Soft Gamma-ray Repeaters in Clusters of Massive Stars

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Abstract. Infrared observations of the environment of the two Soft Gamma-ray Repeaters (SGRs) with the best known locations on the sky show that they are associated to clusters of massive stars. Observations with ISO revealed that SGR 1806-20 is in a cluster of giant massive stars, still enshrouded in a dense cloud of gas and dust [1]. SGR 1900+14 is at the edge of a similar cluster that was recently found hidden in the glare of a pair of M5 supergiant stars [2]. Since none of the stars of these clusters has shown in the last years significant flux variations in the infrared, these two SGRs do not form bound binary systems with massive stars. SGR 1806-20 is at only ∼0.4 pc, and SGR 1900+14 at ∼0.8 pc from the centers of their parental star clusters. If these SGRs were born with typical neutron star runaway velocities of ∼300 km.s⁻¹, they are not older than a few 10⁴ years. We propose that SGR 1806-20 and SGR 1900+14 are ideal laboratories to study the evolution of supernovae explosions inside interstellar bubbles produced by the strong winds that prevail in clusters of massive stars.

INTRODUCTION

Neutron stars and stellar mass black holes are the last phase of the rapid evolution of the most massive stars, which are known to be formed in groups. In this context, it is expected that the most recently formed collapsed objects should be found near clusters of massive stars, still enshrouded in their placental clouds of gas and dust. This should be the case for SGRs, if they indeed are very young neutron stars [3]. Among the four SGRs that have been identified with certainty, SGR 1806-20 and SGR 1900+14 are the two with the best localizations with precisions of a few arcsec (Hurley et al., 1999 [4,5] and references therein). Both are on the galactic plane at distances of ∼14 kpc, beyond large columns of interstellar material; A_v ∼30 mag in front of SGR 1806-20 [6] and A_v ∼19 mag in front of SGR 1900+14 [7]. Because of these large optical obscurations along the line of sights, and in the immediate environment of the sources, infrared observations are needed to understand their
origin and nature.

INFRARED OBSERVATIONS

Mid-infrared (5-18 µm) observations of the environment of SGR 1806-20 were carried out with the ISO\textsuperscript{Cam} instrument aboard the Infrared Space Observatory (ISO) satellite [1]. By chance, the ISO observations were made in two epochs, 11 days before, and 1-4 hours after a soft gamma-ray burst detected with the Interplanetary Network on 1997 April 14 [4].

We also observed\textsuperscript{1} SGR 1806-20 in the J (1.25 ± 0.30 µm), H (1.65 ± 0.30 µm) and K\textsuperscript{'} (2.15 ± 0.32 µm) bands on 1997 July 19, and SGR 1900+14 in the J (1.25 ± 0.30 µm), H (1.65 ± 0.30 µm) and K\textsuperscript{s} (2.162 ± 0.275 µm) bands on 1999 July 25, at the European Southern Observatory (ESO), using the IRAC2b camera on the ESO/MPI 2.2m telescope for SGR 1806-20, and using the NTT/SOFI for SGR 1900+14. In the near infrared, SGR 1806-20 was monitored by us during the last four years, and SGR 1900+14 by Vrba et al. (2000) [2].

SGRS IN CLUSTERS OF MASSIVE STARS

The results of the infrared observations of SGR 1806-20 and SGR 1900+14 are summarized in Figures 1 and 2 respectively. Figure 1 shows a cluster of massive stars deeply embedded in a dense cloud of molecular gas and dust. Using the ISO fluxes as a calorimeter, Fuchs et al. (1999) [1] show that each of the four stars at the centre of the cluster could be equaly, or even more luminous than the LBV identified in the field by Kulkarni et al. (1995) [8].

van Paradijs et al. (1996) [9] reported the possible association of SGRs to strong IRAS sources. The IRAS fluxes listed in Table 1 suggest that the infrared emission at longer wavelengths detected by IRAS do arise in clouds of gas and dust that enshroud these two clusters of massive stars.

TABLE 1. Association between SGRs and IRAS sources. The IRAS position and 12, 25 and 60 µm fluxes for 18056-2025 and 19048+0914 come from van Paradijs et al. (1996) [9].

| SGR     | SGR Position (J2000) | IRAS source | IRAS Position (J2000) | IRAS flux densities (Jy) |
|---------|----------------------|-------------|-----------------------|--------------------------|
|         | α 18 08 39.5          | 18056-2025  | α 18 08 40.4          | 0.98 35 29               |
|         | δ -20 24 40           |             | δ -20 24 41.6         |                          |
| SGR 1806-20 |                       |             |                       |                          |
| SGR 1900+14 | α 19 07 14.33         | 19048+0914  | α 19 07 15.3          | 2.5 6.3 12.3             |
|         | δ +09 19 20.1         |             | δ +09 19 20.0         |                          |

\textsuperscript{1} Based on observations collected at the European Southern Observatory, La Silla, Chile under proposal numbers 59.D-0719 and 63.H-0511.
FIGURE 1. J (1.25 ± 0.32 µm) and K′ (2.15 ± 0.32 µm) band images of SGR 1806-20 with 0.507″/pixel, together with the ISO fluxes (11.35 ± 0.65 µm) and (15 ± 3 µm) in contours with 3″/pixel. The best fit position of SGR 1806-20 (Hurley et al. 1999a [4]) is marked as a small cross and ellipse. These images show that SGR 1806-20 is ≤ 5 arcsec (≤ 0.4 pc at a distance of 14 kpc) from the centre of a cluster of hot giant massive stars, which are still partly embedded in their “placental” cloud of gas and dust.

FIGURE 2. J (1.25 ± 0.32 µm) and Ks (2.16 ± 0.275 µm) band images of SGR 1900+14 with 0.292″/pixel. The two white points on the Ks image are due to detector saturation. The position of a fading radio counterpart (Frail et al. 1999[10]) is indicated by a small circle, and the best fit position of SGR 1900+14 (Hurley et al. 1999a [4]) is marked as a small cross and ellipse. SGR 1900+14 is ~0.8 pc from a pair of M5 supergiant stars (Vrba et al. 1996 [7]) which glare hidde a cluster of stars (Vrba et al. 2000 [2]). SGR 1900+14 is located near the edge of this cluster of massive stars.
CONCLUSIONS

1) SGR 1806-20 and SGR 1900+14 are associated to clusters of massive stars. From ISO observations we find evidence that the cluster associated to SGR 1806-20 is enshrouded and heats a dust cloud that appears very bright at 12-18 μm. Although we did not made ISO observations of SGR 1900+14, the latter is as SGR 1806-20, a strong IRAS source [9], and very likely it is also enshrouded in a dust cloud.

2) These SGRs cannot be older than a few 10^3 years. At the runaway speeds of neutron stars this is the time required to have moved away from the centers of their parental clusters of stars.

3) J, H and K' bands observations of the massive stars close to the SGRs positions show no significant flux variations [1,2]. Therefore, these SGRs do not form bound binary systems with any of these massive stars.

4) There is strong excess emission at 12-18 μm associated to SGR 1806-20. However, there is no evidence of heating by the high energy SGR activity, although observations were made only 2 hours after a soft gamma-ray burst reported by Hurley et al. (1999) [4].

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