Accretion and feedback from stellar-mass black holes at (near-)Eddington rates

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black hole binary

supernova

star
Outbursts: increased accretion

Plant, Fender et al. (2014)
changing spectra

Hardness-Intensity Diagram

changing temperature / optical depth / emission mechanism

Plant, Fender et al. (2014)

(e.g. Homan et al. 2001, Fender, Homan & Belloni 2009, Dunn et al. 2011)
changing variability

RMS-Intensity Diagram

hard states are much more variable

Transition states are associated with a characteristic variability timescale (QPO)

Plant, Fender et al. (2014)
Munoz-Darias, Belloni & Motta (2011)
Evolution of jet from ~steady and compact to bright resolved ejections

Diminishing of jet activity and appearance of strong accretion disc wind
GRS 1915+105: two decades of state transitions and relativistic jets at \( \sim \)Eddington
High accretion rates – sometime $\geq$ Eddington are associated with:

– Rapid state changes, connecting accretion, wind and jet

– Sometimes: ultrarelativistic flow

– Sometimes: strong local absorption (cause and effect)
Ultrarelativistic beams:
Unique to very high accretion rates? (and NS-only?)

Very clear evidence in Sco X-1 with slow blobs at $\beta \sim 0.3$ and faster invisible flow at $\beta > 0.95$

Evidence also in

Cir X-1 (NS)
SS 433 (who knows?)

Fomalont et al. (2001)
Fender et al. (2004)
Migliari et al. (2005)
Naked vs veiled: Type I / II Eddington accretion in X-ray binaries

GRS 1915+105
(fast, structured state changes, very clear X-ray:radio connection)

Neutron star Z sources
(fast, frequent state changes, ultrarelativistic beams)

Most XRB transients
(familiar patterns of behaviour)

SS 433
(highly absorbed X-rays, persistent powerful jets, possible ultrarelativistic beams)

Cir X-1
(periodic ~Eddington accretion, possible ultrarelativistic beams)

Cyg X-3
(scattered X-rays, powerful jets, connection to X-ray states)

0.01
none
intrinsic local absorption

≥1

huge

estimated accretion rate / Edd
At 15-06-15 18:28:07 (Monday) an alert of type: 'Swift BAT GRB - initial position' was received. Details are as follows:
ID: SWIFT_643949
Inferred name: GRB 150615
Trigger time: 15-06-15 18:31:38 (Monday)

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Actions taken:
==============
Observation requested from AMI.
AMI request notified to VOEvent network.

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Site reports:
==============
AMI observatory:
LST: 12:03:29.301799
Target is sometimes visible.
Currently visible? False
Rise time: 15-06-15 20:03:57 (Monday)
Transit time: 15-06-16 02:47:20 (Tuesday)
Set time: 15-06-16 09:30:43 (Tuesday)
Transit alt-az position: Horizontal Coordinates: az=179.595453, alt=71.633651

"Target is sometimes visible"

Trigger time: 18:31:38
Rise time: 20:03:57

V404 Cyg
V404 Cyg in context

V404 Cyg is the second-largest black hole binary system (accretion disc) known

Last outburst in 1989

Dynamically confirmed black hole

Radio parallax distance

Casares et al. (1992)
Miller-Jones et al. (2009)
V404: the first day

First day: Radio flare already declining from >100 mJy two hr after burst

Second day: slow variations at ~50 x quiescent level (0.1 mJy)

Analysis by Kunal Mooley (Oxford) / Fender et al. (in prep)
An extremely violent outburst lasting just two weeks.
Radio flares resolved into relativistic ejections

Black hole jet formation resolved temporally and spatially on time scales of min / hr

Fender et al. / Miller-Jones et al. (in prep)
Highly variable absorption, $N_H$ varying by factor $>1000$

Motta et al., *in prep*
Strong, neutral, accretion disc wind

He I-5876 Å (GTC)

Outer accretion disc wind

Munoz-Darias et al.,
*Nature* (2016)
Massive nebular phase after outburst (0.1-100% of total estimated disc mass)

V404 Cyg:
type I ↔ II from its own accretion disc wind

When there is excess local material, get excess radio emission from external shocks.
Conclusions

· We have established a clear phenomenology connecting accretion to feedback in stellar mass black holes and neutron stars

· At the highest accretion rates:
  · rapid state transitions are very common → frequent powerful jet activity
  · Ultrarelativistic beams are observed co-existing with slower-moving ejecta (the hidden secrets of SS433?)
  · Very high accretion rates are often – but not always – shrouded, sometimes by mass transfer, sometimes by accretion disc wind
Fin.