The tale of the vanishing neutron star

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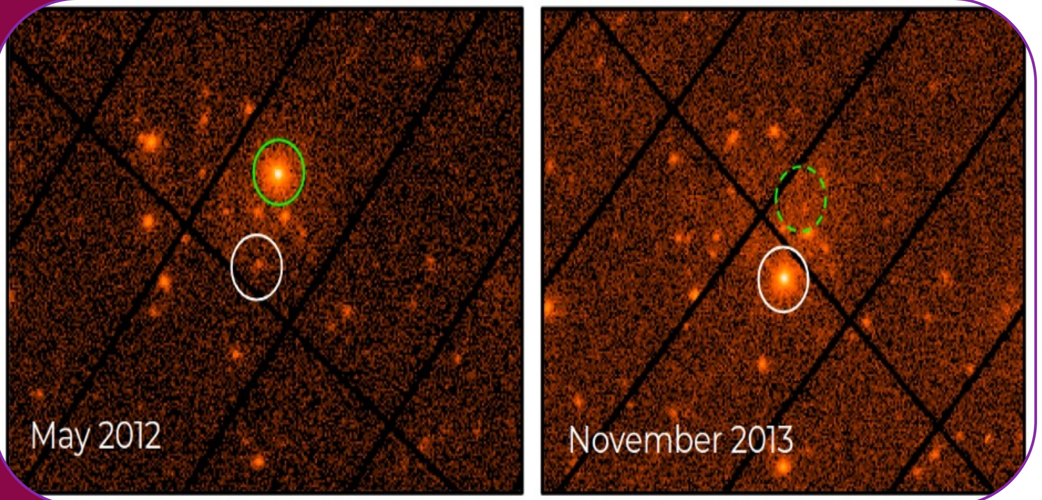

On the 25th of November, 2013, the European X-ray telescope XMM-Newton took its second ever picture of the galaxy NGC 7793. This galaxy is one of our closest cosmic neighbors, at about 4 Mpc from the Milky Way. It is mostly known for being the host of the pulsating Ultra-Luminous X-ray source (ULX) P13, and this source was the target of the observation.

To understand the interest in observing P13, we must first understand what is extraordinary about pulsating ULXs. Accreting objects are thought to respect the Eddington limit, which is the maximum rate at which a compact object can accrete based on our understanding of accretion physics; this also translates into a maximum luminosity, the Eddington luminosity. This limit increases with mass: the larger the object, the more luminous it can be without violating the limit. ULXs are sources that are unusually bright, about 100 times brighter than usual X-ray binaries, and were first discovered in the late 90s. They were at first thought to be very massive black holes, so that they could be this luminous while still respecting the Eddington limit. However, in 2014, coherent pulsations were discovered in a ULX, and those pulsations could only be explained by the presence of a neutron star at the center of the system. Neutron stars cannot be much more massive than a few solar masses; being this luminous and this small thus meant that at least some ULXs largely violate the Eddington limit, by one or more orders of magnitude. Since this discovery, large studies have been undertaken to understand super-Eddington accretion and detect new pulsating ULXs, with only 7 certain candidates to this date.

Understanding super-Eddington accretion was the reason why P13 was observed by XMM-Newton several times. In the November 2013 observation, P13 was much brighter than the first time it was observed, a year and a half before in May 2012 (see white circle in the figure). But by comparing both observations, one can notice a very interesting feature: a very luminous source in May 2012, even brighter than P13 in 2013, had completely disappeared in the second observation (see green circle in the figure). This means that this source saw its flux drop below the detection limit between 2012 and 2013. The automatic detection pipeline of XMM-Newton only works on one observation at a time, and doesn't use prior knowledge of existing sources; no information was extracted for the green source from the 2013 non-detection. However, by computing the sensitivity level of XMM-Newton at the position of the source in 2013, one can put an upper-limit on the source's flux, and thus constrain its overall variability. It was by looking for variable sources using upper limits that the green source was identified as an object of interest that reached ULX level of luminosity at its peak. Further study led to the detection of a candidate pulsation in the X-ray peak lightcurve.

The use of sensitivity computation was thus instrumental in the detection of what is a candidate to be the 8th known pulsating ULX !

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