HIGH RESOLUTION *IRAS* IMAGES OF LARGE SHELLS AROUND WOLF-RAYET STARS

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Abstract. High-resolution *IRAS* images, processed by HIRES, are ideal for the search of large, cold, fossil shell structures around Wolf-Rayet stars. In our preliminary effort, we have confirmed the large, $1^{\circ}\!.5 - 2^{\circ}$, ring structures around NGC 6888 and RCW 58, which are clearly shown in the HIRES processed images. We interpret them as fossil bubbles blown by the main-sequence progenitors of the WR stars, although these large shells were previously suggested to be evolved supernova remnants.

Massive stars experience different episodes of mass loss along their evolutionary paths (Maeder 1990; Langer 1991). During the main sequence (MS) stage, the fast wind is expected to sweep up the interstellar gas into a shell with radius of several tens of parsecs (Weaver *et al.* 1977). After hydrogen is exhausted in the core, the course of stellar evolution and the corresponding mass loss process become highly dependent on the initial mass of the star. Hydrodynamical calculations, using these mass loss episodes, predict a variety of circumstellar shells inside the previous, fossil, MS bubble (D'Ercole 1992; García-Segura *et al.* 1994). The physical structure of fossil bubbles may place constraints on these calculations. Fossil bubbles are expected to be large, cold, and maybe neutral, as several of them have been found successfully in H I observations (*e.g.,* Cappa de Nicolau *et al.* 1988). However, it is impossible to make a systematic H I survey for all galactic WR stars because of the enormous amount of telescope time required. Therefore, we use the existing *IRAS* images to search for fossil bubbles around WR stars.

For our search of shells around WR stars, we take advantage of the HIRES (HIgh RESolution processing) package developed at IPAC to improve the spatial resolution of the ISSA (*IRAS* Sky Survey Atlas). HIRES uses the Maximum Correlation Method algorithm (Aumann *et al.* 1990) to enhance the spatial resolution. After 20 iterations, resolutions of $37'' \times 23'', 35'' \times 23'', 62'' \times 41''$, and $98'' \times 80''$ can be achieved in the 12, 25, 60 and 100 μm bands, respectively, providing an improvement over the ISSA by a factor of 5. Due to the high computing demand of this algorithm, only a $2^{\circ} \times 2^{\circ}$ field is processed each time. The pixel size is $15'' \times 15''$. In this paper we report

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preliminary results for NGC 6888 and RCW 58.

The HIRES processed images of NGC 6888 show not only the well-known $18' \times 12'$ ring but also a large $69' \times 100'$ ring centered roughly at the small ring. Both rings are clearly visible in all four *IRAS* bands. The large ring around NGC 6888 was previously reported by Nichols-Bohlin and Fesen (1993). The superb resolution afforded by the HIRES processing can be illustrated by a comparison between their HCON images and our HIRES processed images: the small ring is clearly visible in our 100 μm map, and the large ring appears more complete in our maps. Using the *IRAS* colors we find further that the outer ring has a lower dust temperature than the inner ring; however, the exact temperatures may be uncertain due to the contributions of forbidden lines to the 60 and 100 μm bands.

For RCW 58 we made $4° \times 4°$ mosaics of HIRES processed images. The $10' \times 8'$ ring of RCW 58 is clearly resolved in the 25, 60, and 100 μm images. We also detected a large, $130' \times 121'$, ring enveloping the small ring of RCW 58. The large ring, best seen in the 60 and 100 μm images, is different from the irregular $2\overset{\circ}{.}7 \times 4°$ ring reported by Nichols-Bohlin and Fesen (1990) based on a 60 μm to 100 μm ratio map.

Adopting the distances of 1.8 kpc and 2.1 kpc to NGC 6888 and RCW 58, respectively (Mathis *et al.* 1992), the actual sizes of these outer shells will be 52 pc and 79 pc. These dimensions agree well with the sizes of the bubbles that the WR progenitors should have blown during their MS stage (García-Segura *et al.* 1994). We prefer the MS fossil bubble explanation for these large shells, although Nichols-Bohlin and Fesen (1990, 1993) suggested evolved supernova remnants. We are also testing whether HIRES processed data may yield spectral information consistent with the analysis by Mathis *et al.* (1992).

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