The Gravitational Redshift of the Neutron Star in Terzan 5 X-2

This source (T5X2) is also called IGR J17480-2446. It has been observed only once, detected in outburst by INTEGRAL. The neutron star has a pulse frequency of 11 Hz and shows type I (thermonuclear flash) X-ray bursts, making it the slowest rotator of all burst sources, for which the rates are 300-600 Hz. For this reason, any atmospheric features at 5 keV — where gravitationally redshifted n=2-1 transitions of Fe XXV or Fe XXVI are expected — should be marginally resolved by the HETGS. For other burst sources, this line would be 30-50x broader and shallower by this factor, making it difficult to detect. Many burst sources have been observed with this immediate goal because the gravitational redshift is a direct measure of M/R, currently unknown for neutron stars. The quantity M/R is a measure of the equation of state of matter at high density, which comprises the bulk of a neutron state, making it very important to high energy physics that M/R be measured.

No HETGS observation of a neutron star has shown unambiguous evidence for narrow absorption features although there have been many attempts. Bursts are normally rare, seen only once per 10-100,000 s. In its 2010 outburst, T5X2 generated many bright bursts at a rates of 1 per 1-3000 s, so the the signal that one may obtain is much 3-100x higher than for other X-ray bursters in a given amount of observing time. As the source brightens, the bursts are more frequent but fainter, so we wish to observe after the source has faded from its peak (see Fig. 1). An HETGS observation on 10/24/10 found about 80 bursts in 31 ks but these were very faint relative to the continuum.

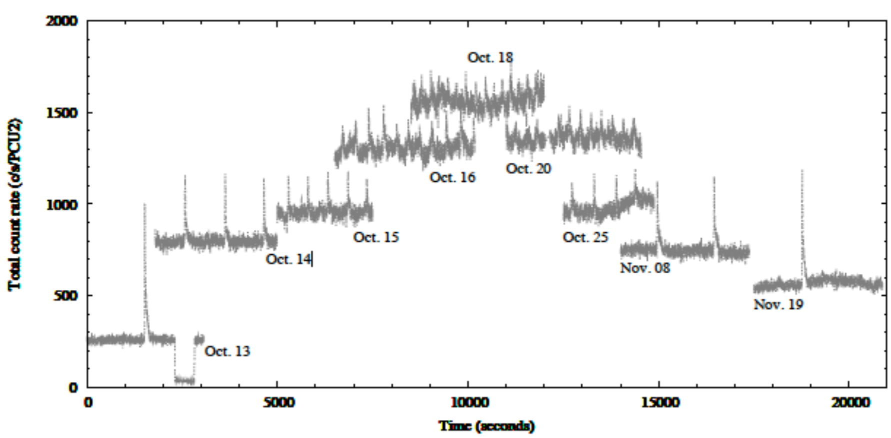

Fig. 1: XTE PCA count rates for T5X2 for different observations. The data were shifted horizontally (but not scaled) and are not shifted vertically; the source brightened from Oct. 13 to Oct. 18, 2010 and then faded for the next month, while burst rates varied with the level of the persistent emission. For GTO, we would trigger about about 20 days after the outburst begins, to get bright bursts at about 2000 s separation.

Because the source is so unusual, we will submit a companion GO proposal that would trigger ~15 days into the outburst cycle, in case the features of interest depend on source intensity. The expected emission lines depend on burst temperature, which varies through the outburst, so it is important to sample the spectrum at different times during the outburst. Observing in CC mode will provide a chance for pulse-phased spectroscopy. In 150 ks, we expect to obtain about 100 bursts (see Fig. 2), compared to EXO 0748-676, with 35 bursts in 300 ks. Triggering will be done with MAXI and confirmed by Swift with a short Chandra observation to confirm that X-2 is the source in outburst. Given that T5X2 has been found in outburst only once in 10-20 yr, we estimate a trigger probability of about 10%.

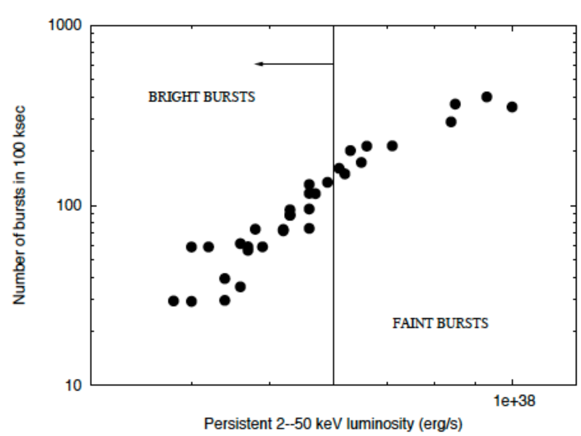

Fig. 2: Rate of bursts observed per 100 ks from the 2010 outburst of Terzan 5 X-2. We would observed when the persistent luminosity is less than 6×10^{37} erg/s.