A Multi-wavelength Study of Newly-Discovered Faint SNRs in the Large Magellanic Cloud

Matthew D. Klimek, Sean D. Points, R. Chris Smith (CTIO)
Robin Shelton (Georgia), Rosa Williams (Columbus State)

INTRODUCTION

The Large Magellanic Cloud (LMC) is an ideal site to study a large sample of supernova remnants (SNRs) in detail. We have identified new LMC SNRs in multi-wavelength data. These SNRs are generally fainter than the known sample.

Our analysis of these remnants is based on:

- XMM-Newton observations
- Optical emission line and echelle data from CTIO
- Plasma hydrodynamic simulations

DETAILED BACKGROUND MODELING

Instrumental Effects

Fluorescent Lines

Gaussian fits to lines at 1.5 keV (Al Kα) and 1.75 keV (Si Kα)

Residual Proton Contamination

Power law fit un-folded with instrumental response function due to low-level contamination not removed by high background time filtering. Not necessarily consistent across observations.

Extragalactic Background

Thermal

Modeled as APEC thermal plasma. Average value

$kT \sim 0.22$ keV

Non-thermal

Modeled as a power law with photon index fixed at 1.46.

Local Hot Bubble

Modeled as APEC thermal plasma. Average value

$kT \sim 0.10$ keV

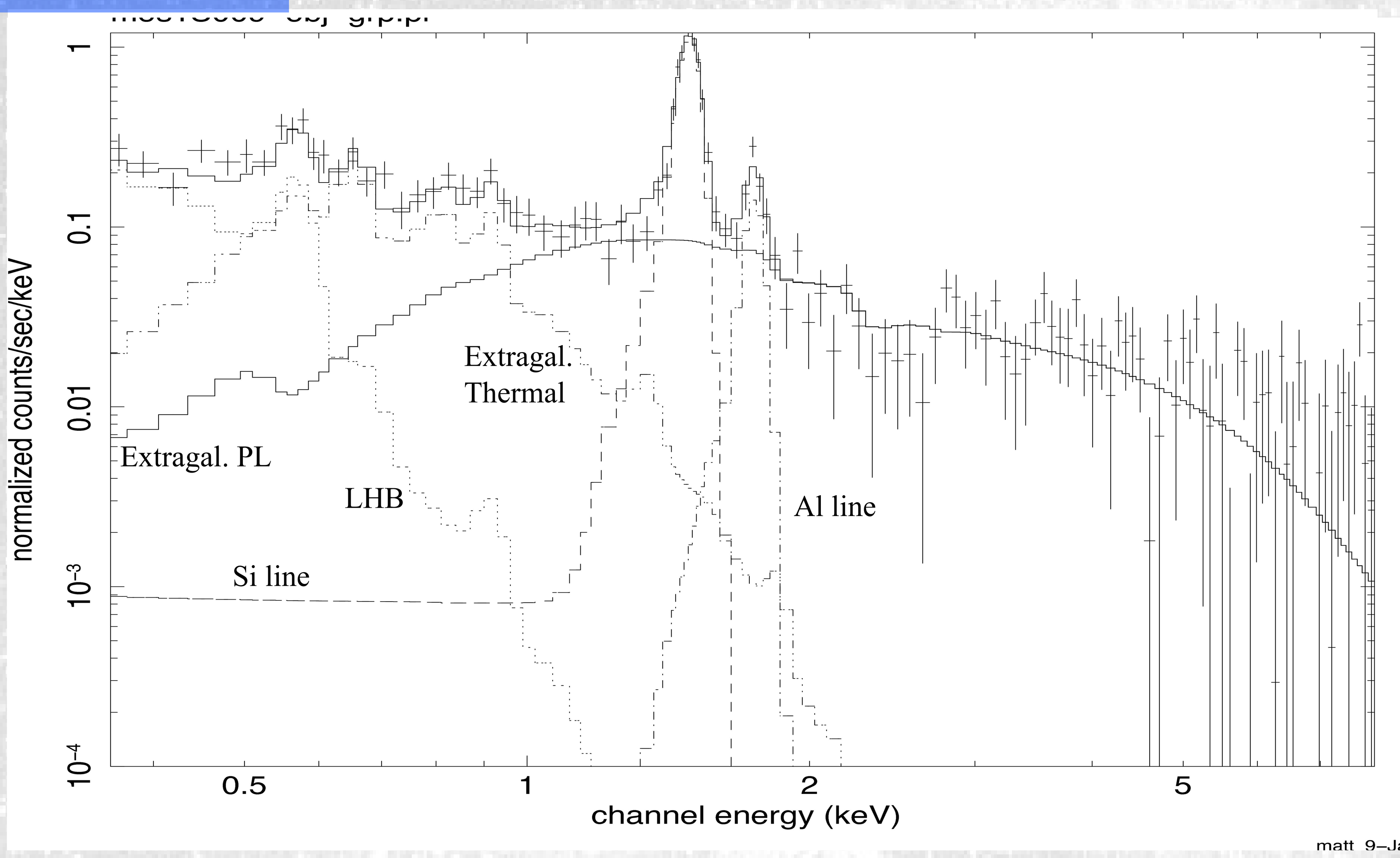
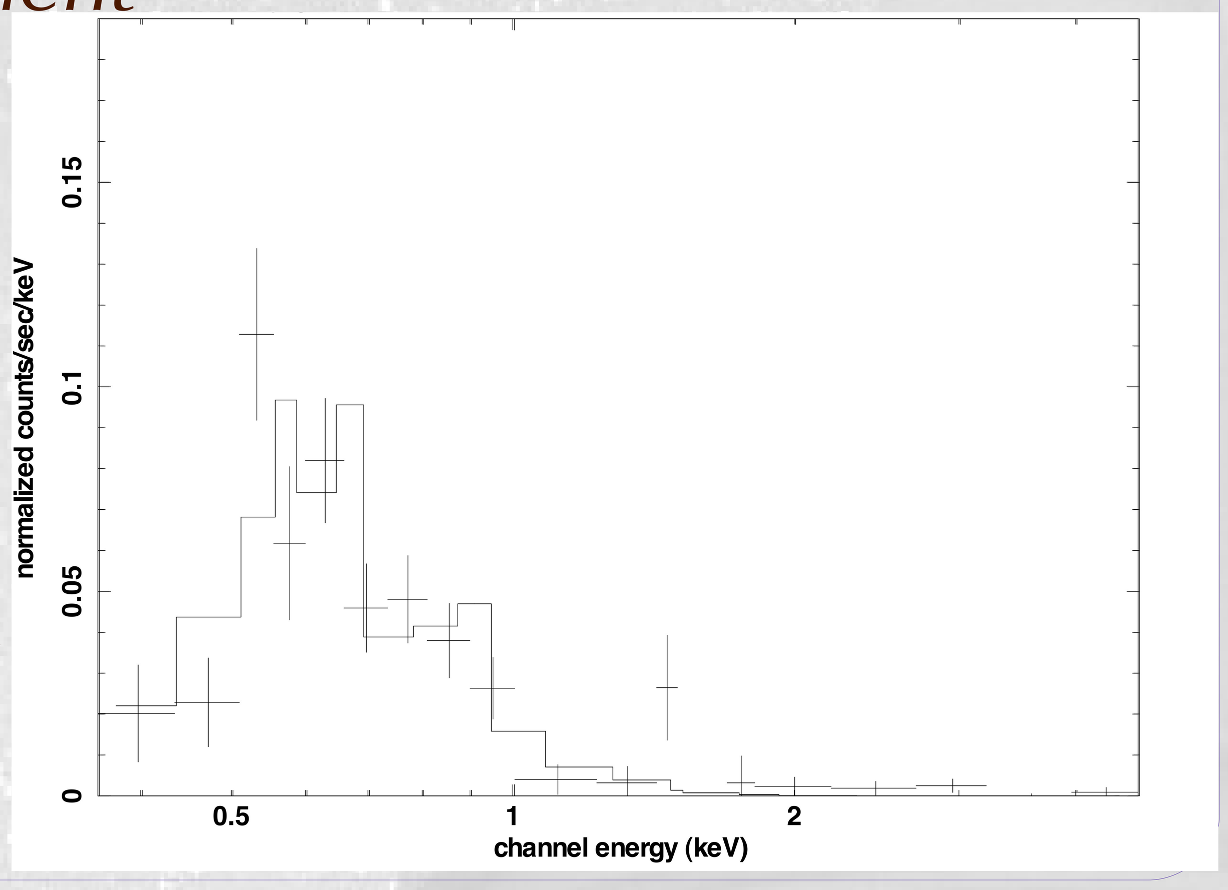


Figure 1: Background spectrum overlaid with individual model components

SOURCE MODEL & SIMULATION

Source Component

- APEC thermal plasma added to background model
- Source component fitted with background parameters fixed.
- Abundances fixed at the standard LMC value of 0.3 solar.



1-D Simulations

- Simulations are based on properties calculated from the observations.
- The simulations output temperature, density and ionization level as a function of radius and age.
- These are converted to spectra.

We replace the fitted source component as described at left by the simulated spectrum, and step through the various epochs of the simulation to find the best fit.

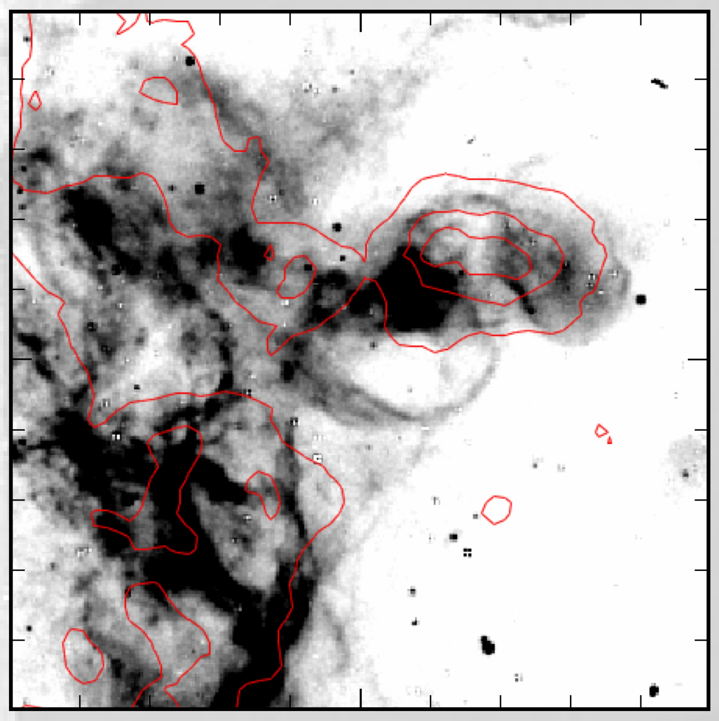
Physical Properties of SNRs

	SNR0449–6921	SNR0506–6541	SNR0537–6628
R (pc)	19×11	60×40	23
SB (10^{-15})	0.9	0.5	0.4
$v_{\rm exp}$ (km s^{-1})	70	90	55
$n_{\rm e,shell}$ (cm^{-3})	5.5	3.0	3.2
$V_{\rm shell}$ (cm^3)	1.4×10^{59}	1.7×10^{60}	4.3×10^{59}
$M_{\rm shell}$ ($M_\odot$)	820	5.6×10^3	1.4×10^3
K (erg)	4.2×10^{49}	4.5×10^{50}	4.4×10^{49}
$P_{\rm shell}$ (dyne cm^{-2})	1.5×10^{-11}	8.2×10^{-12}	8.8×10^{-12}
kT (keV)		0.17(1)	0.22(5)
Normalization (10^{-14} cm^{-5})		0.004(2)	0.0009(9)
V (cm^3)		1.3×10^{61}	1.5×10^{60}
$n_{\rm e,hot}$ (cm^{-3})		0.11(7)	0.1(1)
$M_{\rm hot}$ ($M_\odot$)		$1.3(9) \times 10^3$	200(200)
$E_{\rm th}$ (erg)		$1.07(4) \times 10^{51}$	$2.0(8) \times 10^{50}$
$P_{\rm hot}$ (dyne cm^{-2})		$5.5(2) \times 10^{-11}$	$9(3) \times 10^{-11}$
$n_{\rm ISM}$ (cm^{-3})	> 4.0	0.5	1.315

Left: Table of SNR properties as calculated from H alpha, echelle and X-ray spectral observations.

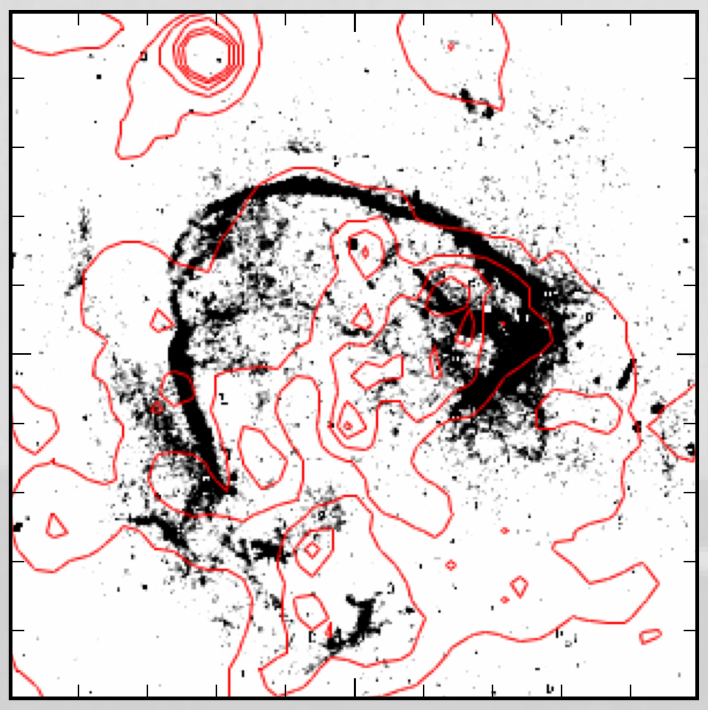
Below: H alpha images of individual objects overlaid with X-ray contours. Images are 10 arcseconds square.

SNR0449-6921



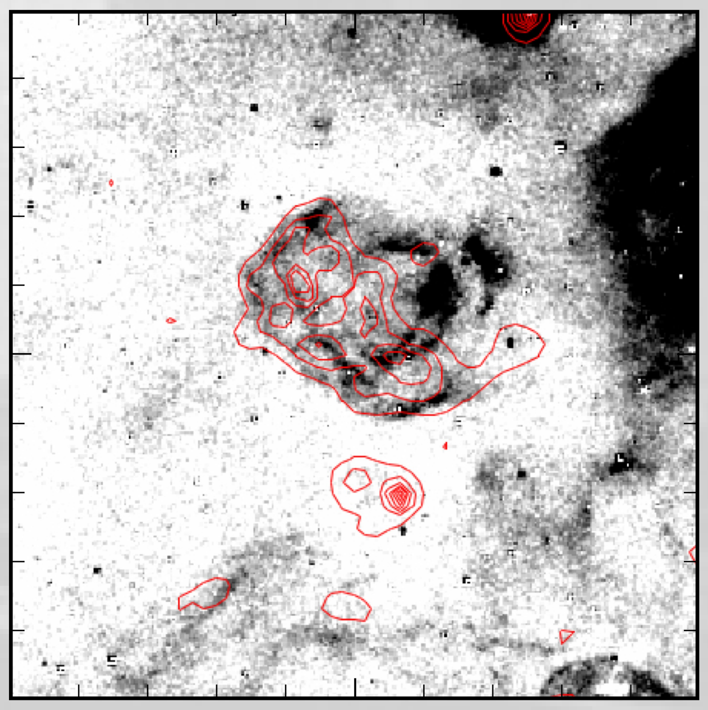
- Lies on the edge of a large H II region.
- Well-defined shell structure visible in optical data.
- Optical shell contains smooth distribution of soft X-ray emission.
- Too few X-ray counts to constrain model fit.

SNR0506-6541



- Shell structure in optical data though not a clean sphere as in SNR0449-6921.
- Second-largest known SNR shell in the LMC.
- Good agreement between properties derived from expansion and spectral data. Implied age around 150 kyr.
- Evidence for freshly shocked gas behind the shell implies higher expansion velocity and younger age ~95 kyr.
- Simulations favor an age of 100 kyr.

SNR0537-6628



- Lies on the edge of a large H II region.
- Optical filaments visible but in a nested shell-like pattern.
- The two shells have distinct echelle expansion patterns.
- X-ray emission confined to the area enclosed by the outer half shell. Possible bilobed structure?
- Disagreement between properties derived from expansion data and spectral data when assuming spherical symmetry.
- Agreement achieved for a bilobed structure with a viewing angle of 55 degrees, which gives an age of 70 kyr.
- 1-D simulations support and age >80 kyr.

ACKNOWLEDGEMENTS:
This project was supported by NASA grant #NNG06EQ01I.