Accretion disks torn apart by magnetic neutron stars

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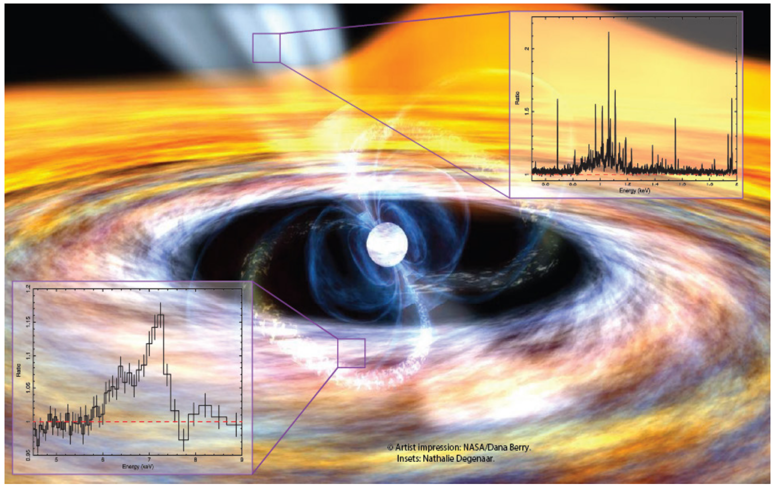

Artist impression of a magnetic neutron star that truncates the accretion disk and drives an outflow. The insets show simulations of a 150 ks Athena/XIFU observation, based on the accreting pulsar IGR J17062-6143. Inset top-right shows the unprecedented clarity with which Athena can detect the ionized emission line spectrum of an outflow. Inset bottom-left shows the footprint of a strongly truncated accretion disk as measurable with Athena. The Athena simulations are based on the properties of that source as reported by van den Eijnden et al. 2018 MNRAS 475, 2027 (based on XMM-Newton data). Credit artist impression: NASA/Dana Berry. Credit insets: Nathalie Degenaar.

Astronomical bodies attract material from their surroundings due to their gravity, which both allows them to grow and to increase their rotation rate. We refer to this process as "accretion", and it plays a fundamental role in astrophysics. For instance, accretion forms stars and planets, it determines how galaxies grow and evolve, and it is responsible for the large-scale structure in the Universe that we call the cosmic web. Studying accretion processes under different physical circumstances is therefore a cornerstone of modern astrophysics. A prime example of accreting systems are X-ray binaries.

X-ray binaries consist of two stars, one of which is a regular star (e.g. like our Sun) and the other a remnant of a once massive star that ended its life in a supernova explosion: a neutron star or a black hole. These stellar corpses exert immense gravity, especially in nearby regions, allowing them to devour their unfortunate companion star. The gas that neutron stars and black holes strip off from the other star forms a flat disk, where the gas spirals in at high speed until it eventually plunges onto the hungry cannibal.

Neutron stars and black holes have quite similar "eating" habits. However, black holes have an event horizon behind which the accreted gas irrevocably disappears, whereas neutron stars have a solid surface and a magnetic field attached to it. Under some circumstances, the magnetic field of the neutron star may be strong enough to push the accretion disk away and even act as a propeller that expels gas from the disk into space. Whereas there are some theoretical ideas for how a magnetic neutron star may tear apart a surrounding accretion disk, it has been challenging to study this observationally. This is because a truncated disk and such outflowing gas, if present, will only emit extremely weak emission.

With the large mirror area of *Athena* and the exquisite energy resolution of the X-ray Integral Field Unit (X-IFU), we will finally be able to witness and study in detail how the magnetic field of neutron stars can disrupt accretion disks. Firstly, *Athena* will allow us to study the weak X-ray light that reflects off the inner edge of the accretion disk and creates a distinctive broad emission line from innershell iron ions at energies around 6.5 keV. This provides a measure of how far out the accretion disk is truncated by the magnetic field. Secondly, *Athena* will be able to detect a forest of weak and narrow emission from ionized gas that is being blown away by the magnetic propeller. Combining these two types of measurements will allow us to obtain a detailed picture of how accretion disks react to the magnetic field of neutron stars.