



# Investigating the nature of the brightest ULXs

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# Why we study ULXs

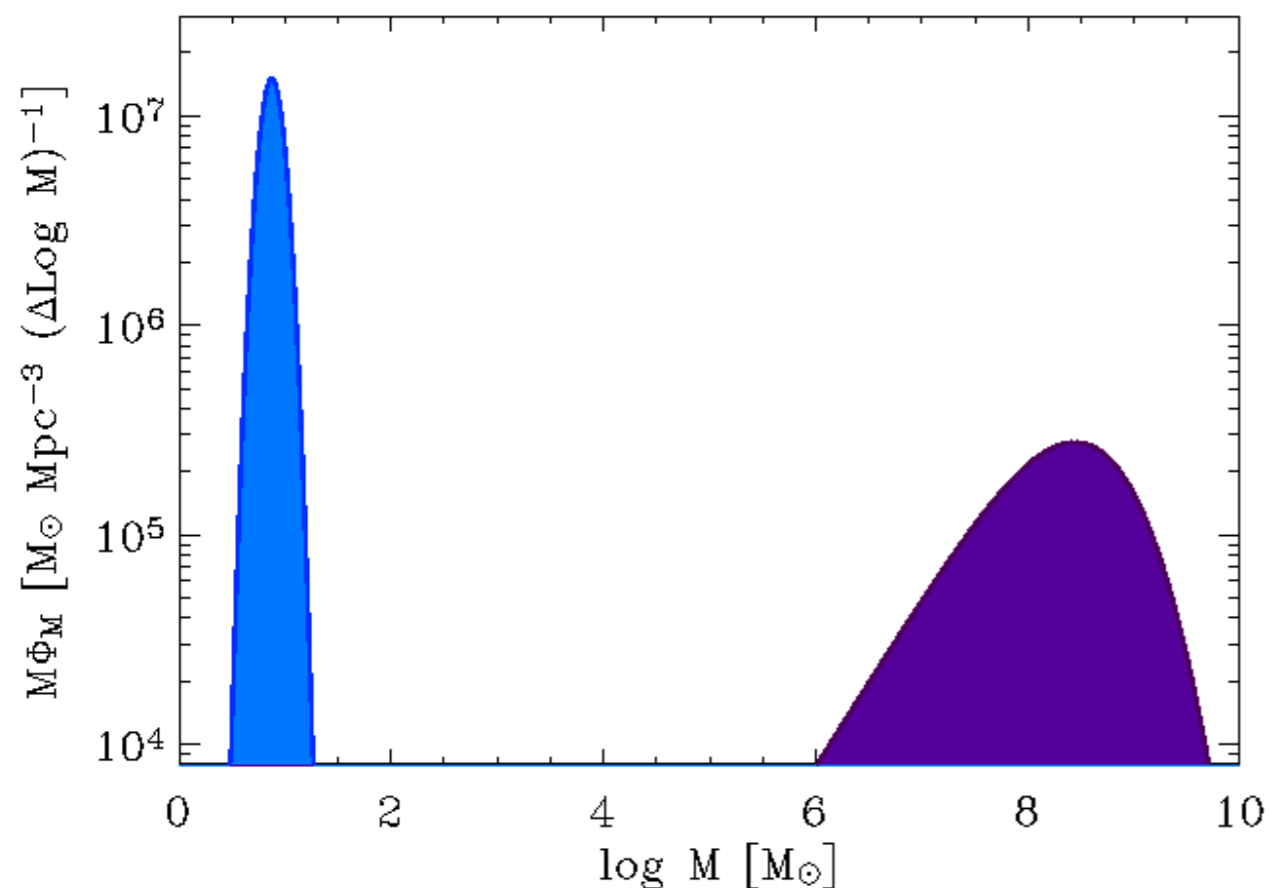
- Most ULXs are probably stellar mass or massive stellar black holes.
- The brightest ULXs may host intermediate mass black holes.
- Some of them may be recoiling supermassive black holes.



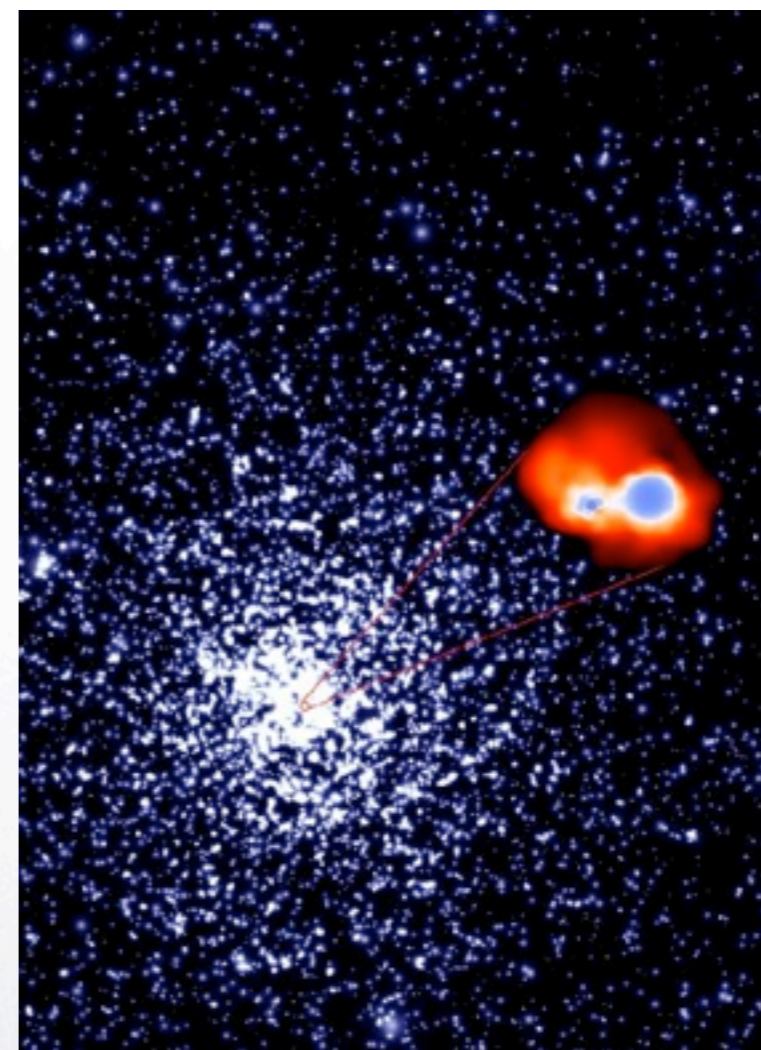
ESO 243-49 HLX-1, a candidate intermediate mass black hole



# Intermediate mass black holes



Distribution of black hole masses;  
figure courtesy of A. Merloni

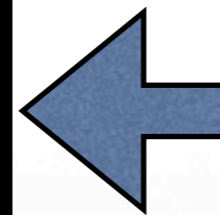


Simulation of MGG I, a compact cluster in M82  
(Portegies Zwart et al. 2004)

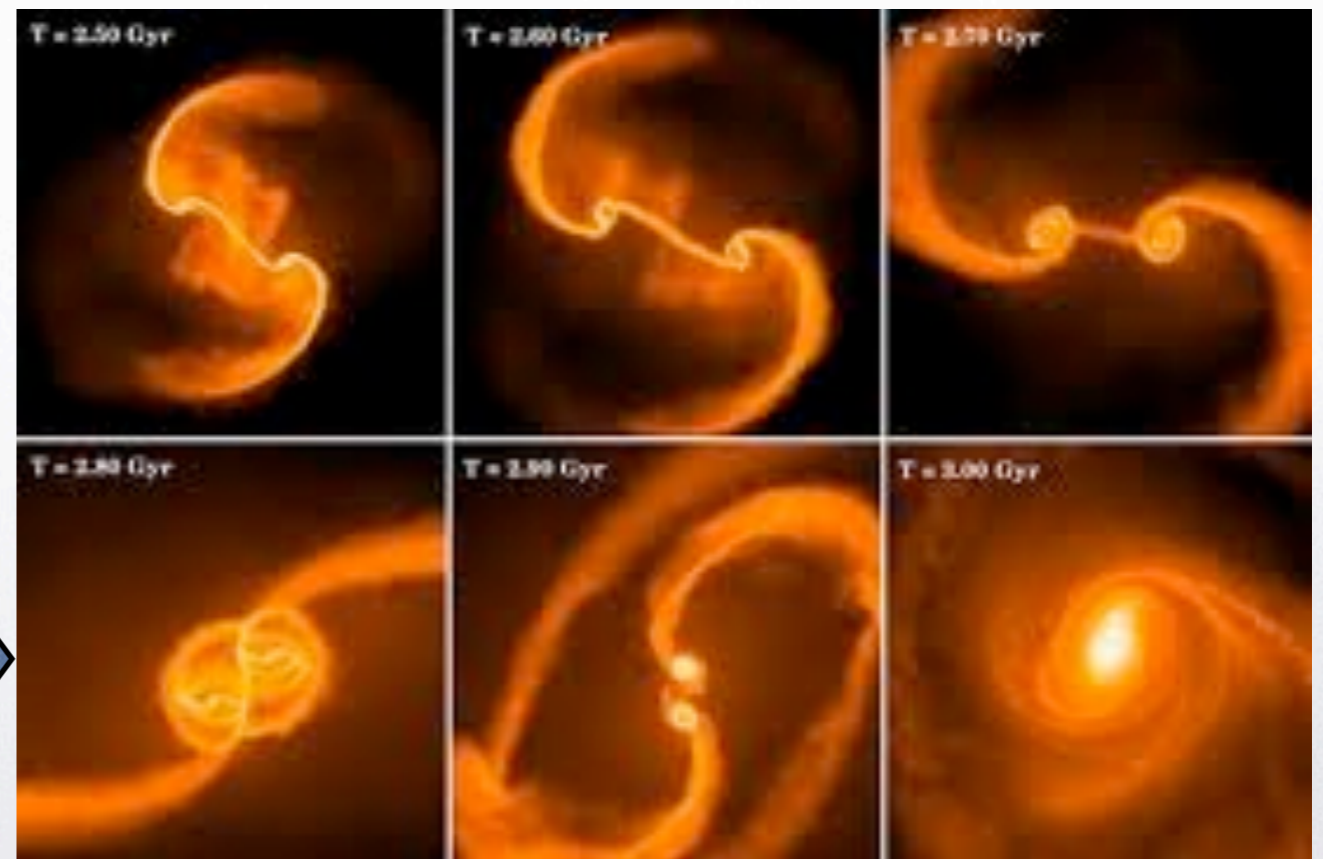


# Recoiling SMBHs

Galaxies NGC 2207 and IC 2163



Galaxies grow through mergers:  
HST image of merging galaxies  
NGC 2207 and IC 2163



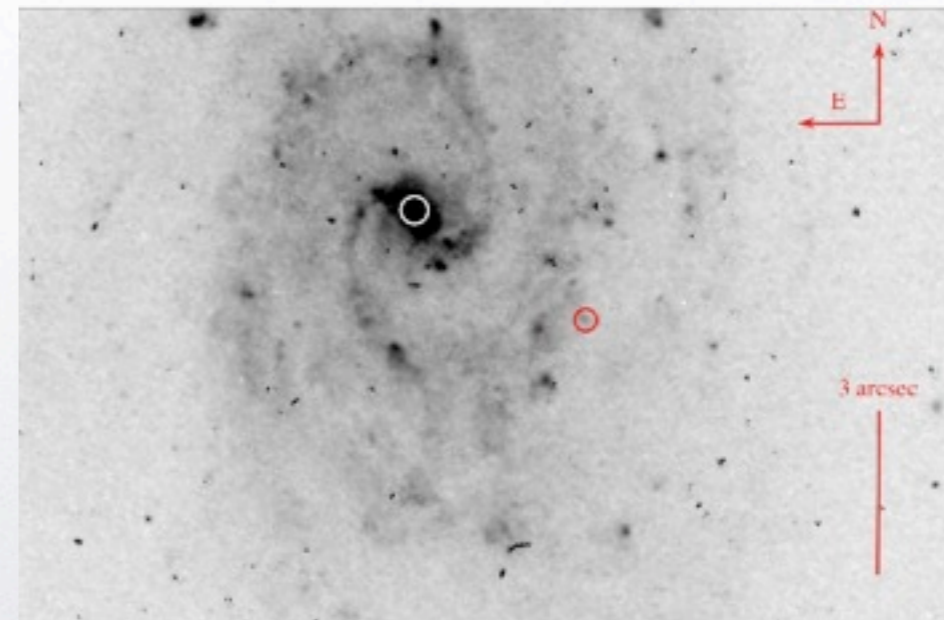
Simulation of a galaxy merger (Mayer et al. 2010). Numerical simulations show that merging black holes can be ejected from their host nucleus.



# Our method

- With optical spectra we can distinguish background AGN, quasars and SN IIn from 'real' ULXs.
- We observed 5 ULXs with bright optical counterparts with VLT/FORS 2 and found 4 background objects and one ULX embedded in an HII region.

HST image of a spiral galaxy with the Chandra position of a bright ULX (Jonker et al. 2010). It could be an IMBH, recoiling SMBH, or a SN IIn.





# AM 0644-741

The Hubble Space Telescope image of AM 0644-741, a ring galaxy at a distance of 87 Mpc (redshift  $\approx 0.02$ ). It contains an X-ray source that would be a ULX if it is associated with the galaxy. The X-ray source has a bright optical counterpart.

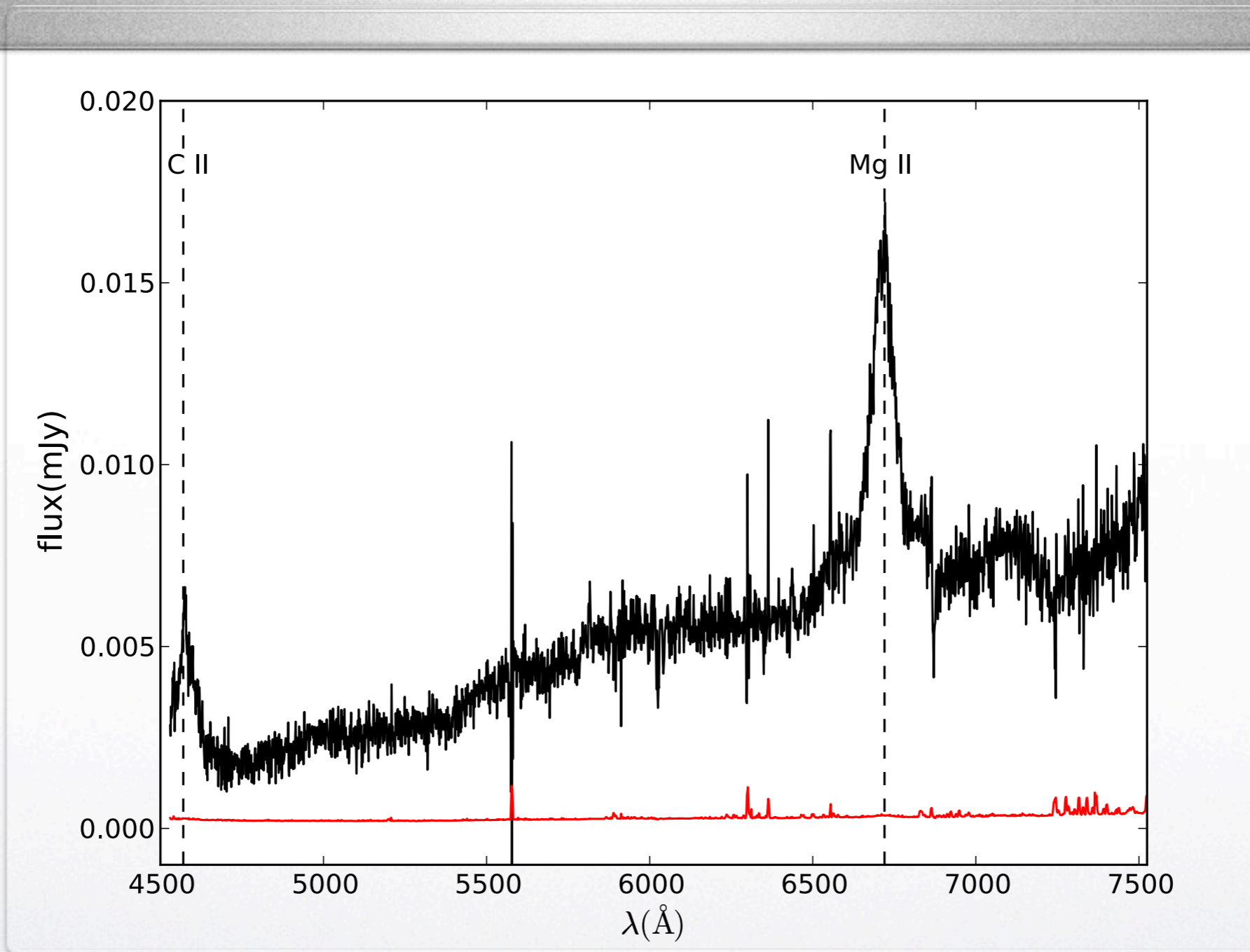




# AM 0644-741

The *Chandra* position of the ULX overplotted on the HST image.



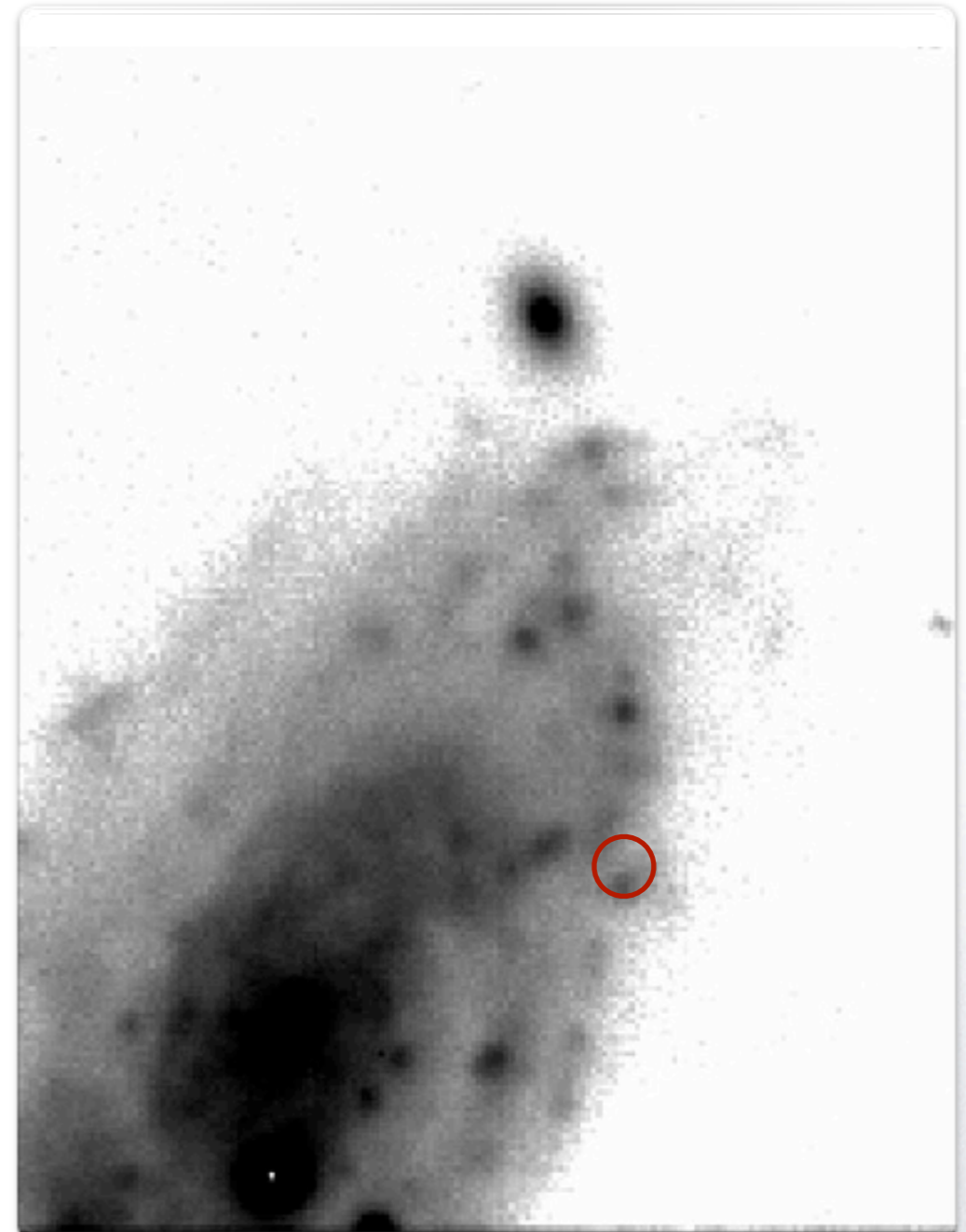
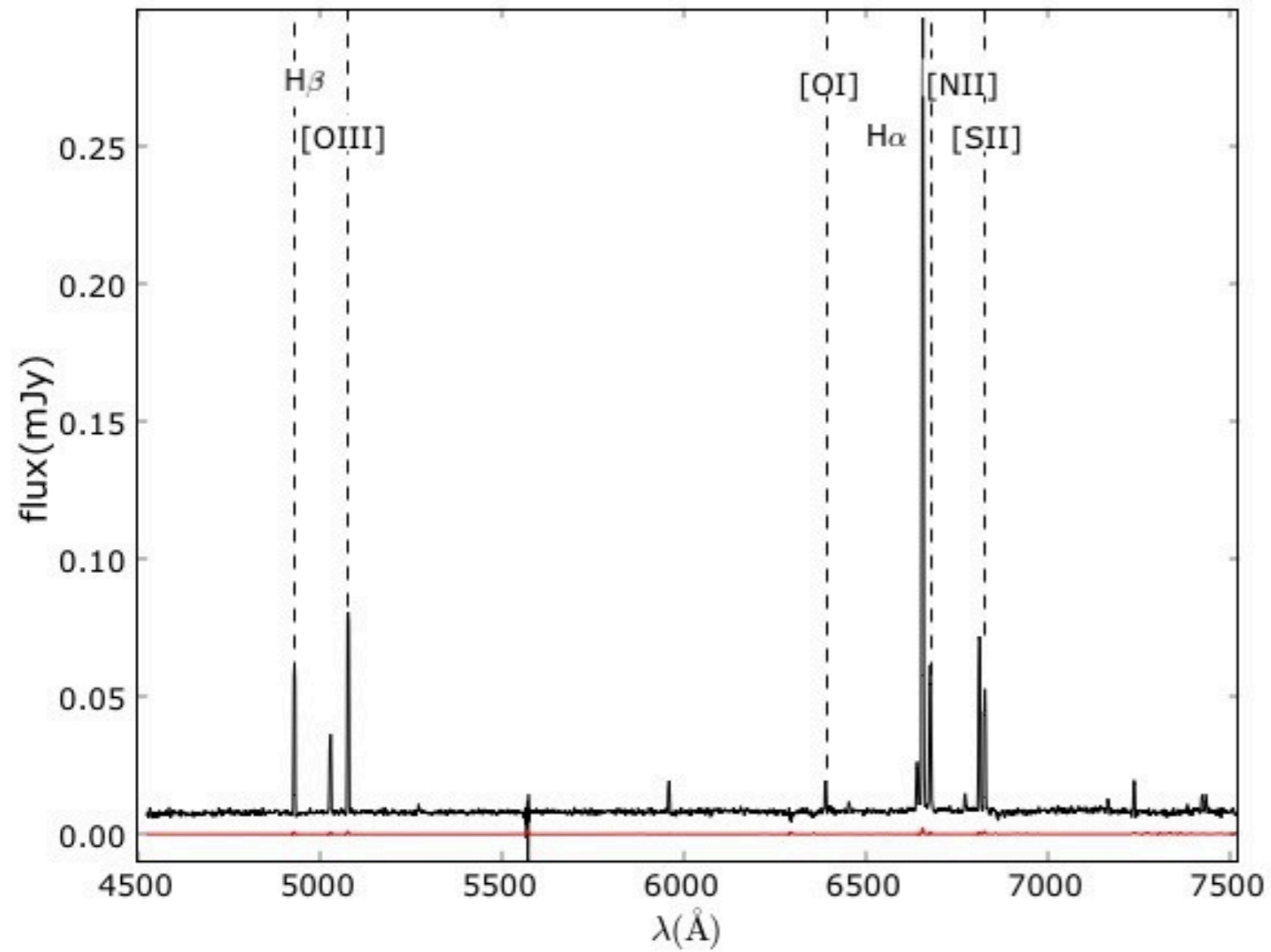


The spectrum of the optical counterpart taken with the FORS2 spectrograph at the VLT. The 'ULX' turns out to be a quasar at redshift  $\approx 1.4$ .





# ESO 306-3





# ESO 306-3

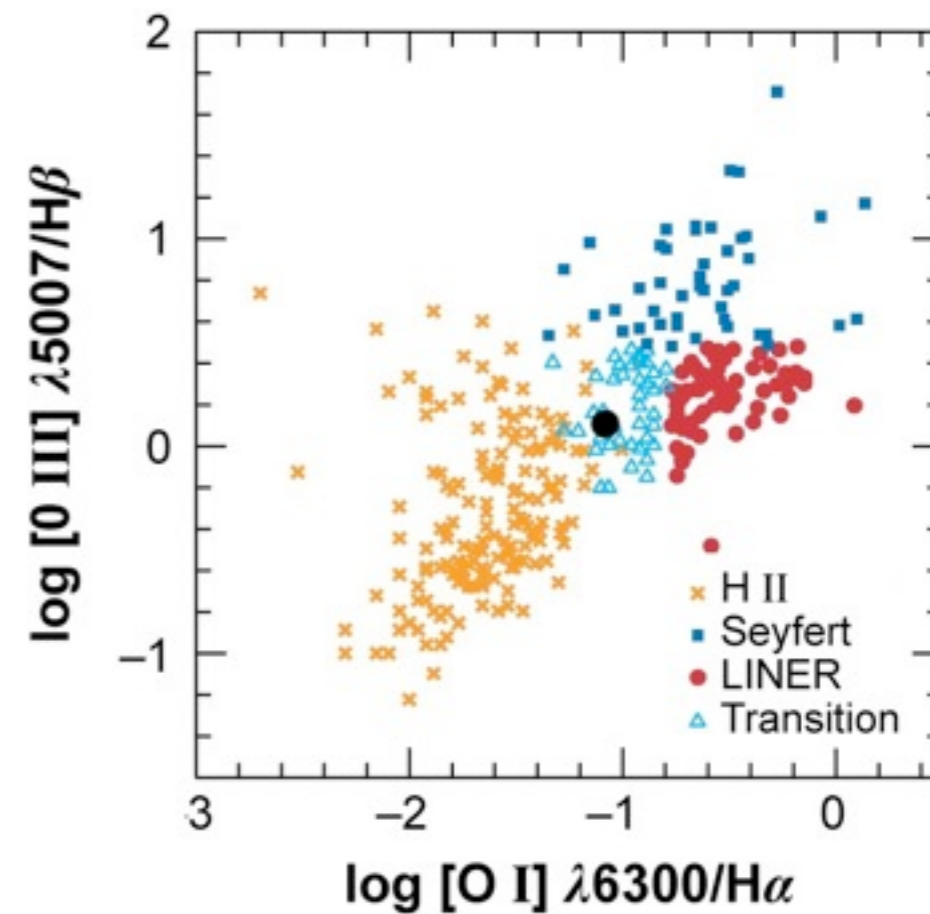
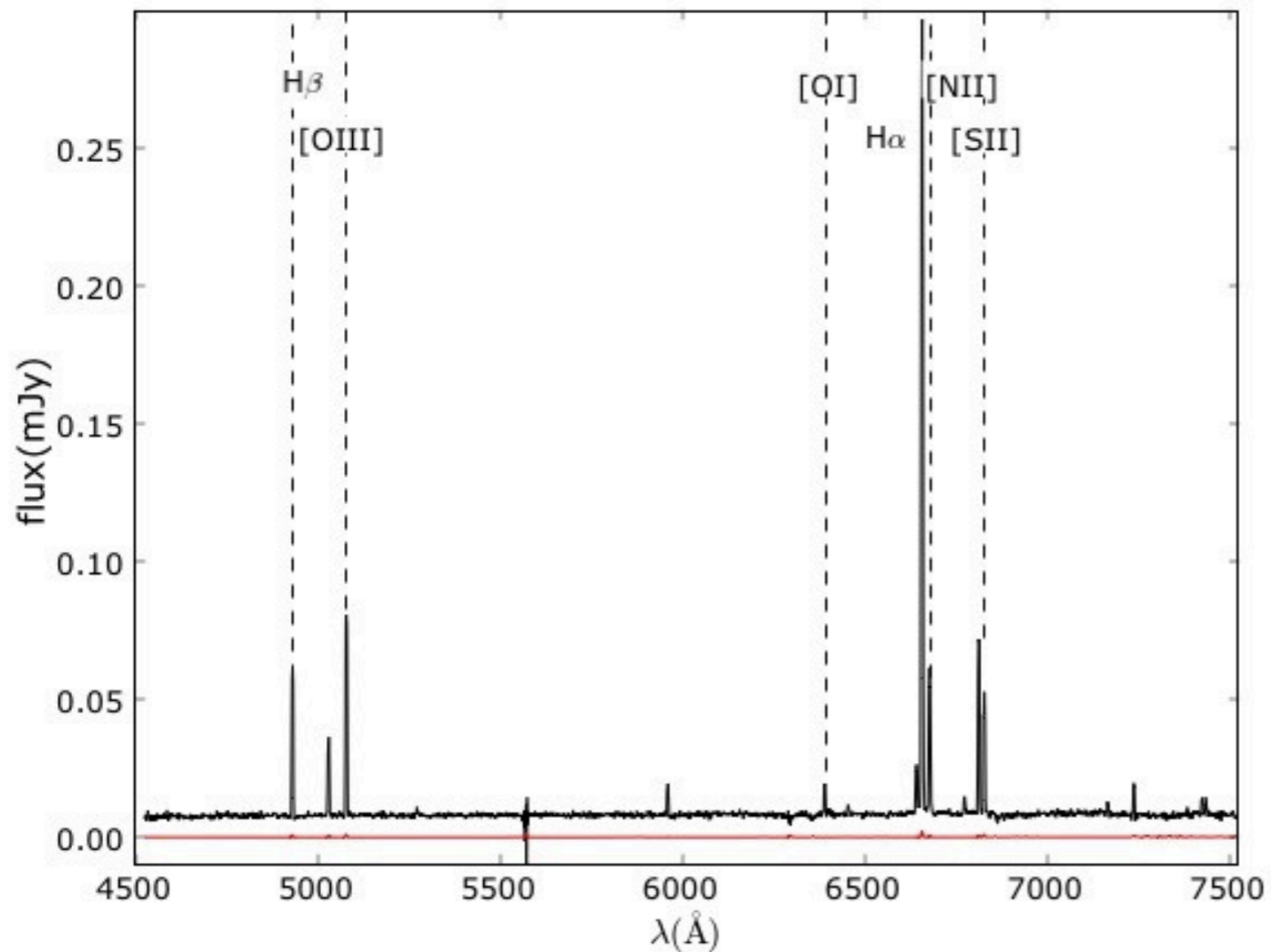


Figure adapted from Ho 2010



# Conclusions

- The brightest ULXs may host intermediate mass black holes and/or recoiling supermassive black holes. With optical spectra we can learn more about the nature of these sources.
- Optical spectra can also help us remove contaminants, like the quasar in AM 0644-741.
- We detect narrow emission lines and strong forbidden lines from the region around the ULX in ESO 306-3. This is probably a ULX embedded in an HII region.