Super-Eddington driven winds in Ultraluminous X-ray sources

Ciro Pinto,

Andy Fabian, Dom Walton, Matt Middleton, Davide Fiacconi, Will Alston, Tim Roberts, Hannah Earnshaw, Roberto Soria, Ryan Urquhart, Erin Kara

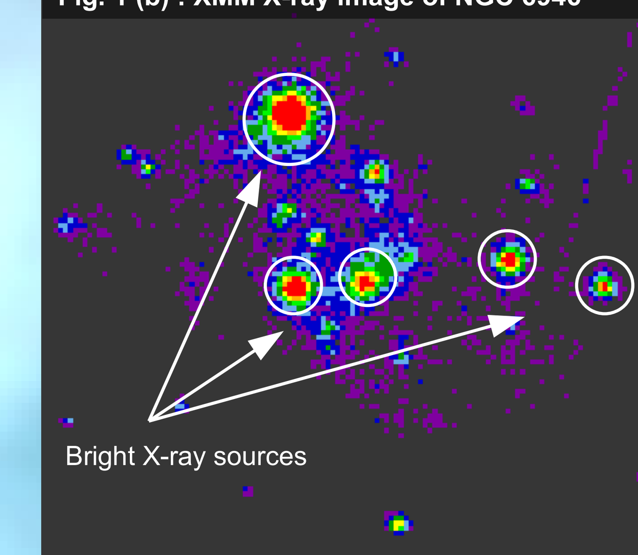
Abstract

The detection of fully-grown supermassive black holes powering active galactic nuclei at high redshift, when the Universe was young, challenges the theories of black holes growth, requiring long periods of high accretion, most likely above the Eddington limit. This is a focus of the next generation large missions, but cannot be done with the current instrumentation due to the large distances. Most ultraluminous X-ray sources (ULXs, luminosity $>10^{39}$ erg/s) show X-ray spectra that are consistent with stellar mass black holes or neutron stars accreting at or above Eddington and provide the best workbench to study super-Eddington accretion and fast growth rates. Here I show our very recent discoveries of relativistic outflows in some archetypal ULXs that were predicted by models of super-Eddington accretion and our first mass constraints.

ULXs can be brighter then the host galaxy in the X-ray energy band (Fig. 1 a,b). Their spectra are soft with optical depths of several if modeled with Comptonization (Fig. 2). Residuals appear in broadband CCD spectra on top of their continuum model (Fig. 3). We have resolved them into a system of rest-frame emission and blue-shifted absorption lines produced by an outflowing gas near the compact object (Fig. 4). We have used the energy subtracted to launch the wind to place constraints on the mass (Fig. 5).

Fig. 1 (a) : Optical image of NGC 6946 "Fireworks Galaxy"

Fig. 1 (b) : XMM X-ray image of NGC 6946



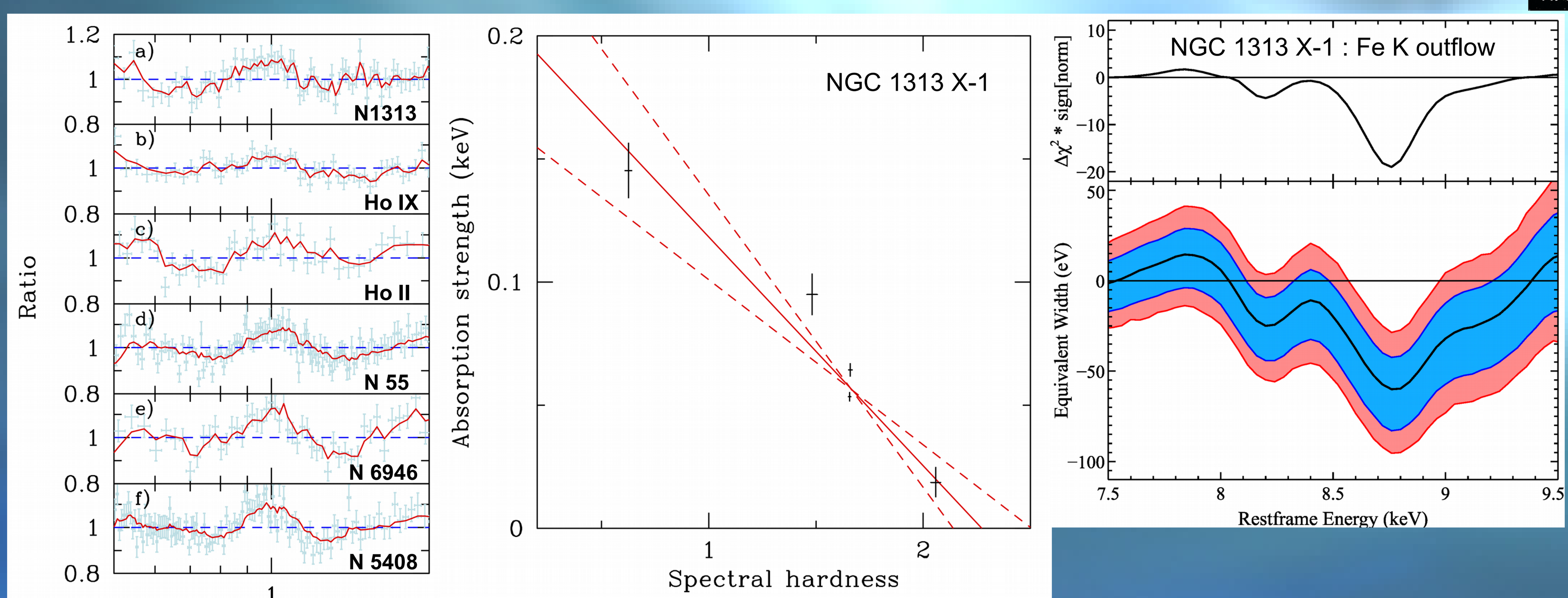
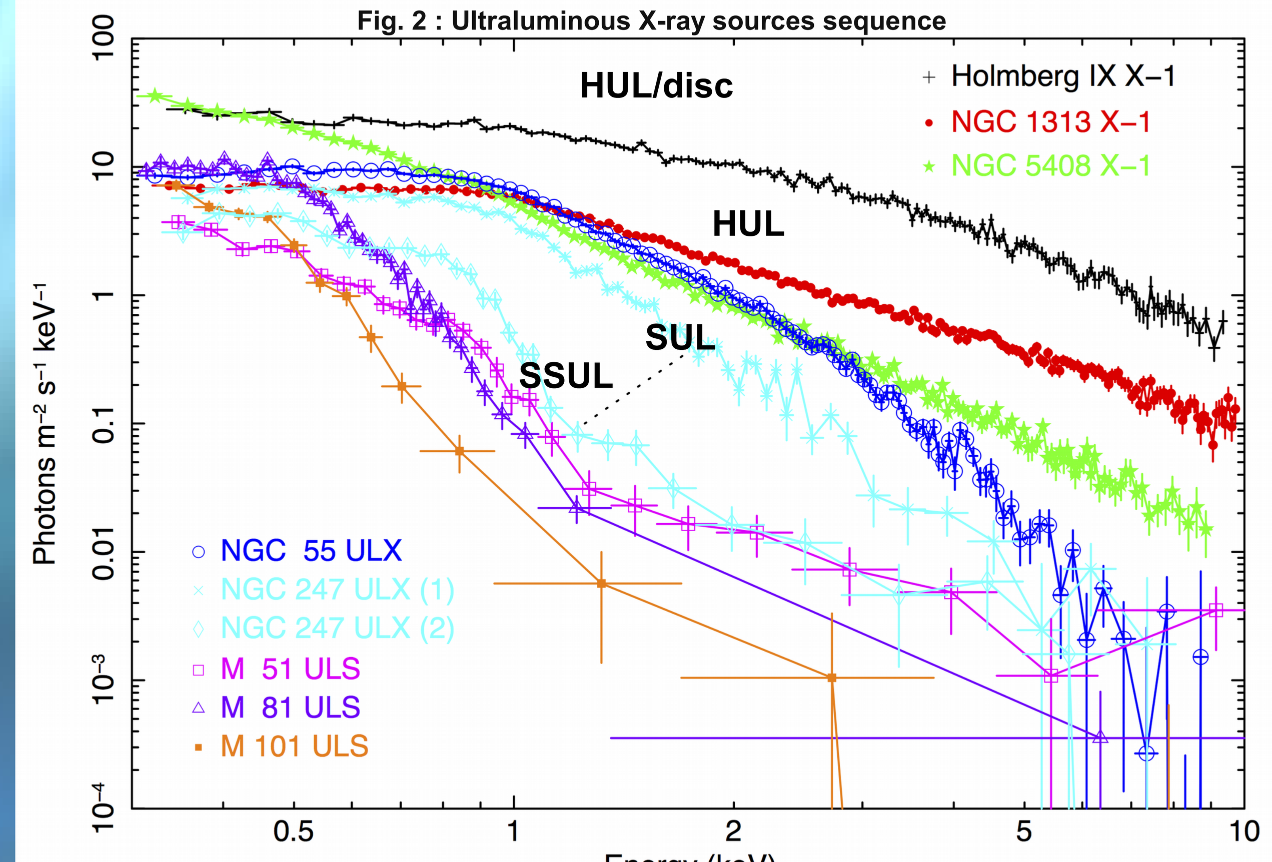


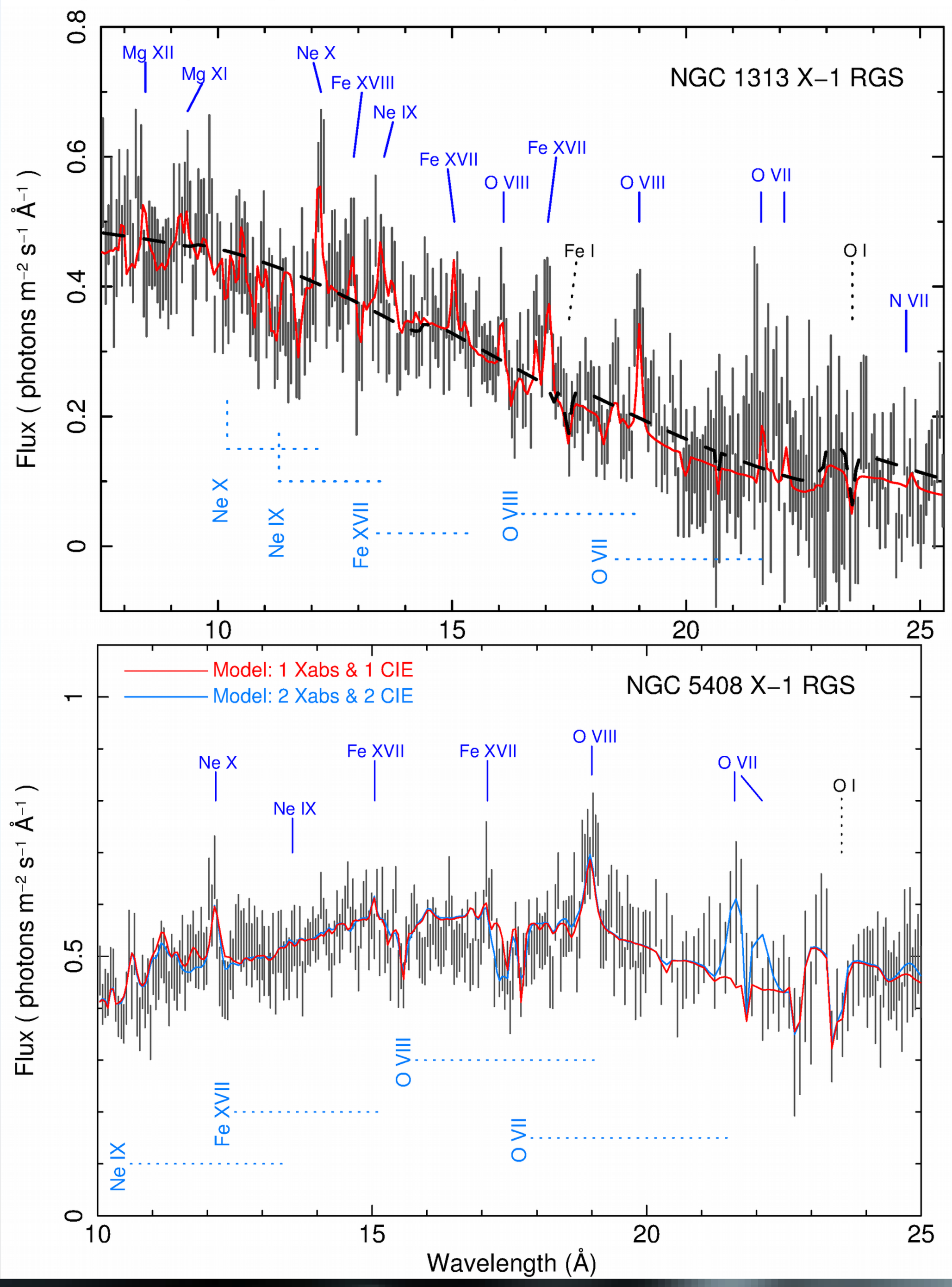
Fig. 3 : Residuals in XMM-Newton/EPIC CCD spectra

Fig. 2 : Ultraluminous X-ray sources sequence



HUL, SUL, SSUL = Hard, Soft, Supersoft ultraluminous

Fig. 4 : deepest high-resolution X-ray spectra from two archetypal ULXs



The detection of absorption lines from the wind is more likely at intermediate angles. Face on, the spectra are nearly featureless due to seeing through a highly ionized funnel. At high viewing angles more velocity components sum up and additional emission lines come out above the featureless continuum partly obscured by the wind. Edge on the inner regions are obscured and the source becomes supersoft (Fig. 2,6).

Fig. 5 : upper limits on the mass of the compact object

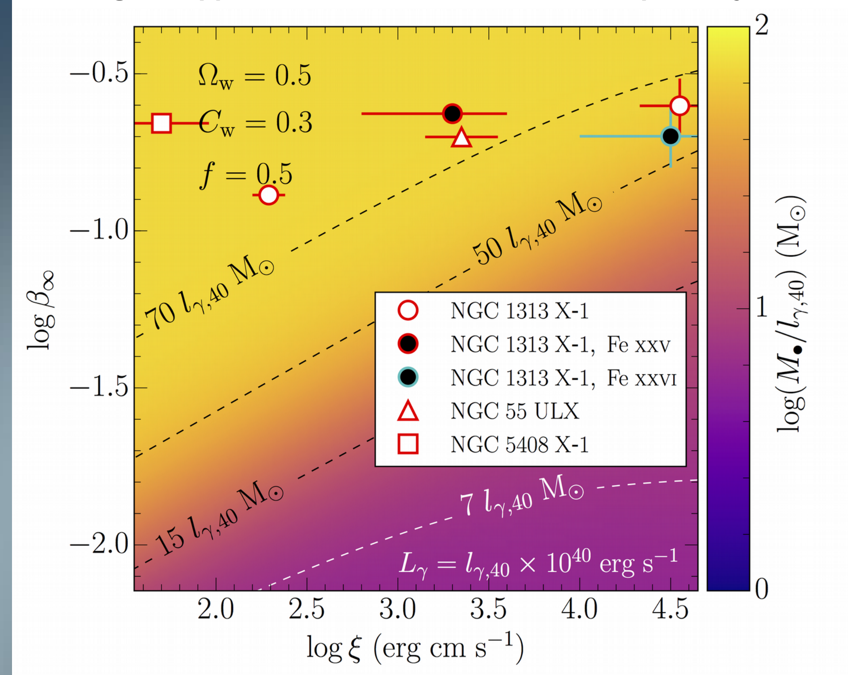
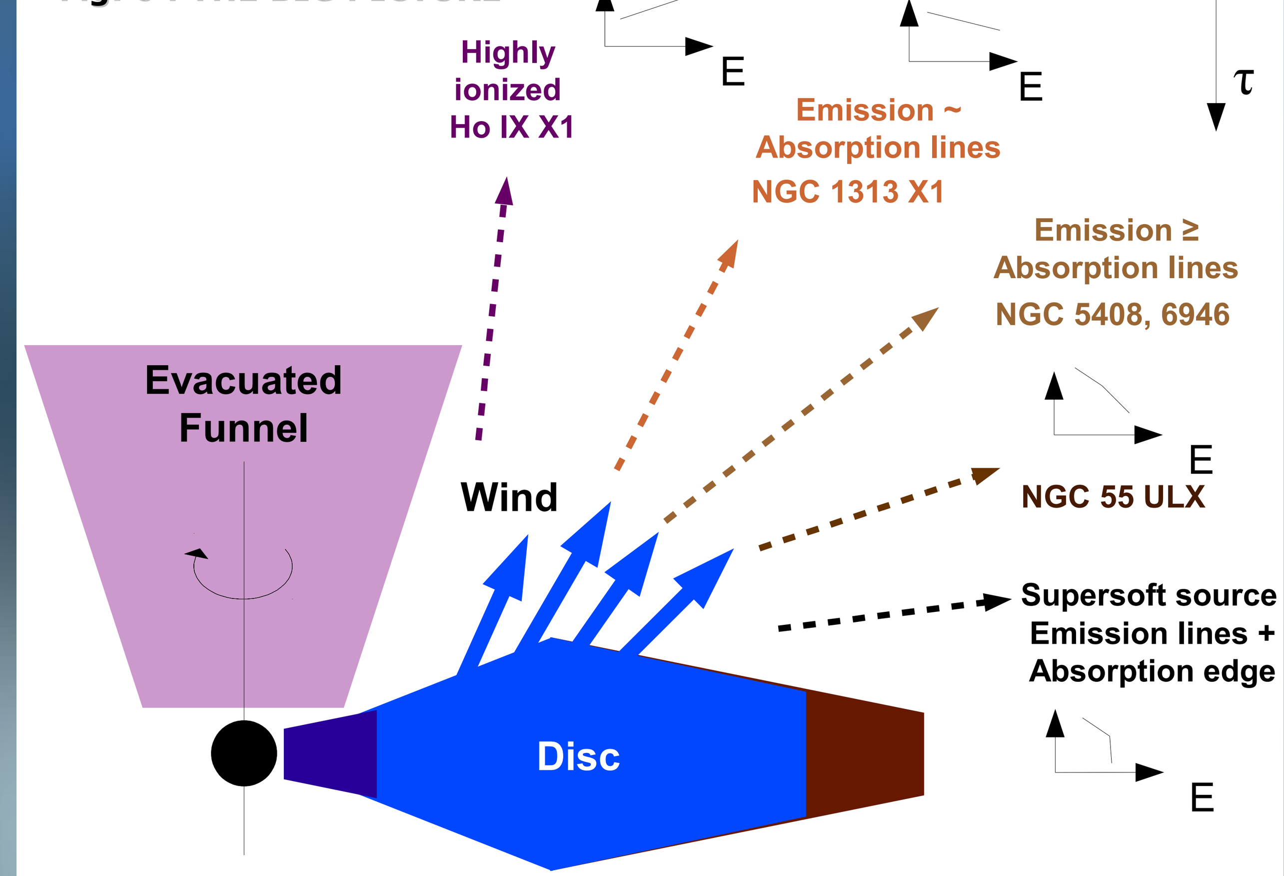


Fig. 6 : THE BIG PICTURE



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