An Infrared Supernova Remnant Survey in the Galactic Plane

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ABSTRACT
We searched for infrared counterparts of known supernova remnants that fall within the boundaries of the Spitzer/GLIMPSE Legacy survey (galactic coordinates |b|<1°, 65°>|l|>10°). The survey uses the Infrared Array Camera (IRAC) with four bands at 3.6, 4.5, 5.8, and 8 μm. Ninety-six known supernova remnants are included in the survey, which is ongoing but nearly complete. We detected infrared emission from several supernova remnants, and for many of them it is the first detection of their infrared emission. The 4.5 μm images made at least some supernova remnants distinct from the blending by bright emission of HI regions and molecular clouds in the galactic plane. The 4.5 μm images are dominated by molecular line emission (H2 and CO) and possibly Brackett alpha. The infrared images reveal not only the supernova remnants themselves but also nearby surrounding interstellar medium such as HI regions, dark clouds and possible young stars. Some of the most impressive images include G331.5-0.3, W 44, X 3, 391, and RCW 103.

INTRODUCTION
Much of the radiation from supernova remnants is expected to be in the infrared range, from heated grains and nebular emission lines. However, supernova remnants have generally proven to be difficult targets in the infrared, especially in the galactic plane where HI regions are far brighter than supernova remnants. Infrared supernova remnants were been nearly impossible in the galactic plane. Two attempts using IRAS found possible emission from 12 and 14 remnants, respectively, and only 7 in common, from the sample of 96 remnants in the portion of the Galactic plane covered by our survey. The new Spitzer/IRAC results presented here are a significant advance because of the large increase in angular resolution and sensitivity.

DATA ANALYSIS

RESULTS
We detect infrared emission from 10 remnants with the new Spitzer/GLIMPSE/IRAC data. The set of infrared detected remnants is mostly different from those reported with from the IRAS-based surveys, both because of different wavelengths and severe source confusion in the IRAS (~2′′) beam compared to IRAC (~2′). Using the color templates described above, we classified the emision. Six remnants have colors characteristic of shocked molecules. Such emission stands out as “green” on the color images shown in this poster because of relatively bright H2 and CO emission in IRAC channel 2. Five of these already had good indications of interaction with molecular clouds; the other one, G311.5-0.3, is a relatively unstudied remnant.

INFRARED COLORS
We use the following templates, with the proportion notation for channels 1:2:3:4 (wavelengths 3.6:4.5:5.8:8 μm), to classify infrared emission:

ISM: ISO spectra of the reflection nebula NGC 7023 yield colors 0.054:0.060:0.410:1, and GLIMPSE images of NROA 530 yield colors 0.040:0.046:0.351:1. The colors are a combination of PAH and nebular line emission

Shocked molecules: An H2 excitation model for IC 443 (Rho et al. 2001) yields colors 0.160:0.155:0.055:1. A CO fundamental band falls within channel 2, comparable to H2 in molecular shocks in HH objects, so a molecular clump would have colors 0.16:0.30:0.55:1. Such shocks are distinguishable by strong channel 1+2 enhancement.

Ionized gas: Pure H recombination (case B) has colors 0.25:3.7:0:1. Including atomic line-structure lines (mostly Fe and Ar), and using RCW 103 as a guide to the brightness relative to H lines, the predicted colors for ion shocks are 0.010:0.10:0.699:1. Such gas is distinguishable from the ISM and shocked molecular gas by bright channel 3+4 and very faint channel 1. If the shocks cannot destroy grains as efficiently as in RCW 103, then channel 3 (dominated by Fe II) remains cases, while channel 4 (dominated by Ar) remains bright.

CONCLUSIONS
The data for the survey have been collected and over half of the remnants have been analyzed. Many of the most noticeable infrared-emitting supernova remnants in the galactic plane are those interacting with molecular clouds. Results from the complete survey are being compiled into a journal article to be submitted this Spring.