Understanding super-Eddington accretion through winds in ultraluminous X-ray sources

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Super-Eddington accretion

How much matter and how fast can a black hole accrete?

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) are stellar-mass black holes or neutron stars accreting at or above Eddington. ULXs are the best workbench to study super-Eddington accretion and fast growth rates. Theory suggests that at high accretion rates, radiation pressure would blow powerful, relativistic, winds. Here we show our recent discoveries of outflows in ULXs and their properties.

ULXs

ULXs can outshine their host galaxy in X-rays (Figs. 1 a,b).

Fig. 1 (a) : Optical image of NGC 1313

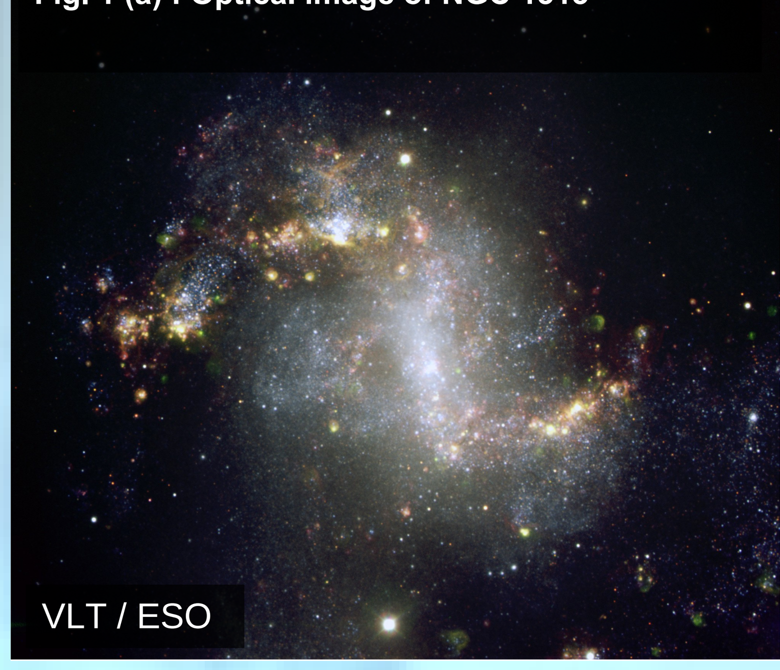
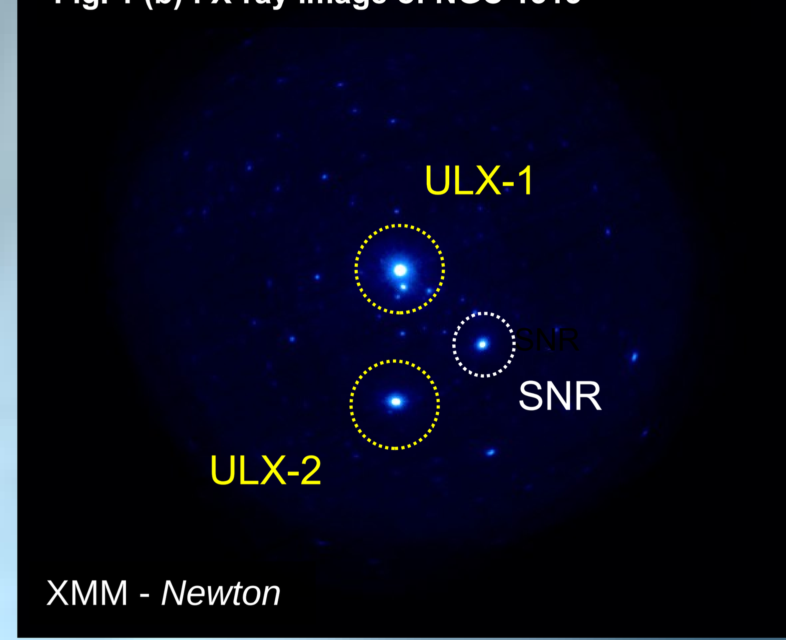


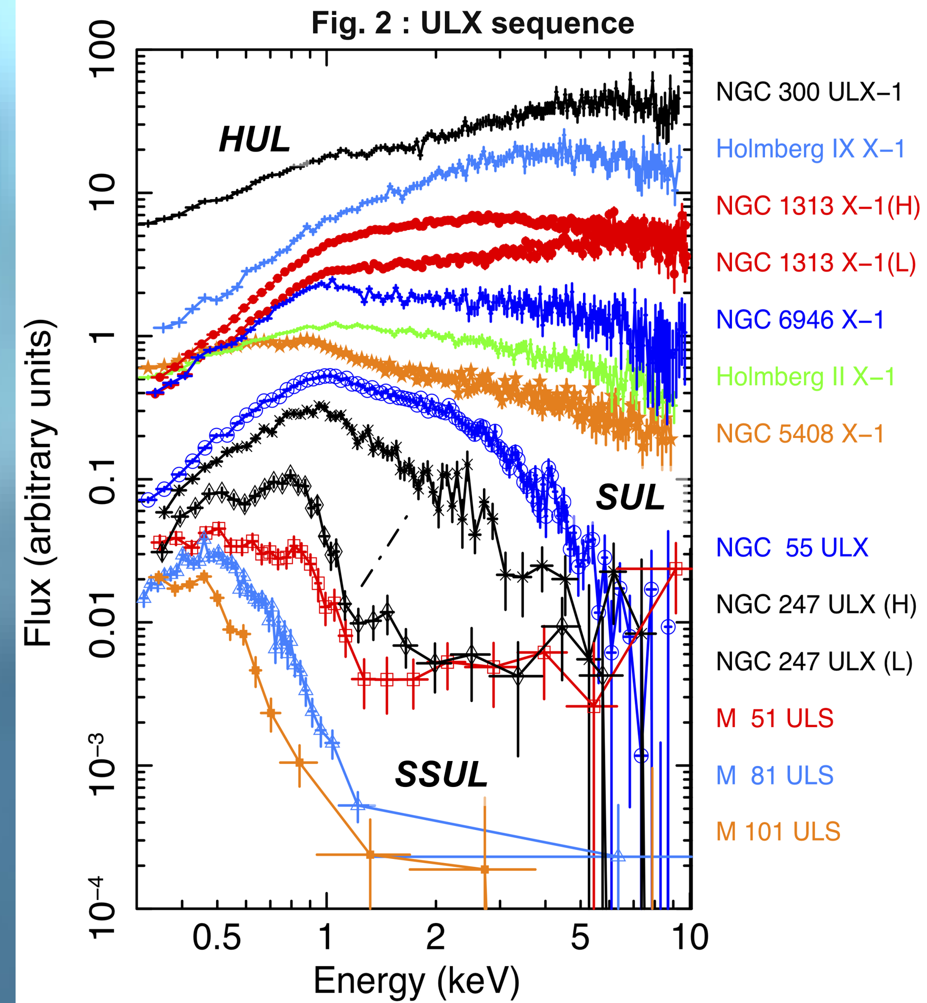
Fig. 1 (b) : X-ray image of NGC 1313



ULX X-ray spectra

A complex phenomenology with X-ray spectra from supersoft to hard (Fig. 2). Some are pulsars: require thick discs & high accretion rates.

Fig. 2 : ULX sequence



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

ULX Winds detection

Spectral features appear at ~1keV in CCD spectra, these are stronger when the ULX softens (Fig. 3). We resolved them into a forest of rest-frame emission and blue-shifted absorption lines that unveil outflowing gas near the compact object (Fig. 4).

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

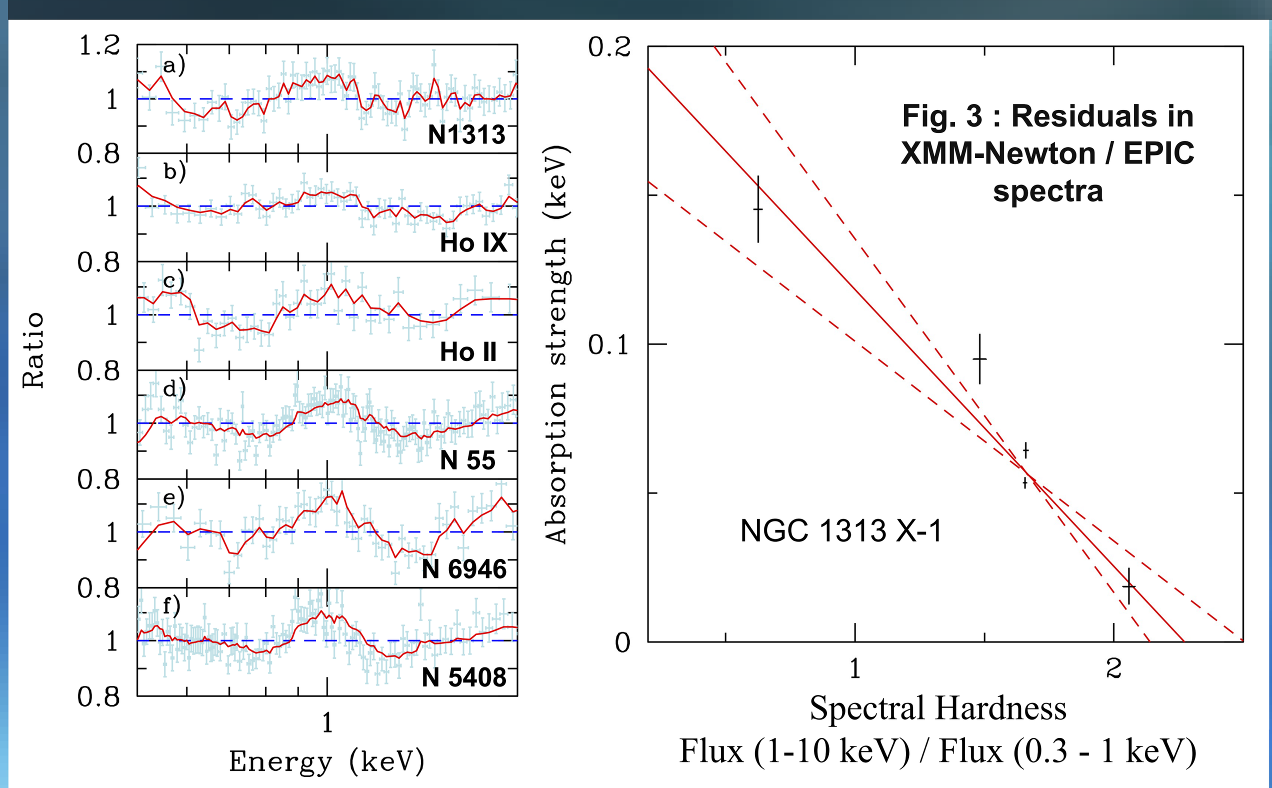


Fig. 4 : 1st ULX high-resolution X-ray spectrum and wind detection

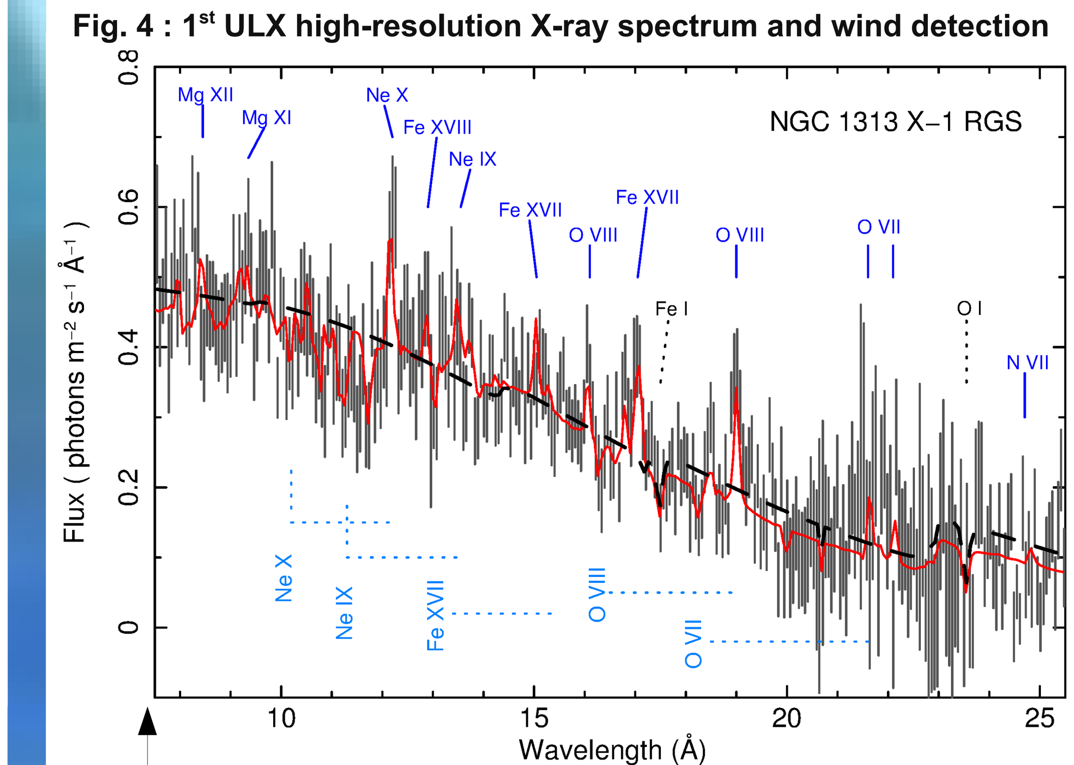


Fig. 5 : WIND properties

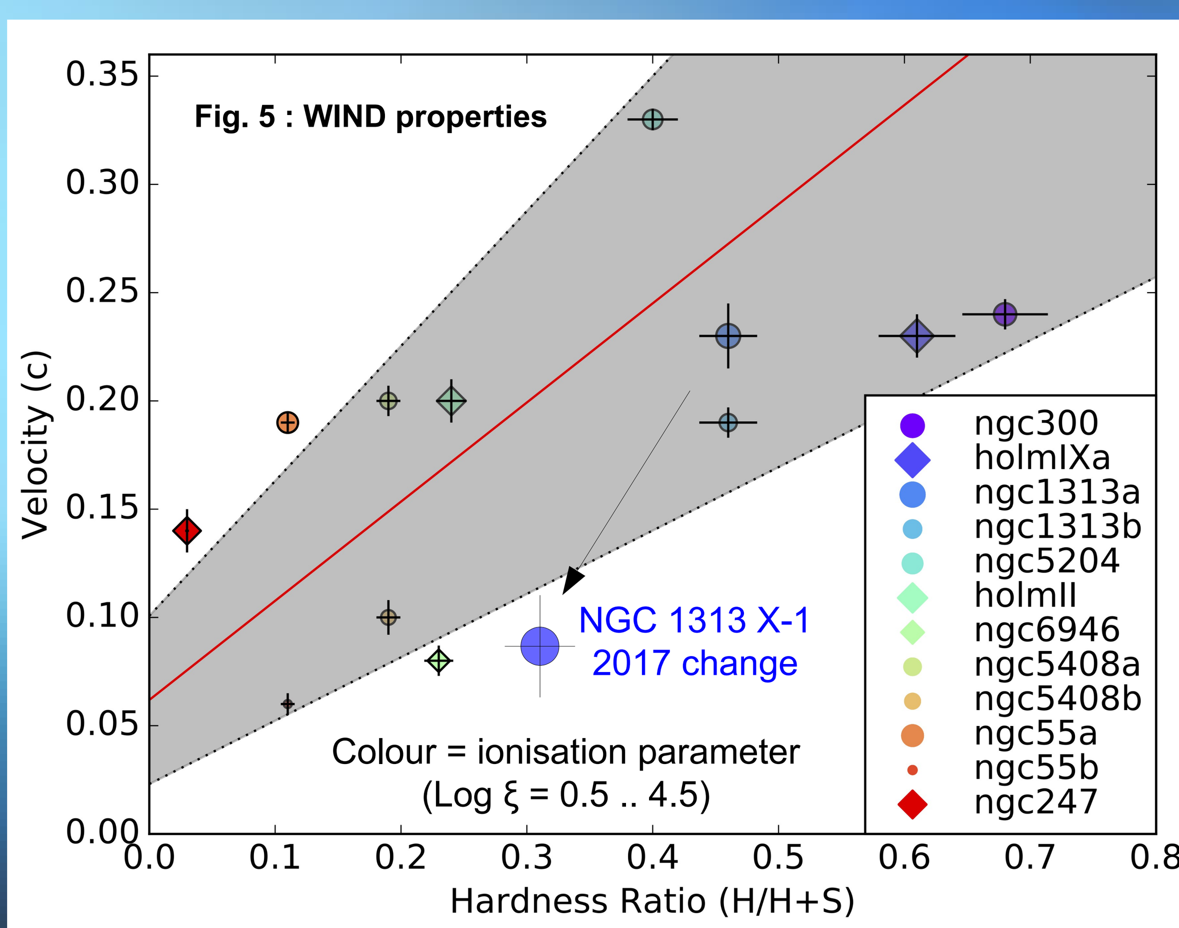
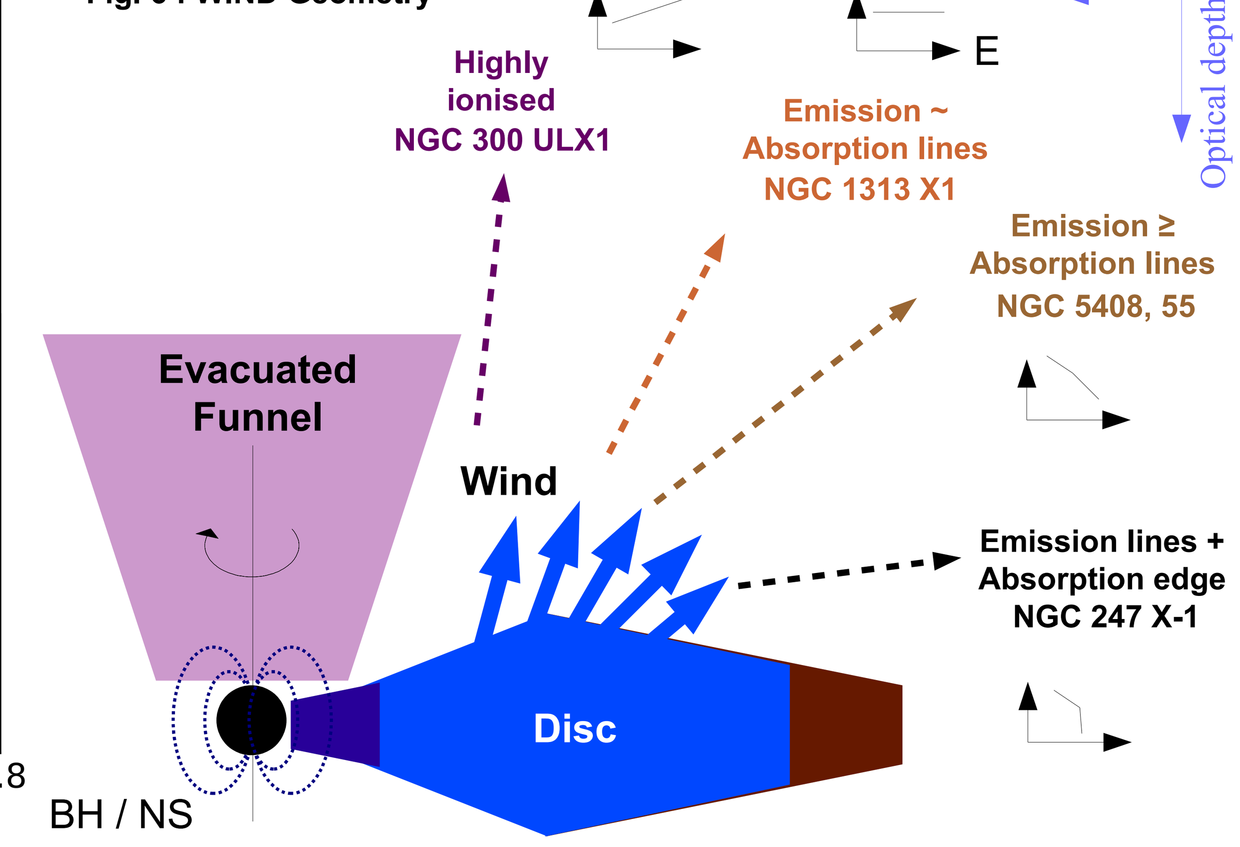


Fig. 6 : WIND Geometry



ULX Wind – disc geometry

Face on, ULX spectra are nearly featureless due to seeing through a highly-ionised funnel. At higher view angles & accretion rates, slower & cooler gas phases obscure the inner regions and additional emission lines spring on a weaker continuum (Figs. 5, 6). The wind takes away up to ~50% of matter & power, enough to inflate the ULX optical super bubbles.

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