Examination of the X-ray Spectrum of the SNR 0509-67.5

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SNR 0509-67.5 overview

- Location: LMC
  - Low column density, absorption
  - Distance: 50 kpc
- Size: 25"
  - R = 3.6 pc
- SN type Ia
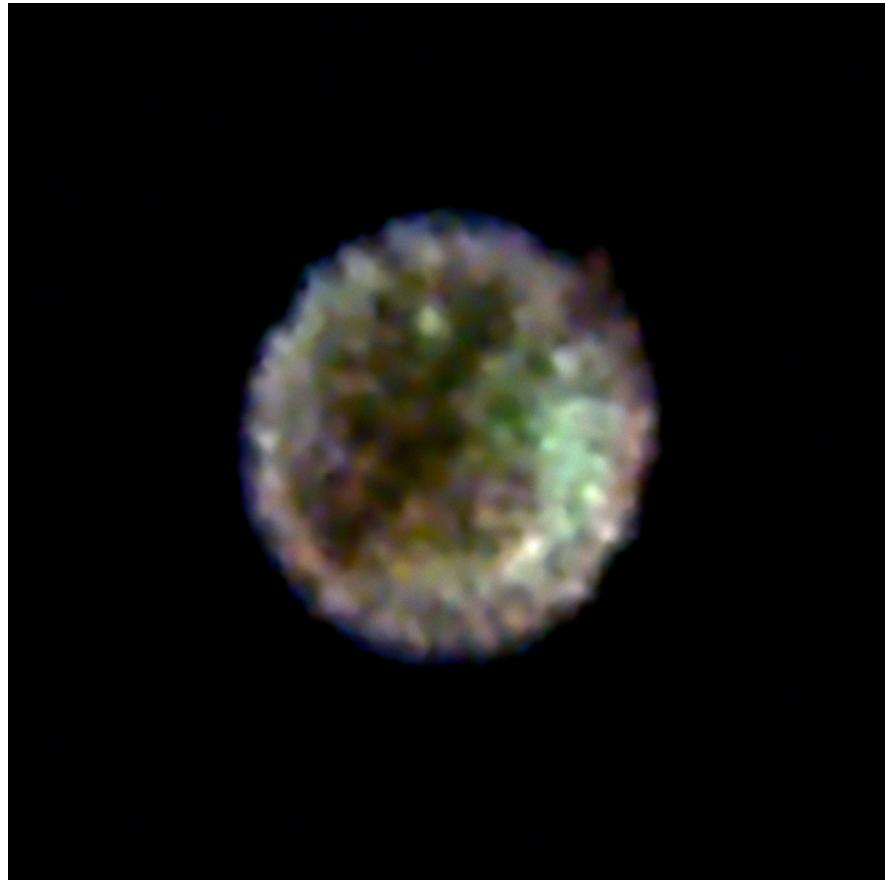
SNR 0509-67.5 overview

- Optics, UV
  - Light echo
    - Rest+ 05; Rest+ 08
  - Ly β
    - Ghavamian +07
- X-ray
  - Chandra
    - Warren & Huges'04; Badenes+ 08
 - ASCA
    - Hughes+ 95
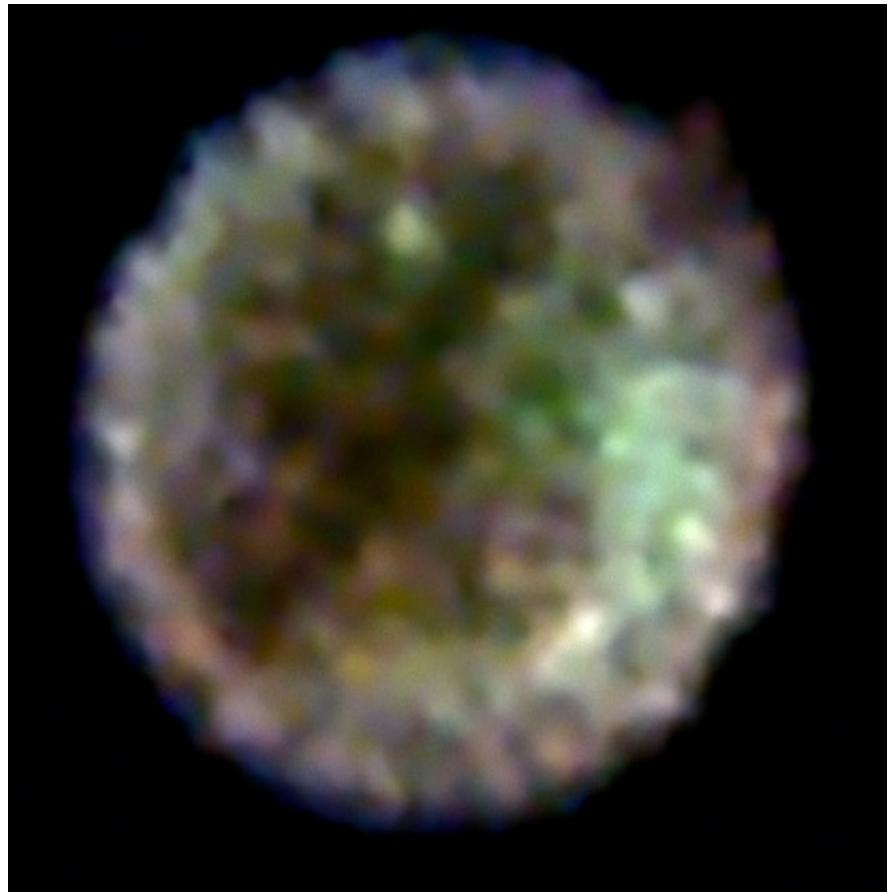
SNR 0509-67.5 overview

- **Light echo**
  - 400 yrs
  - SN 1991T-like explosion

- **Ly β**
  - V_{SH} = 5200-6300 km/s

- **Chandra**
  - Si, S, Fe – rich
  - α_{POW} = 3.4
  - SN 1991T-like (modeling)
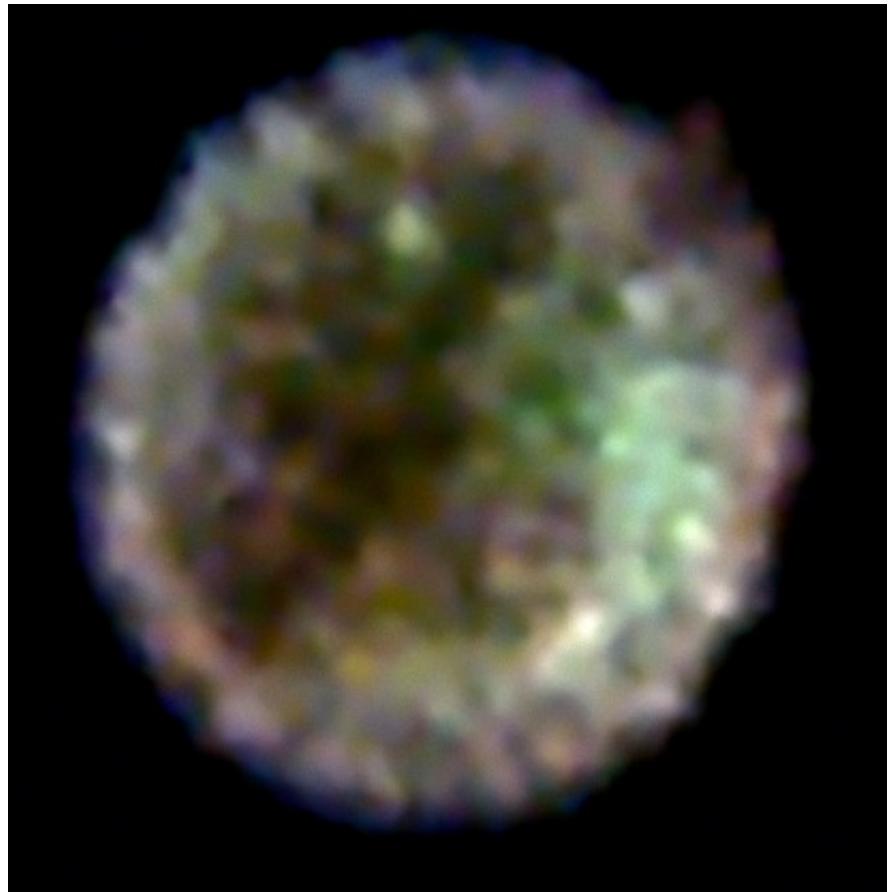
XMM-Newton data

EPIC MOS, RGS spectra
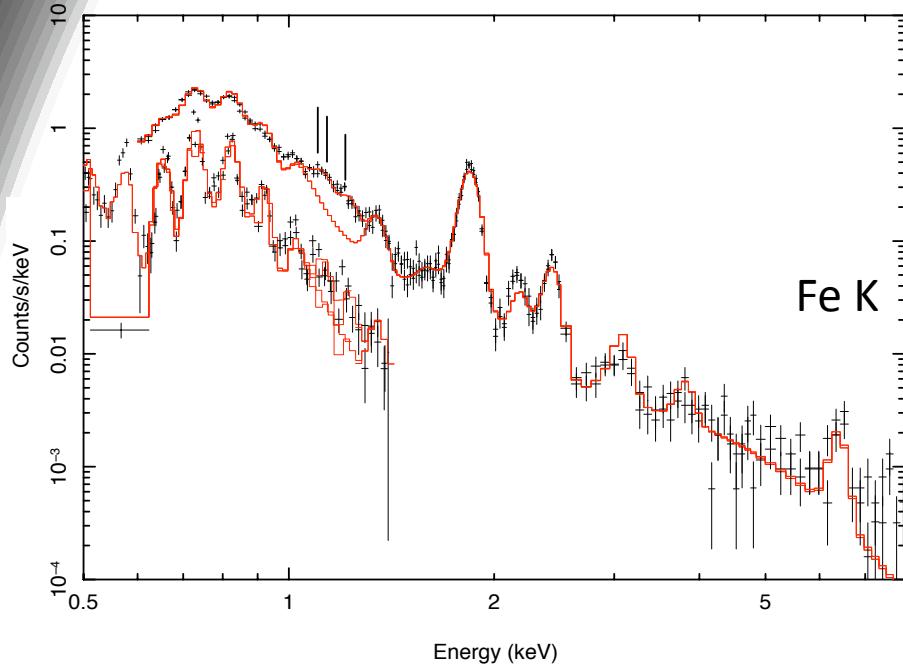
SPEX NEI model

Best-fit parameters

$n_e n_H V$ = $(1.0 \pm 0.1) \times 10^{58}$ cm^{-3}

kT_e = 4.0 ± 0.2 keV

$n_e t$ = $(1.4 \pm 0.03) \times 10^{10}$ s/cm^3

$n_e t$[Fe K] ≈ 10^9 s/cm^3

α_{POW} = 3.5 ± 0.1

n_{CSM} ≤ 0.6 cm^{-3}

M_{Fe} ≤ 0.1 M$_\odot$

XMM-Newton data

EPIC MOS, RGS spectra

SPEX NEI model
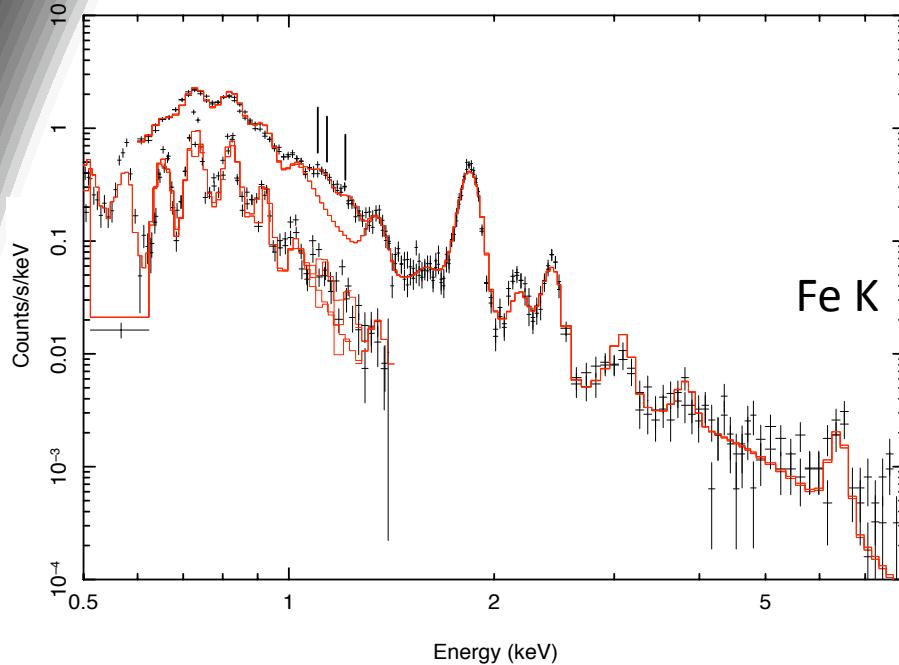
Best-fit abundances
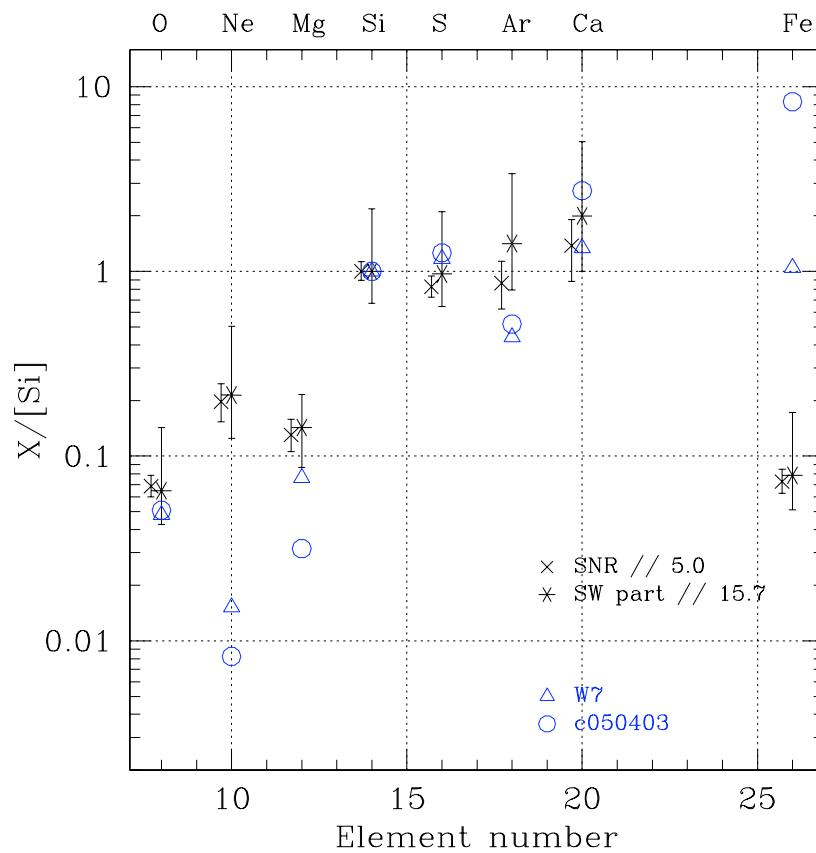
XMM-Newton data

RGS spectra

SPEX NEI

Best-fit parameters
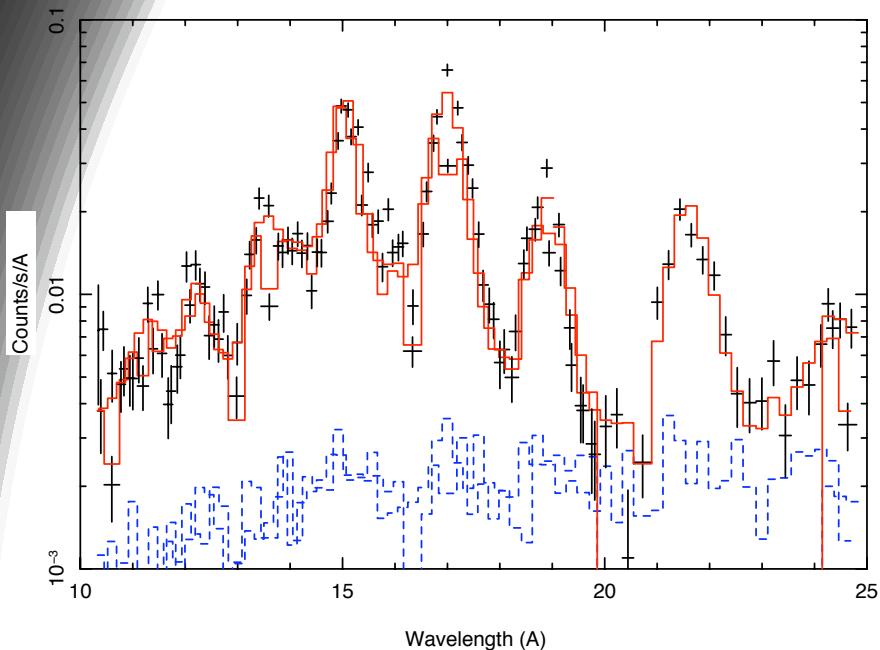
	EPIC	RGS
kT_e, keV	**5.2 ±0.2**	**0.8 ±0.3**
$n_e t$, s/cm^3	**1.62 +0.05**	**1.3 ±0.3**

XMM-Newton data

RGS spectra

SPEX NEI
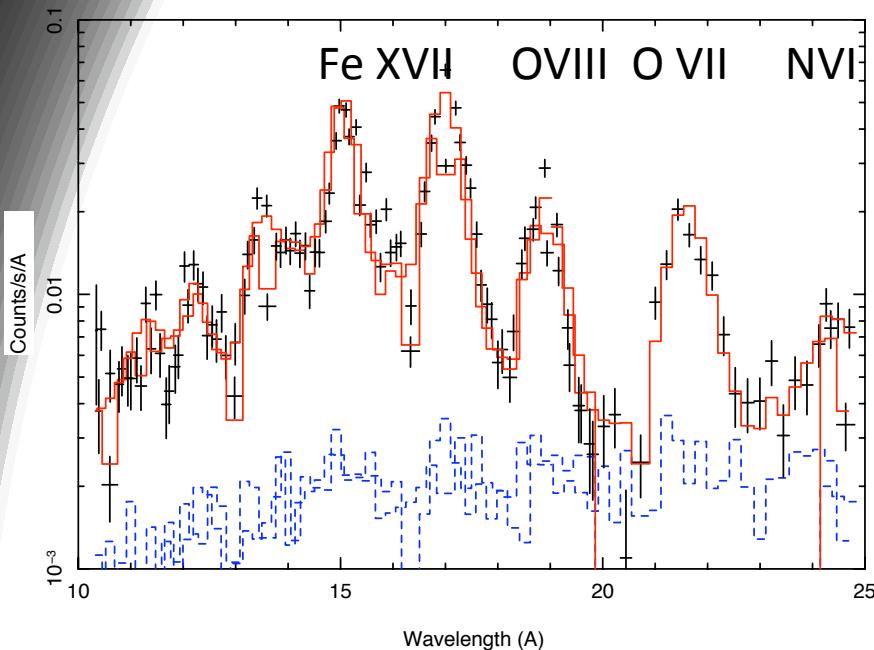
Parameters

- σ_V = 4900 km/s in ejecta
  - $V_{SH} \leq$ 6500 km/s

- N – not a SN Ia product
  - $n_{CSM} \approx$ 0.4-0.8 cm^{-3}

High resolution spectra of SNR 0509-67.5

- High resolution spectra
  - Line velocity broadening of the ejecta
  - Nitrogen abundance – CSM density
- Soft X-ray range
  - Low temperature component
  - Constrain on power-law index

Application of the data

- Numerical HD simulation input
  - Explosion model (energy, abundances)
  - CSM density, age
  - Physics: parameters
- Comparison the data with the HD models output
  - Velocities, temperatures ...
  - X-ray emission (atomic data?)

Numerical models of SNR 0509-67.5

- Size, age, ejecta velocities (RGS) and CSM density (EPIC, RGS)
  - explosion model
    - require energetic explosion for the remnant: $E \approx 1.4 \times 10^{51}$ erg.
  - physics in the remnant
    - suggests noticeable contribution of relativistic particles (cosmic rays): $E_{CR} \approx 40\%\ E_{th}$
    - temperature equilibration between electrons and ions: $T_e \approx 0.01 T_i$