Chandra ACIS Survey of M33 (ChASeM33): X–ray Imaging and Spectroscopy of the Bright SNR M33SNR21

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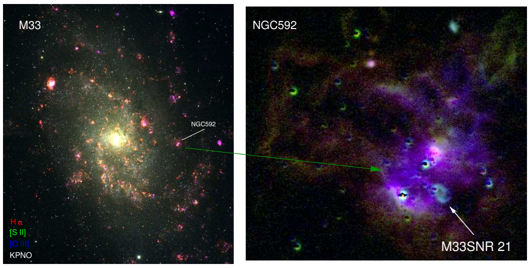
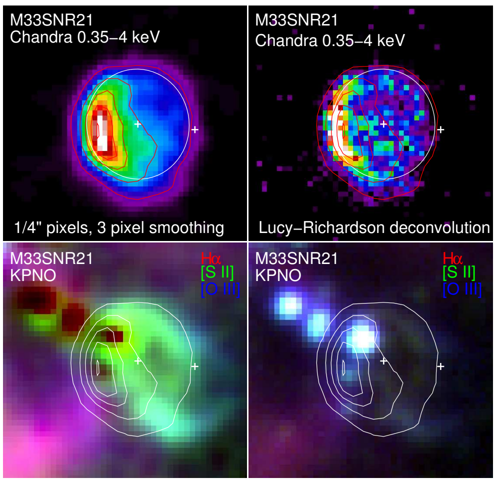
Introduction

Multiwavelength studies of nearby galaxies are effective at providing statistically interesting samples of many classes of objects. M33, a late type Sc spiral at 817 ± 58 kpc [1] (but see [2]) and relatively face on ($i = 55^\circ \pm 1^\circ$, [3]) is a key galaxy for such studies. At that distance, $1'' = 4$pc, and at least some supernova remnants (SNRs) can be resolved. We present new X-ray data for M33SNR 21, the brightest M33 X-ray supernova remnant, obtained as part of the ChASeM33 [4]. 200 ks of nearly on-axis data shows the remnant to be $\sim 5''$ in diameter, and a slightly elliptical shell which is much brighter on the eastern side than the rest of the remnant, suggestive of a strong density gradient.



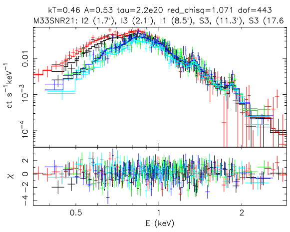
NGC592 & M33SNR 21

M33SNR 21 appears in projection against the giant H II region NGC 592 (see figure). NGC 592 is $\sim 4 \times 10^6$ yr old [5], and dominated by a pair of bright cores. Optical emission (high [S II]/Hα ratio) characteristic of SNRs was found for M33SNR 21, in addition to nonthermal radio emission [7]. Density-sensitive [S II] line ratios show gas density $n_e \sim 270\ \mathrm{cm}^{-3}$ [7], supporting the idea that the SNR is associated with the H II region.



M33SNR 21 Analysis

We combined the nearly on-axis and off-axis *Chandra* data to obtain a total of ~ 10000 counts from the remnant. We fit with an absorbed nonequilibrium ionization model in xspec (`vsedov`); the resulting remnant properties (assuming a Sedov model) are listed in the table. The remnant is ≈ 20pc in diameter and ≈ 6000–9000 yr old. Its likely association with the H II region suggests that it is the remnant of a Type II explosion. The mean abundances are low, consistent with what would be expected for M33. We searched for enhanced abundances by fitting the bright eastern portion and the faint remainder of the remnant, but did not find any significant differences in abundances.



M33SNR 21 Properties

R_s	$2.68'' \times 2.47''$		radii
	10.2×9.5	pc	
	9.85 ± 0.8	pc	
T_s	0.46 ± 0.02	keV	postshock temperature
$n_{e,s}t_0$	$(2.2 \pm 0.02) \times 10^{12}$	cm^{-3} s	ionization scale
Z	~ 0.5	$Z_\odot$	abundances
v_s	610 ± 10	$\mathrm{km\,s}^{-1}$	shock velocity
n_0	1.6 ± 0.2	cm^{-3}	preshock density
t_0	6500 ± 500	yr	expansion age
	9100 ± 1800	yr	ionization age
M_{SU}	240 ± 66	$M_\odot$	swept-up mass
E_0	$(1.3 \pm 0.4) \times 10^{51}$	erg	explosion energy
L_X	$1.05 \pm 0.2) \times 10^{37}$	$\mathrm{erg\,s}^{-1}$	0.5–5.0 keV

Discussion

M33SNR 21 appears to be interacting with denser gas on the eastern part. This suggests comparison to the LMC remnant N23, which also shows which show strong X-ray and optical enhancements, and evidence for interacting with denser gas. N23 has diameter ~ 16pc, and the ambient density variation is more than a factor of 10 around the remnant [8]. The abundances of O, and Ne (possibly Mg) are enhanced in one region. Assuming a Sedov model using the long radius (12 pc) toward the low density side, they obtain $n \sim 0.25\mathrm{cm}^{-3}$ and an age of ~ 4600 yr.

In contrast to N23 in which the bright X-ray and optical emission appear on the same side of the remnant, in M33SNR 21, the bright X-ray optical emission appears to be anticorrelated. The short axis of the M33SNR 21 X-ray axis runs through the brightest part of the remnant, and the optical emission extends well beyond the X-ray rim in the southwest. The reasons for this complex morphology are not yet clear, but may be further evidence of interaction with a complex environment.

Acknowledgments

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