A State Transition of the Luminous X-ray Binary in the Low-Metallicity Blue Compact Dwarf Galaxy I Zw 18

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Reionization

- After recombination, the universe was filled with neutral gas. By redshift ~ 6, the universe was ionized.
- Need UV or soft X-rays (E > 13.6 eV) to ionize H.
- Reionization is usually ascribed to UV from low metallicity and very massive stars, but there are issues with escape of UV from the host galaxies.
- Mirabel et al. (2011) suggested that X-ray binaries may have helped reionize the universe because soft X-rays are more penetrating than UV, but need enhanced XRB formation.

Is X-ray binary formation enhanced under the conditions found in the early galaxies?

BCDs are Analogs to Early Galaxies



Blue Compact Dwarfs

- Large gas fraction
- Low metallicity (0.02 Z_{\odot} for I Zw 18)
- Dominated by young stars
- Similar to early galaxies (lots of gas, few metals, young and massive stars)

Is X-ray binary formation enhanced in BCDs?

I Zw 18 (HST, Aliosi)

XRBs at low metallicity

X-ray binary production appears to be enhanced at low metallicity (Mapelli+ 2010, Kaaret+ 2011, Prestwich+ 2013).
Provides support for theoretical predictions (Zampieri+ 2004, Dray 2006, Linden+ 2010, Fragos 2013).





- Low flux: hard spectrum $\Gamma = 1.9 \pm 0.2$, no evidence for curvature
- High flux: $L = 1 \times 10^{40}$ erg/s, disk makes 76% of flux (2-10 keV)
- States are similar to those of stellar-mass BH binaries
- ULXs spectra usually dominated by power-law/Comptonization, exceptions (M82 X-1, HLX-1) are good IMBH candidates
- Hard state luminosity suggests $M > 85 M_{\odot}$

X-Ray Spectrum in Thermal State

- Thermal spectrum has temperature kT ~ 1 keV.
- Fits with simpl*kerrbb suggest rapidly rotating, massive black hole.
- Presence of an intermediate mass black hole in a BCD would be of great interest for supermassive black hole formation.



Conclusions

- The low-metallicity blue compact dwarf galaxy I Zw 18 contains an ultraluminous X-ray source.
- Its X-ray spectral states are similar to those of stellar-mass black hole binaries and suggest an unusually massive BH.
- X-ray binary production is enhanced at low metallicity. Thus, X-ray binaries may be important for reionization.
- X-ray study of analogs of early galaxies (BCDs, LBAs) is important to understand the thermal history of the universe and early galaxy formation.