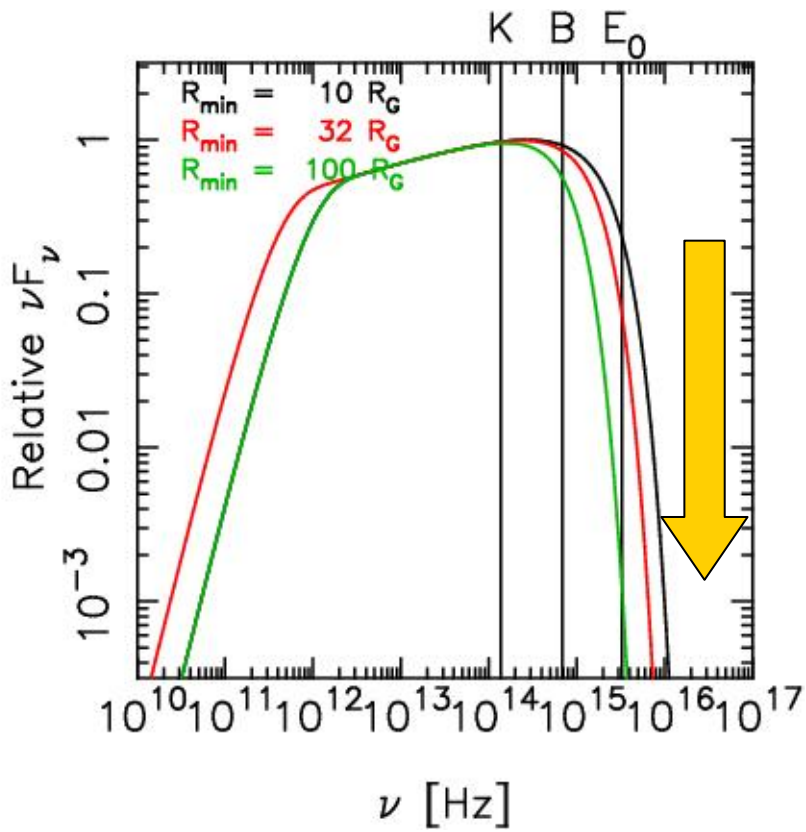


Analogy with Galactic sources

- Compare AGN with Black Hole X-ray binary systems (microquasars) – similar structure and more user-friendly timescales.
- When matter is ejected into the jet, the inner accretion disc (observed via hard X-rays) is depleted, leaving the jet emission (radio) to dominate. (eg. GRS 1915+015, Naik et al 2001)
- Transient phenomenon – does this mean BL Lacs are also a transient phase of quasars?
  - 100s for BHXRB implies ~30-300 yrs for AGN.
- Can we model BL Lacs in this way?

Disrupted Thin Discs

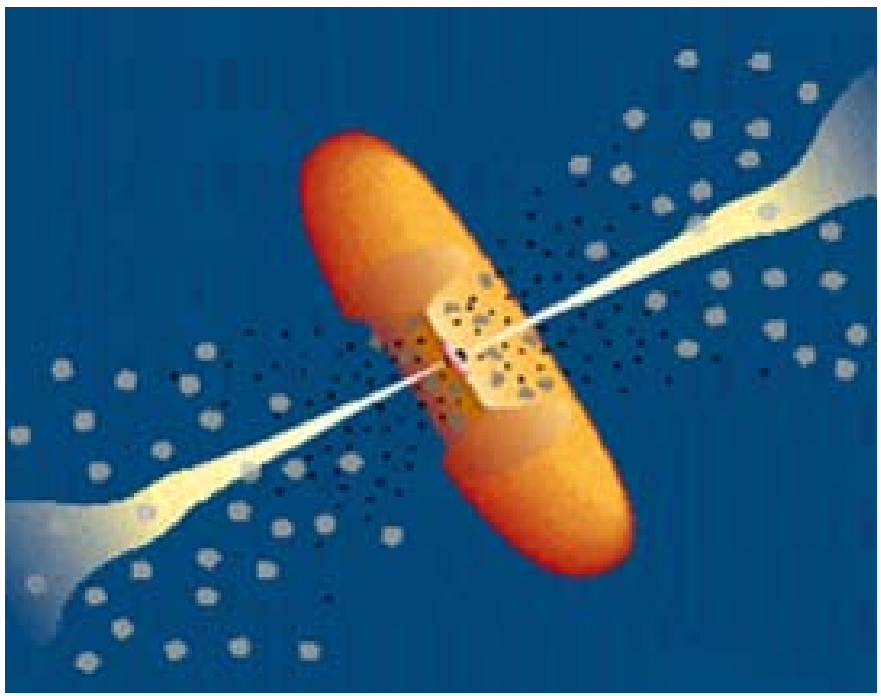




Summary

- Optical SEDs of flat-spectrum sources imply that the featureless spectra in BL Lacs are due to intrinsically weak lines.
  - Not merely due to a strongly-boosted synchrotron component.
  - Lessens strict requirement on viewing angle.
- Different accretion processes occurring in BL Lacs.
- May be due to episodic disruptions of the inner accretion disc.
  - BL Lacs are a transitory phase of radio-loud quasars.
- Ongoing and further work needed:
  - Better spectral modelling of accretion disc and jet.
  - More spectroscopic monitoring of BL Lacs.

Typical descriptive image



BL Lac

Quasar