Answers for Star Formation and U/HLXs in the Cartwheel Galaxy ds9 Activity

Determining the size of the ring:

12. The diameter of the ring is ~170 pixels.
13. 170 pixels (0.5 arcsec / 1 pixel)(1 rad / 206,625 arc sec) = 0.00041 rad
14. (0.00041 rad)(380 ly) = 160,000 ly

Conclusions and Analyses:

1. Most of the X-ray sources are along the lower part of the ring where Hubble observed bright blue knots that are gigantic clusters of newborn stars.
2. Using the expansion rate given in the background material and the distance the ring has moved from the center (half your answer to #14):
   (200,000 mi/h) / (5.88 X 10^{12} mi/ly) X (24 h/day) X (365.25 days/y) = 0.0003 ly/y
   v = d/t so t = d/v = (80,000 ly) / (0.0003 ly/y) = 300 million years
3. No, there is no X-ray source corresponding to the galactic nucleus as seen in the optical image.
4. Answers may vary, but X-ray sources along the ring could be supernova remnants, neutron stars or black holes because the lifetime of a massive star is less than 300 MY which is approximately when the galaxy collision occurred and new star formation was triggered.
5. From *Nonnuclear Hyper/Ultraluminous X-Ray Sources:*
   A. "It has been argued on observational and theoretical grounds (Appleton & Struck-Marcell 1996; Bransford et al. 1998) that the triggering of newly formed stars in ring galaxies occurs approximately simultaneously as the wave propagates out through the disk—the outer ring representing the most recently formed stars, with representative ages < 10^7 yrs. In this picture, the ring represents the outermost progress of a wave that began at the disk-center some 300 Myrs previously, created by the central perturbation of the intruder, either G3 or G1."
   B. "Almost all the X-ray emission in the Cartwheel originates from point-like sources within the southern quadrant of the outer ring. The sources are nearly coincident with the strong H, radio continuum emission and blue super-star clusters (SSCs)."
   C. "The companion galaxy G1 (spiral) contains 6 point-like X-ray sources, and the early-type spiral G2 is seen as a fainter diffuse source (Fig 1). The farthest companion galaxy G3 is also significantly detected, with one ULX in the eastern edge of its disk. In addition, a faint, diffuse X-ray envelope which includes the Cartwheel, G1 and G2 is marginally detected."
   D. "The absence of any point-like X-ray source in the nuclear region of the Cartwheel rules out the existence of AGN."
   E. "A point-like source 31, 10 kpc north of G2, is likely a background galaxy or AGN as it has a faint optical counterpart in the HST image."
   F. "The two most likely sources of X-ray emission associated with massive young star-forming regions are probably supernovae (SNe) or extremely young SN remnants (SNRs) and the high-mass X-ray binaries (HMXBs). We can almost rule-out low-mass X-ray binaries (LMXBs) to be the significant sources for

H/ULXs along the Cartwheel narrow ring, although intermediate mass black holes (IMBHs, see review by Miller & Colbert 2003) are likely viable. It is conceivable that LMXBs and/or background sources could be responsible for the three ULXs interior to the ring. Three "ULXs" outside the Cartwheel with faint optical counterparts are likely background galaxies. "