Sources in the images

In the INTEGRAL images you are provided with for the *Explore the high-energy Universe* competition research project, 3 main types of high-energy sources can be seen. A brief description about the behaviour of each type of source is given below. To identify the sources in the images you will need to look at the clues given and compare them to the results of your own investigations. Use the Glossary in the right-hand menu for any terms you are unfamiliar with.

1. Black-hole X-ray binaries (BHXB)

In these systems all the emission detected comes from the accretion disk that is formed around the black hole. This disk changes with time, leading to sometimes very strong variations in the flux seen at different energies. BHXB can emit very high energy radiation which means that their spectra are bright up to many 100 keV or even MeV (in high-energy astronomy these are known as 'hard' spectra). These systems can also experience a change in the behaviour of the material in the accretion disk - which means that their spectra also change - so that almost all emission occurs at low energies and there is very little above 10-20 keV.

As an example, here are light curves of the famous black hole system Cygnus X-1 showing how emission from these types of sources can vary over long timescales. Note that when the flux at higher energies reduces, it rises at lower energies and vice versa.

- Long-term light curve of Cygnus X-1 in 15-50 keV:

  http://swift.gsfc.nasa.gov/docs/swift/results/transients/CygX-1/

- Light curve in X-rays (2-20 keV) for Cyg X-1 since 2009:

  http://maxi.riken.jp/top/index.php?cid=1&jname=J1958+352

- Find out more about the black holes and the Cygnus X-1 system:

  http://imagine.gsfc.nasa.gov/docs/science/know_l2/black_holes.html]

Some BHXB emit a constant stream of high-energy radiation that does vary but can be detected all of the time. Others are transient systems, which are only seen when they release a sudden burst of high-energy radiation. During these outbursts, their spectra change dramatically over a timescale of just a few weeks.

Black hole systems sometimes emit powerful jets of high-energy radiation during some stages of their activity. Such sources are often called "micro-quasars" because of their similarity to quasars (Active Galactic Nuclei).

- Observation of black-hole jets:

  http://www.nasa.gov/topics/universe/features/black-hole-jets.html]

2. Accreting X-ray pulsars

These sources are neutron stars with strong magnetic fields. While they can have accretion disks, their magnetic field disrupts them, even if the disk is several thousand kilometres away from the neutron star itself. This means that changes in the spectra driven by the accretion disk are not seen. In accreting X-ray pulsars, the high-energy emission comes from accretion columns at the magnetic poles. These are formed when material is funnelled by the strong magnetic fields towards the magnetic poles of the neutron star.

Accreting X-ray pulsars can vary a great deal in brightness, but usually their spectrum does not change much as they get brighter or fainter. The spectrum is typically a power law up to a certain energy and then falls off quickly towards higher energies. The energy of this turn over is quite different between sources; often it is in the 10-30 keV range.

3. Neutron stars with 'weak' magnetic fields in Low Mass X-ray Binaries (LMXB)

Some binary systems consist of a neutron star and a small (low mass) companion star. This system is only classed as an X-ray binary if the two components are close enough together for material/gas to be stripped from the small companion to form an accretion disk around the neutron star.

In the case of neutron stars with smaller magnetic fields, the accretion disk can form close to neutron star and will – as for Black Hole X-ray Binary systems - dominate the observable emission.

For this reason it can sometimes be difficult to distinguish between neutron stars and black holes in LMXB. Both objects can exhibit changes in their spectra and emit jets of high-energy radiation. There is a tendency for the neutron star systems to be less extreme, but for some systems the question of whether a black hole or a neutron star is present has not been resolved, despite decades of observations. Today, spectra showing emission at very high-energies and rapid, strong changes to the spectrum are usually taken to be an indication of a possible black hole.