The physical link between jet formation, hot plasma and black hole spin

Qingwen Wu, Huazhong University of Science and Technology, China

1.Introduction

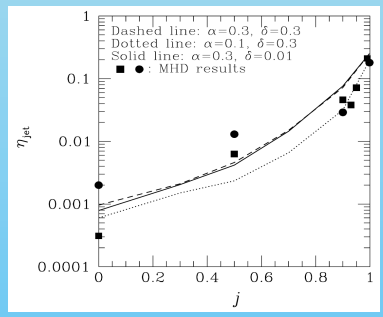
Jet formation mechanism is still unclear. The possible creation mechanisms include: accretion mode (e.g., ADAF, radio emission in low/hard, LH, state of XRBs); black hole spin (BZ mechanism); radiation pressure acceleration etc. The suppressed radio emission in high/soft (HS) state of XRBs suggests that BH spin cannot be the only parameter that control the jet formation. Zdziarski et al. (2011) proposed that radio emission may relate to corona at HS state, which suggest that the evolution of accretion processes may also play a key role in jet formation.

2. Evidence for rapidly rotating BHs in low-power FR I radio galaxies

2.1 Model: ADAF + Jet

ADAF surrounding a Kerr BH is adopted. To estimate the jet power extracted from the inner region of ADAF, we use the hybrid jet model (Meier 2001), $P_{\rm jet} = B_{\rm p}^2 R^4 \Omega^2 / 32c$ where R=R_{ms} is adopted.

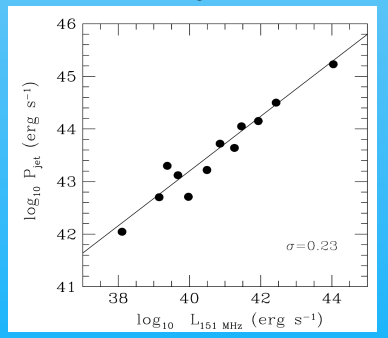
Jet efficiency of this model is roughly consistent with MHD results.

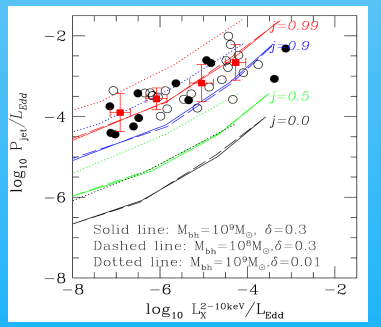


Wu et al. 2011, ApJ

2.2 Results

We estimate the jet power for a sample of FR Is from their X-ray cavities directly or cavity power & L_{151MHz} correlation, bottom-left figure).





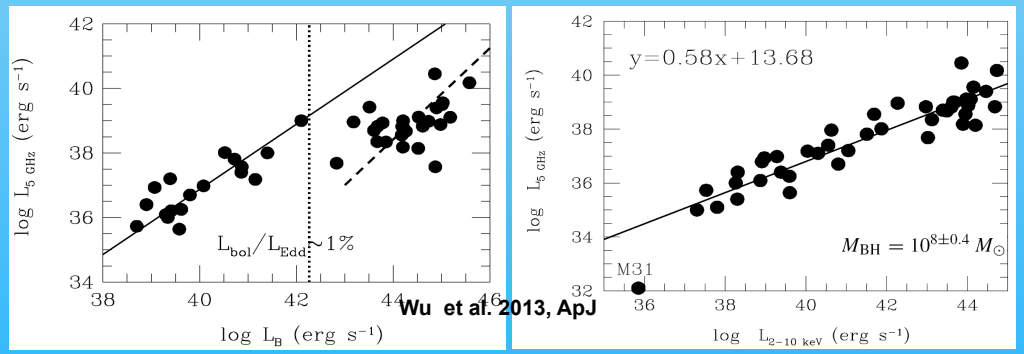
We find that dimensionless BH spin j>~0.9 is needed to reproduce the P_{jet}/L_{Edd}-L_X/L_{Edd} correlation as observed in FR I radio galaxies (bottom-right figure).

Continue (Wu et al.)

3. The relation between jet/outflow and hot plasma

We select two samples of AGNs (with and without large-scale jets) to test the possible relation between hot plasma and jet/outlfow. Each sample have BH mass in a narrow range but with wide Eddington ratio distribution (10^{-8}-1), which can be used to simulate a single BH evolving across a wide spread of states. Sample I include traditionally RQ AGNs (LINERs, Seyfert, QSOs) and Sample II include RL AGNs (FR I/IIs with large jet viewing angles) .

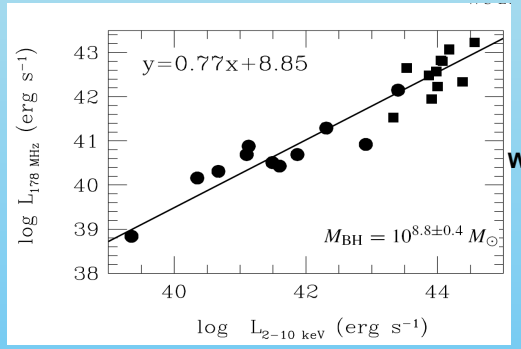
Result:



Wu et al. 2013, ApJ

The radio-optical correlation is roughly consistent with that of XRBs, where the radio emission is suppressed at L_{bol}/L_{Edd}>1%. However, the radio-X-rays follow a single correlation for all sources (the slope is similar to that of XRBs), which suggest that jet/outflow should only correlate to hot plasma (ADAF and corona).

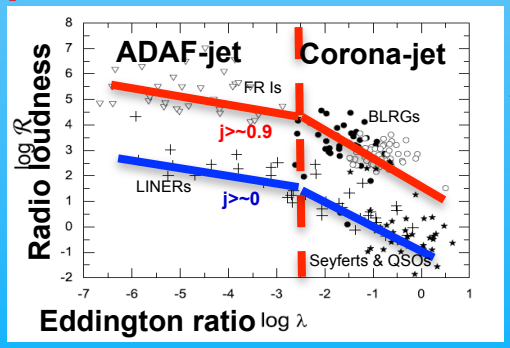
The conclusion is similar for RL AGNs (FR I/ IIs), where jet contribution to X-ray may be not important due to de-boosting effect and $L_{151\ MHz}$ also less affected by boosting effect.



Wu et al. 2013, ApJ

Therefore, these results support that both jet /outflow may closely correlated to hot plasma.

4. Proposed Scenario and Conclusion



Data from Sikora et al. 2007, ApJ, 658, 815

Both the HOTPLASMA and BH SPIN may play important roles in jet formation and evolution!