fermi-lat observations of snr n132d in the lmc

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pierrick martin, marianne lemoine-goumard, fabio acero, liz hays, on behalf of the fermi-lat collaboration,
pat slane, paul plucinsky, jack hughes
why should you care about the connection between SNRs and cosmic rays?

what evidence is there that SNRs accelerate cosmic rays?

what have we learnt recently by studying SNRs in x-rays and gamma-rays?
why?

- origin
- \(\gamma\)-ray background
- particle acceleration
- snr evolution
- cr feedback

fermi-lat 10-year all-sky pass 8 intensity map (>1 GeV)
what evidence?

- shock structure

- non-thermal x-rays
  - synchrotron emission
  - magnetic field amplification

- \( \gamma \)-ray emission
  - leptonic vs hadronic
open questions

dynamically young + fast shocks

dynamically evolved + dense
open questions
open questions

[Graphs showing data for IC 443 and W44]
• brightest x-ray snr in the lmc – irregular shell of radius 50” (mathewson+ 1983, hughes+ 1987)

• morphology also matched by synchrotron radio emission (dickel+ 1995)

• like cas a – prototypical example of oxygen-rich class
  origin: collapse of very massive stars.

• from x-rays: pre-shock densities of $2 - 3 \, \text{cm}^{-3}$ (south)

• sedov similarity:
  explosion energy $E = 2.3 - 11.4 \times 10^{51} \, \text{ergs}$
  age $t = 4300 - 7200 \, \text{yr}$

• detected at TeV γ-ray energies with hess
<table>
<thead>
<tr>
<th>n132d</th>
<th>w49b</th>
<th>cas a</th>
<th>w51c</th>
<th>w44</th>
<th>ic443</th>
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<td><strong>luminosities (erg/s)</strong></td>
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<td><strong>radio</strong></td>
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<td>1 GHz</td>
<td>0.1-10 keV</td>
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<td>n132d</td>
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<td>9.9 x 10^{37}</td>
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<td>w49b</td>
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fermi-lat 10-year all-sky pass 8 intensity map

>1 GeV
10 years of data
region = 10° x 10° of lmc
(centered on n132d)

preliminary
fermi-lat γ–ray count map of lmc

2 – 200 GeV
9.5 years of data
10° x 10° of lmc
   (centered on n132d)
smoothed to $\sigma = 0.3^\circ$

pass8 data
front only
fermi-lat γ–ray count map of lmc combination of diffuse emission and point sources.

p1 – p4 detected in ackermann+16

p1 – psr b0540-69
p2 – pwn n157b
p3 – cxou j053600.0-67350 (γ–ray binary)
p4 – n132d
preliminary – count map

preliminary – test statistic map

ts peaks at 26 (roughly 5σ)
x-ray extent in green (chandra)
TeV extent in black (hess)
fermi-lat $\gamma$-ray spectrum of lmc n132d

- 9.5 years of data
- lmc background from emissivity model in ackermann+16
- pass8 data
- front+back events
- best fit model powerlaw:
  \[ \Gamma = 1.6 \pm 0.3 \]
luminosities (erg/s)

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preliminary
N132D - ACIS

max possible powerlaw component
Both leptonic and hadronic require $E_{cr} > 10^{51}$ erg.

Leptonic requires $k_{ep} > 0.1$ for $n_0 < 1$ cm$^{-3}$.
both leptonic and hadronic require $E_{cr} > 10^{51}$ erg
- leptonic requires $k_{ep} > 0.1$ for $n_0 < 1$ cm$^{-3}$

5.8 µm IRAC image – molecular hydrogen
$E \frac{dN}{dE}$ [erg cm$^{-2}$ s$^{-1}$]

Energy [MeV]

preliminary

$E = 2dN/dE, \quad E \approx 200 \text{ cm}^{-3}, \quad d = 2.9 \text{ kpc}$

$E = 2dN/dE, \quad E \approx 200 \text{ cm}^{-3}, \quad d = 2.9 \text{ kpc}$
$n_0 = 200 \text{ cm}^{-3}$

$d = 50 \text{ kpc}$

leptonic model

hadronic model

radio

chandra powerlaw upper-limit

fermi-lat

hess (TeV)

$E^2 dN/dE \ [\text{erg cm}^{-2} \text{s}^{-1}]$

Energy [MeV]
not re-acceleration?

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$E^2 dN/dE$ [erg cm$^{-2}$ s$^{-1}$]

-- leptonic model
-- hadronic model
radio
chandra powerlaw upper-limit
fermi-lat
hess (TeV)

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preliminary

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$E^2 dN/dE$ [erg cm$^{-2}$ s$^{-1}$] vs Energy [MeV]
Energy [MeV]

- Leptonic model
- Hadronic model
- Radio
- Chandra powerlaw upper-limit
- Fermi-LAT
- Hess (TeV)
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tea temim – stsci

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