Survey of dust emission in Galactic supernova remnants

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Why study supernova remnants?

• Theory predicts that supernovae can produce $0.1 - 1.0 \, M_\odot$ of dust

• Interactions between supernova remnants and ISM cause shocks which may destroy large mass of dust

• Shocks may change the dust structure
Survey of Galactic FIR supernova remnants

1. Search for dust within Galactic supernova remnants
2. Measure mass of supernova ejecta dust
3. Analyse mass, temperature, and dust property variation across remnants

The dusty Galactic Plane as seen by ESA/PACS & SPIRE Consortium, S. Molinari, Hi-GAL Project
Supernova Remnant Identification (e.g. G11.1-1.0)

Herschel
70 μm = blue, 160 μm = green, & 250 μm = red

Hα with radio contours
Stupar & Parker, 2011

Chawner et al. (submitted)
• Iron detected in shell and knots around pulsar wind nebula

• Cool ejecta dust heated by pulsar wind nebula in central region (circled)

• Reverse shock reached centre (Borkowski et al. 2016)
How much dust is there?

G11.2 - 0.3
Kes 75 (G29.7 - 0.3)
G21.5 - 0.9

SED Fitting
SNR Search
PPMAP Analysis

Chawner et al. (submitted)
How much dust is there?

<table>
<thead>
<tr>
<th>Dust Temperature: (Kelvin)</th>
<th>26.6</th>
<th>28.6</th>
<th>45.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust Mass: (M_⊙)</td>
<td>1.0</td>
<td>0.05</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Dust Temperature:

- G11.2 - 0.3
- G21.5 - 0.9
- Kes 75

Dust Mass:

- 1.0 M_⊙
- 0.05 M_⊙
- 0.03 M_⊙

SED Fitting

SNR Search

PPMAP Analysis

Chawner et al. (submitted)
Structures are made up of building blocks with:

- Unit column density
- Unknown temperature & emissivity
Point Process Mapping, PPMAP

- Increase image noise until there is no information
- Decrease noise in steps
- Update knowledge about building block temperature and emissivity at each step
At what temperatures is there dust?

- Apply PPMAP using 6 images between 24 and 500 μm
- Analysis of dust column density across map for each temperature and emissivity
- Collapse results → grid showing the column density map at each of the 12 temperatures

Herschel false colour image: blue = 70 μm, green = 160 μm, red = 250 μm
Are the ejecta and ISM dust different?

Chawner et al. (submitted)

- Collapse results → maps of column density at each value of emissivity index
- Sum column density of regions within apertures
- Some evidence for variation in emissivity between ISM and ejecta

![Graph and image showing emissivity index vs. normalized column density.](image)
How much dust is there?

<table>
<thead>
<tr>
<th>Description</th>
<th>SED fit dust mass</th>
<th>PPMAP dust mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>(M⊙)</td>
<td>1.0</td>
<td>0.50 ± 0.22</td>
</tr>
<tr>
<td>PPMAP dust mass</td>
<td>0.05</td>
<td>0.29 ± 0.08</td>
</tr>
<tr>
<td></td>
<td>0.03</td>
<td>0.64 ± 0.18</td>
</tr>
</tbody>
</table>

Kes 75 (G29.7-0.3)

Red = 31K, green = 41K, blue = 75K

G21.5-0.9

Red = 25K, green = 34K, blue = 37K

G11.2-0.3

Red = 28K, green = 31K, blue = 75K

Chawner et al. (submitted)
Conclusions

• Add 24 sources to the sample of dusty supernova remnants

• Detect 3 supernova remnants containing ejecta dust heated by pulsar wind nebulae

• Analysis of dust mass indicates supernovae may produce significant amounts of dust

• Marginal evidence for variation in dust properties of G21.5-0.9 compared with surrounding ISM

Questions?
**Catalogue detection types**

**Level 1:** good detection of SNR

**Level 2:** detection of FIR emission likely associated with SNR, but confused

**Level 3:** detection of FIR emission unlikely associated with SNR

**Level 4:** no detection of FIR emission

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**Graph:**

- **x-axis:** Supernova remnant age, kyr
- **y-axis:** Number of detections

- **Legend:**
  - level 1
  - level 2
  - level 3
  - level 4

- **Data points:**
  - Type Ia
  - Core Collapse Supernova type
  - unknown
Applying a Gaussian prior to the distribution of mass across emissivity index

No prior for the distribution of mass across emissivity index