How are winds generated around stellar-mass black holes and neutron stars?

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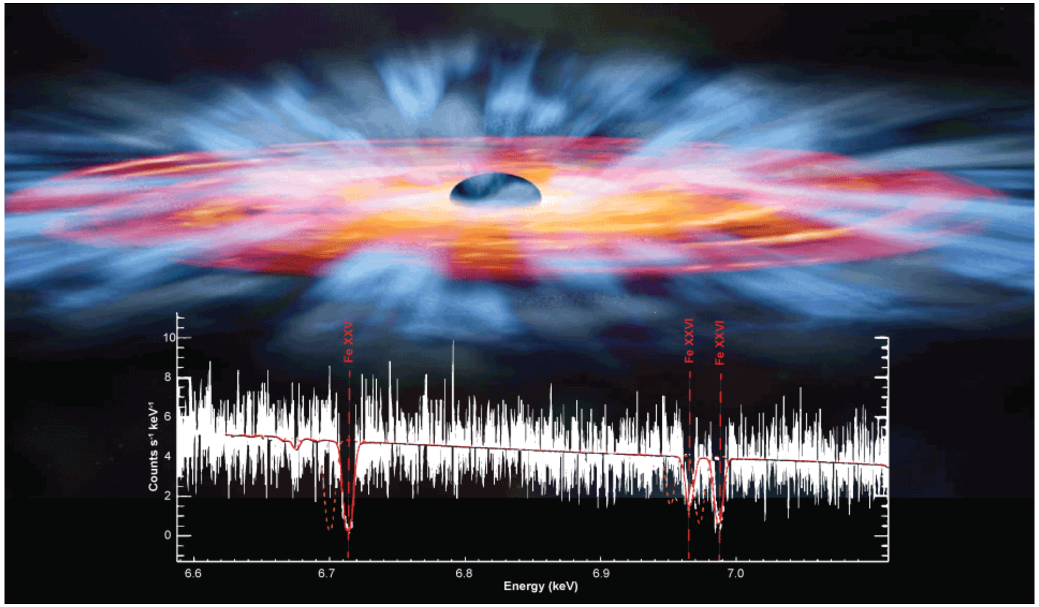
The brightest X-ray sources in our galaxy are X-ray binaries. In these systems, a normal star and a collapsed star, such as a stellar-mass black hole or a neutron star, orbit around each other. Their extreme luminosity in X-rays is generated by matter falling from the normal star (the so-called "donor") into the compact black hole or neutron star (also called "accretor"). The extreme density of the black hole or neutron star generates a powerful gravitational field that rips gas from the donor, which spirals around the compact object before being sucked down by the black hole or crushed onto the surface of the neutron star, a process known as "accretion".

It has been long suspected that at least a fraction of the mass that is being channelled towards the black hole or neutron star could be expelled in the form of winds before it reaches the compact object. In recent years, X-ray observations with high resolution spectrometers have revealed the existence of such winds mainly via the detection of highly-ionised absorption lines with significant blue-shifts. The amount of matter expelled, and the conditions required to launch such winds crucially depends on their power source, which may be magnetic fields, thermal pressure or radiative pressure. The power source also determines the amount of energy that is deposited in the environment of the X-ray binary.



Artist's impression of an equatorial accretion disc wind as observed in X-ray binaries. X-IFU on-board Athena will allow the detection of weak lines and an unprecedented precision in the measurement of the width, position and depth of all the detected lines (see inset). This information will be used to disentangle the different components of the winds and to infer their characteristics to ultimately determine what powers them.
Credit: image (Chandra/NASA). Inset: Fig. 2, Motch et al 2013.

The Athena satellite will characterize these winds using the high spectroscopic resolution and throughput provided by the X-IFU instrument. The precise measurement of outflow velocities, column densities and ionization states of the winds will allow researchers to disentangle different wind components and to compare the measured wind parameters with those expected from theoretical models to understand the mechanism that powers them, a breakthrough in the study of accretion disk winds. Observations at infrared and millimetre wavelengths with the ESO ELT and ALMA telescopes will provide complementary information. Coordinated X-ray and infrared observations will allow to establish a link, if existent, between winds observed at different temperatures, as is the case for X-ray and molecular winds from supermassive black holes. In addition, coordinated X-ray and millimetre observations will allow to study the interplay between the X-ray wind and the relativistic jet, which is bright at millimetre wavelengths.