Ultra-Luminous X-Ray Sources:

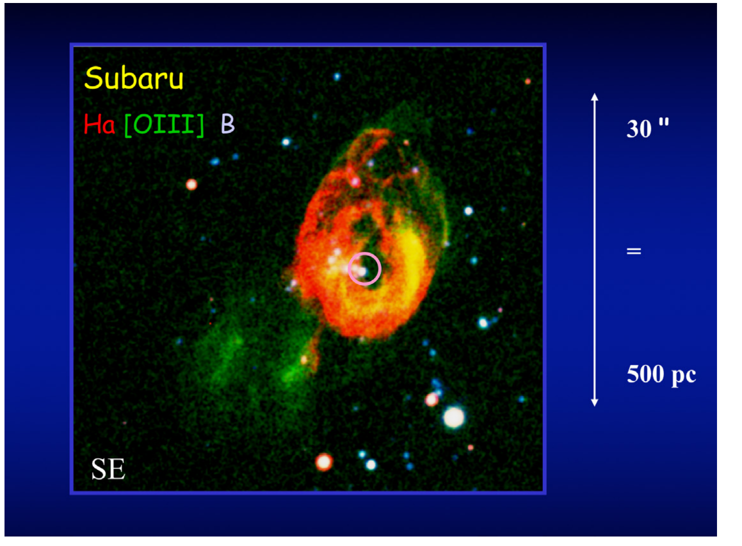
When Compact Objects Become Gluttonous Accretors

by Christian Motch. Observatoire Astronomique Strasbourg, France

Galaxies often host non-nuclear accreting ultra-luminous X-ray sources (ULXs). Their X-ray output exceeds the highest luminosity that can be theoretically achieved by steady spherically symmetric accretion onto the most massive end-products of individual star's evolution (~ 10 solar masses) in our galaxy. Termed the "Eddington limit", after its discoverer, this is the luminosity where the radiation pressure pushing on the inflowing material balances the gravitational force pulling it in and prevents the additional matter from reaching the compact star. Most of the known "mainstream" X-ray sources seem to obey this luminosity limit.

We now have the observational proof, however, that some of ULXs harbour neutron stars accreting more than two orders of magnitude above the Eddington limit, while indirect evidence suggests that "overfed" stellar mass black holes are also likely to be present in many ULXs. Although accretion onto an intermediate-mass black hole (100-10,000 solar masses) may explain the high X-ray luminosity of a small number of ULXs, it seems clear that nature has found a way to overcome the Eddington limit in a very efficient manner in most ULXs. This came as a big surprise; the physics involved in this extreme accretion mode is still not very well understood. It is however established that such a huge radiation field must drastically impact the structure of the accreting flows of matter.

These "super-Eddington" accretion regimes are indeed associated with high velocities collimated outflows. Evidence of winds propelled at 20% of the velocity of light have been found in two ULXs by XMM-Newton. Perhaps the most striking manifestation of these outflows is the presence of huge bubbles of collisionally excited and X-ray ionized gas around several ULXs. Interestingly, the mechanical energy required to blow these bubbles is of the same order as the energy radiated in X-rays, showing that ULXs do have a strong impact on their interstellar surroundings.



A multicolour Subaru/FOCAS (Faint Object Camera and Spectrograph) image of the shell-like bubble MH9-11 around the ultra-luminous X-ray source Holmberg IX X-1. Holmberg IX X-1 is an ultra luminous X-ray source with Lx ~ 10^{40} erg/s. The pink circle shows the position of the optical counterpart of the X-ray source which has blown the ~ 500pc diameter bubble around. Credit: Grisé et al. 2011, ApJ 734, 23

Very few of the central massive black holes in active nuclei override the Eddington limit in the local universe. ULXs are therefore unique laboratories to study the physics of accretion in an extreme mode. For instance, they may help us to understand how seed black holes could have grown so rapidly to masses of billions of solar masses in the young universe and how the jets and winds launched may have provided feedback to the host galaxy.

In this respect, the high throughput and exquisite spectral resolution of Athena will allow us to survey a wide range of super-Eddington ratios and type of compact objects in the local universe. This will bring crucial information on the density, velocity and variability of the massive outflows generated by these outstanding sources, on the structure of their swelled accretion discs and on the accretion physics involved.