Searching for Young Type Ia Supernova Remnants in M83

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Abstract. Young Type Ia supernova remnants (SNRs) are characterized by Balmer-dominated optical spectra, well-defined shell morphologies, $> 10^{36}$ ergs s^{-1} X-ray luminosities, and a lack of massive stars and dense interstellar gas in their vicinity. Applying these characteristics and using archival deep *HST* and *Chandra* observations of M83, we search for young Type Ia SNRs in this spiral galaxy. This is a very difficult task!

Keywords. ISM: supernova remnants

1. Introduction

M83 (NGC 5236), at a distance of 4.61 Mpc, is a nearby large grand-design spiral galaxy (see Figure 1). Supernova remnants (SNRs) in M83 have been identified using the criterion [S II]/Hα ratio > 0.3 in Dopita *et al.* (2010) and Blair *et al.* (2012). Using a deep, 790 ks, *Chandra* ACIS X-ray observation of M83, Long *et al.* (2014) compared X-ray point sources with SNR candidates identified from [S II]/Hα ratios or nonthermal radio sources, and confirmed 87 SNRs. Using an expanded Hubble Space Telescope (*HST*) WFC3 survey of M83, in conjunction with the deep *Chandra* observation of M83, Blair *et al.* (2014) made a targeted search of young SNRs, resulting in 63 objects.

These surveys have been successful in finding SNRs expanding into a dense medium and exhibiting forbidden lines with high [S II]/Hα ratios or young super-luminous SNRs dominated by emission from O-rich SN ejecta. However, young Balmer-dominated Type Ia SNRs have escaped detection because of their lack of forbidden lines. Adopting the characteristics of Type Ia SNRs in the Large Magellanic Cloud (LMC) reported by Ou *et al.* (2017), we started to search for young Type Ia SNRs in M83.

2. Search for Young Type Ia SNRs in M83

The young Type Ia SNRs in the LMC are characterized by (1) Balmer-dominated optical spectra, (2) well-defined shell structure, (3) X-ray luminosities of a few $\times\ 10^{36}$ erg s^{-1}, and (4) Population II stellar and interstellar environments.

To search for Balmer-dominated SNRs in M83, we start with the *Chandra* X-ray sources from Long *et al.* (2014), and examine the *HST* Hα images for shell structures associated with the X-ray sources. We immediately find it a very difficult task, as our initial search did not turn up any obvious candidates for Type Ia Balmer-dominated SNRs. Only three candidates are marginally identified (shown in Figure 2).
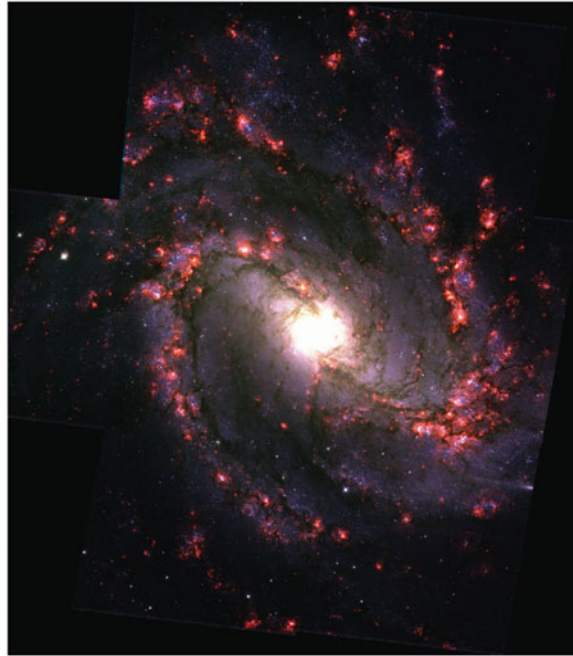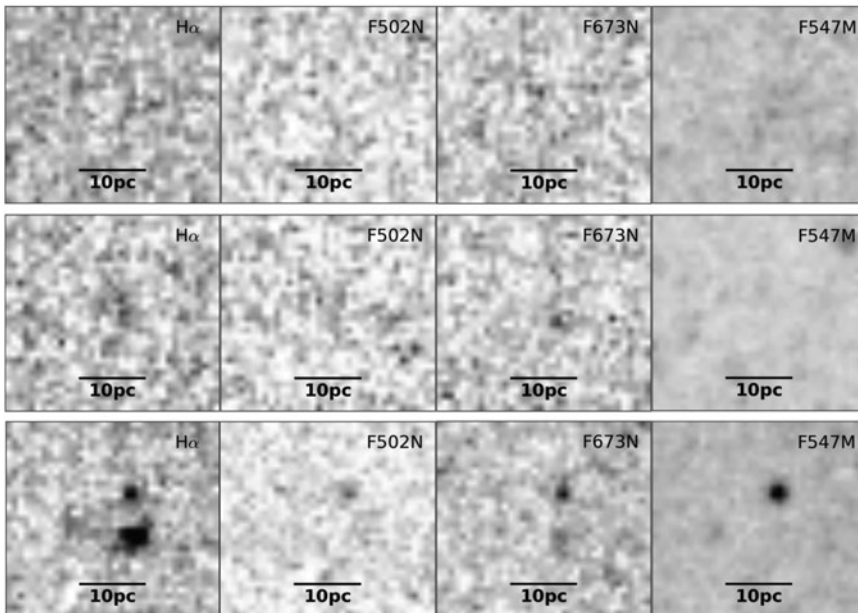
Figure 1. *HST* image of M83.

Figure 2. Images of 3 Type Ia SNR candidates (from left to right) showing Hα (F657N), [O III] (F502N), [S II] (F673N), and stellar continuum (F547M).

Are these candidates viable? Why do Balmer-dominated Type Ia SNRs appear so scarce in M83? To answer these questions, we scale their LMC counterparts and estimate their expected surface brightness if located in M83. The SNR 0519-69.0 is a 33" × 33" Balmer-dominated Type Ia SNR in the LMC at a distance of 50 kpc, reported by Smith

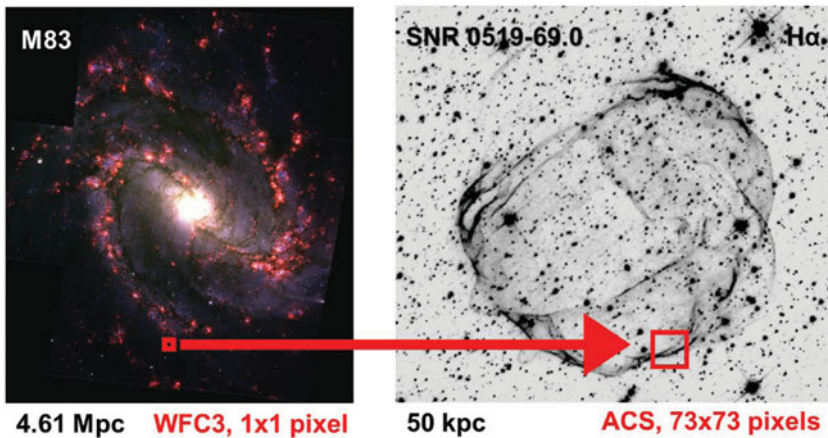**Figure 3.** For *HST* images, a WFC3 pixel (0.0396" × 0.0396") in M83 corresponds to 73 × 73 ACS pixels in the LMC.

et al. (1991). For *HST* images, a WFC3 pixel (0.0396" × 0.0396") in M83 corresponds to 73 × 73 ACS pixels in the LMC (see Figure 3). The Balmer filaments in 0519-69.0 are ∼0.3" (∼6 pixels) wide; thus, only a small fraction of a 73 × 73 area centered on a filament will be filled with emission. The average surface brightness of a 73 × 73 area in 0519-69.0 will be its expected surface brightness in M83. We find the average surface brightness of 0519-69.0 to be $(4\text{-}11) \times 10^{-16}$ erg cm^{-2} s^{-1}arcsec^{-2}. The *HST* Hα image of M83 has a background of ∼3.4×10^{-16} erg cm^{-2} s^{-1}arcsec^{-2}. Comparisons between these figures indicate that a Balmer-dominated Type Ia SNR in M83 is expected to be detected at generally ∼2-3σ level and up to ∼5σ level for the brightest filaments.

The three objects in Figure 2 indeed are detected at ∼2-3σ levels. Their sizes, smaller than 15pc, are consistent with young SNRs. The lack of dense ionized interstellar gas and massive stars in their vicinity and their X-ray luminosities of a few × 10^{36} ergs/s are consistent with those of young Type Ia SNRs. The detection thresholds of the [S II] or [O III] images are too high to provide meaningful upper limits of these forbidden line emission. We suggest that the three objects in Figure 2 are promising candidates for Balmer-dominated Type Ia SNRs in M83.

Acknowledgements

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