The Large Deficit of HMXB Emission from the Circumnuclear Starburst Ring in NGC 7552 and Luminous Infrared Galaxies

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Abstract

Luminous infrared galaxies (LIRGs), the most extreme star-forming galaxies in the nearby (D < 30 Mpc) Universe, show a notable X-ray emission deficiency (up to a factor of ~10) compared with predictions from scalings of the high mass X-ray binary (HMXB) luminosity function with star-formation rate. In the nearby (≈20 Mpc) LIRG NGC 7552, the majority of the IR emission originates in a circum-nuclear starburst ring, which has been resolved into several discrete knots of star formation. We present results from recent *Chandra* observations of NGC 7552, which reveal a major deficit in the 2-7 keV X-ray emission from two of the three most powerful star-forming knots. The luminous HMXB populations in these knots are thought to be either (1) missing due to relatively high metallicity and/or young ages in these knots or (2) obscured by a very large column density. We aim to distinguish between these possibilities with data from very recent *NuSTAR* observations, whose sensitivity above 10 keV is expected to uncover any obscured HMXB population, since emission at these energies is more immune to absorption effects.

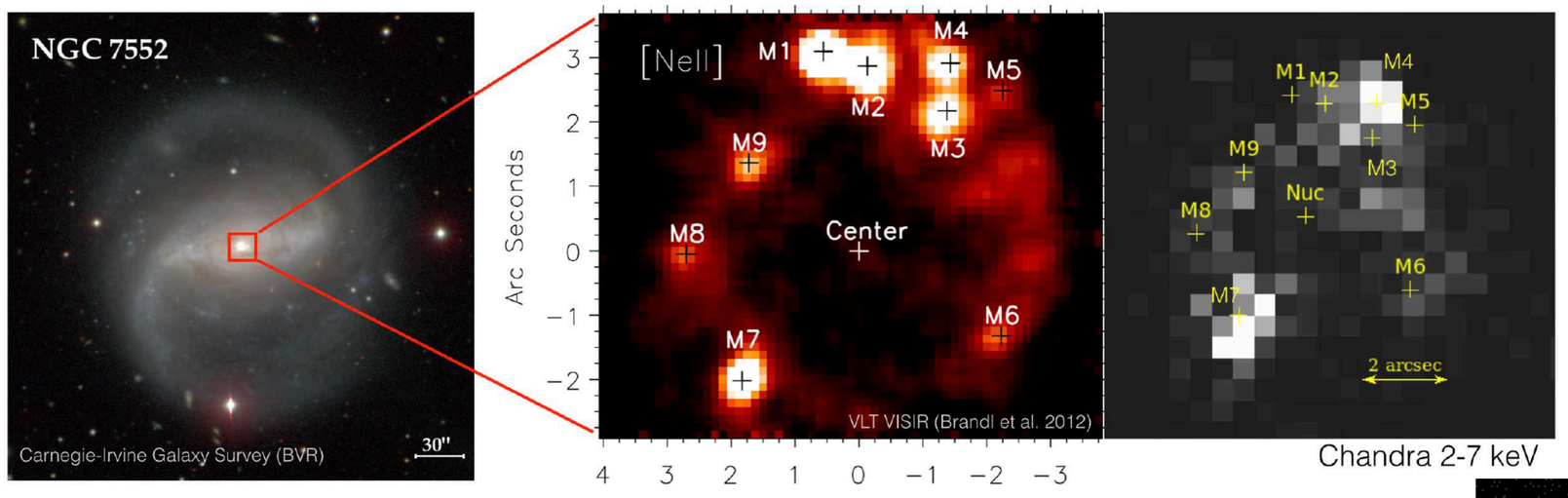

Figure 1**: (Left) Carnegie-Irvine BVR image of NGC 7552, (center) "zoomed-in" VLT VISIR image of the [Ne II]-emitting star-forming knots, as defined by Brandl et al. (2012), and (right)* Chandra *2–7 keV image of the same "zoomed-in" region, with knot locations labeled. The most powerful star-forming knots (M1 and M2) show major deficits in their X-ray emission for their SFRs.* ***We seek to determine with* NuSTAR *whether this population is buried behind a very large obscuring column or if the population is simply not present due to age and/or metallicity effects.

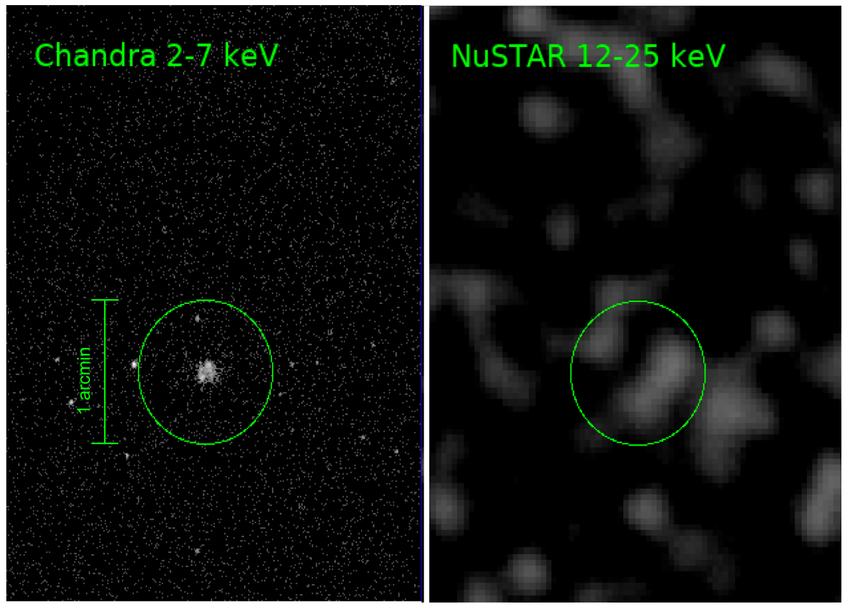

***Figure 2**: Images of NGC 7552 from (left)* Chandra *in the 2-7 keV band and (right)* NuSTAR *in the 12-25 keV band. If the star-forming region is deficient in XRBs, we would expect 45 source counts and 178 background counts in the10-20 keV band from extrapolating the* Chandra *data. We measure 40.5 source and 167.5 background counts in the 12-25 keV* NuSTAR *data, indicating that there is no buried XRB population and that the region is deficient in XRBs given its measured SFR.*

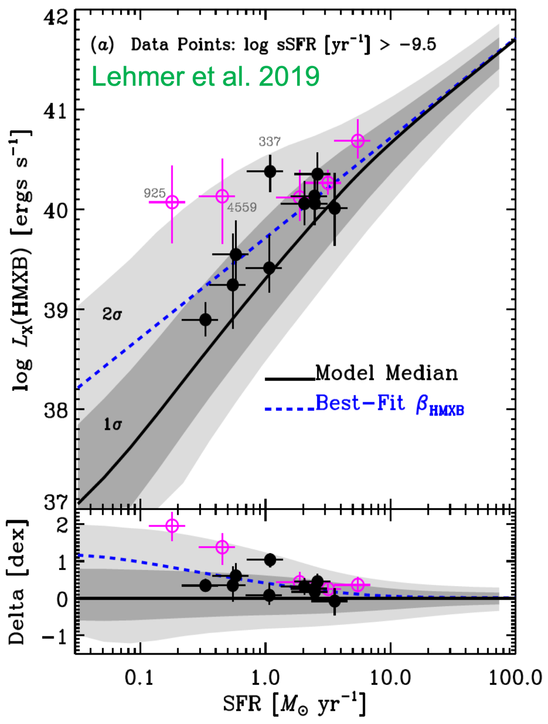

***Figure 4**: We will use observed X-ray luminosities (or upper limits) derived from* Chandra *at the location of each star-forming knot, along with SFR values at each location (Brandl et al. 2012) to compare the L_X–SFR for each knot with the L_X(HMXB)–SFR relation from Lehmer et al. 2019 for star-forming galaxies, shown above. Based on our initial analysis, we expect most of the knots will not be consistent with this relation, likely due to age/metallicity effects.*

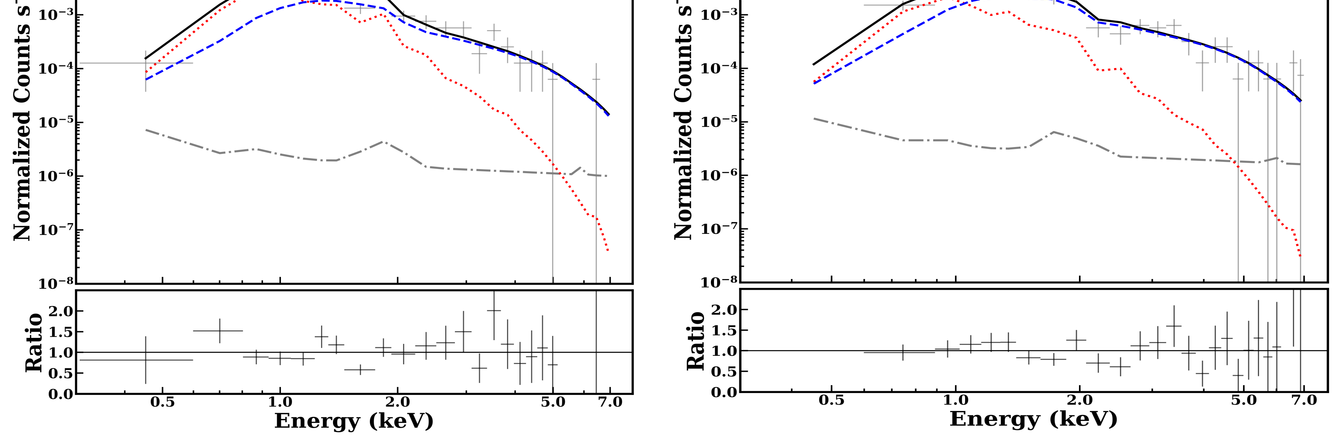

***Figure 3**: Fits to* Chandra *0.3-7 keV spectra. Source and background models fit simultaneously to unbinned spectra in XSPEC. Spectra extracted from the (left) northern point source, (center) southern point source, and (right) entire nuclear region. Point source spectra are fit well by two-temperature (T ~ 0.3 and 0.8 keV) hot gas plus power-law models. Although not tightly constrained, the data appears to prefer a steep power-law slope (Γ ~ 2.2-2.3) in both cases. Spectra binned for plotting purposes only.* Chandra *background model developed following Bartalucci et al. 2014.*

Initial Results and Future Work

(1) Individual *Chandra* point source spectra associated with SF knots (Fig. 1) are fit well by two-temperature hot gas plus steep power-law model components, consistent with expectations for a population of XRBs (Fig. 3). Parameters are not tightly constrained by this data set, so we will use additional *Chandra* observations and our newly-obtained *NuSTAR* data to better constrain the models.

(2) Preliminary analysis of newly-obtained *NuSTAR* data is consistent with predictions for a **circumnuclear region that is deficient in XRBs given its measured SFR**, and inconsistent with expectations for a buried population of XRBs (Fig. 2).

(3) We will use observed X-ray luminosities (or upper limits) derived from *Chandra* at the location of each star-forming knot, along with SFR values at each location (Brandl et al. 2012) to compare the L_X – SFR for each knot with the L_X(HMXB)–SFR relation from Lehmer et al. 2019 for star-forming galaxies. Our preliminary analysis of the *Chandra* and *NuSTAR* data suggests that most of the knots will be inconsistent with the Lehmer et al. 2019 relation, likely due to very young ages (≲ 5 Myr) and/or high metallicity (>1.5 $Z_\odot$)

Acknowledgements

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