SEARCH FOR INTERACTIONS BETWEEN EJECTIONS OF GRS 1915+105 AND ITS ENVIRONMENT

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ABSTRACT

To unravel the effect of likely interactions between the energetic ejections of the galactic superluminal source GRS 1915 + 105 and its surrounding interstellar medium, we observed its environment. Two IRAS sources are symmetrically placed with respect to GRS 1915 + 105, and are aligned with the sub-arcsec ejections of this source. We analyzed these two sources IRAS 19124 + 1106 and IRAS 19132 + 1035 through near-infrared, millimeter and centimeter wavelengths. The evidence for these regions being interaction zones seems inconclusive.

KEYWORDS: Stars: individual: GRS 1915+105 – HII regions – ISM: individual objects: IRAS 19124+1106, IRAS 19132+1035 – ISM: jets and outflows – X-rays: stars

1. INTRODUCTION

The first known galactic superluminal source GRS 1915 + 105 is a highly energetic and relativistically ejecting source. Consequently one wonders if there is an observable interaction when the frequently ejected plasma clouds collide at relativistic velocities with the interstellar medium, or heat molecular clouds surrounding this source. Indeed, the ensemble of ejections of such a microquasar must have an effect on its environment, as it is the case for the well-known ejecting source SS 433. Therefore, we undertook a comprehensive study of the environment of GRS 1915 + 105 at near-infrared, mid-infrared, radio centimeter and millimeter wavelengths. Here some of the radio observations are described and discussed; the reader can refer to Chaty et al. (2000, hereafter C00) for a complete description of the study.

2. THE OBSERVATIONS: TWO AXISYMMETRIC SOURCES

The region surrounding GRS 1915 + 105 was inspected and described by Rodríguez and Mirabel (1998, hereafter RM98). This search was performed at $\lambda = 20$ cm, with the VLA (Very Large Array) of NRAO\textsuperscript{1} in C-configuration, giving a resolution of 15". The resulting map is shown in Figure 1. They discovered that there were

\textsuperscript{1}The National Radio Astronomy Observatory is operated by Associated Universities, Inc., under cooperative agreement with the USA National Science Foundation
two axisymmetrically placed continuum radio sources, each located at 17′ from GRS 1915 + 105, and coincident with IRAS sources. Their positions are given in Table 1. Furthermore, the position angle of these sources is $157 \pm 1°$ from GRS 1915 + 105, very similar to the one of the well studied sub-arcsec radio-ejections from GRS 1915 + 105 ($\sim 150°$). In order to interpret the radio data, we remind here that the angle between the ejections and the line of sight towards GRS 1915 + 105 is 70°, that the South component is approaching us, and the North component is receding (Mirabel and Rodríguez, 1994; Fender et al., 1999).

Although these two sources could be a chance alignment, the striking point-symmetric position of these two clouds suggests that they result from an association with the high-energy source GRS 1915 + 105.

### Table 1. Positions of GRS 1915+105, IRAS 19124+1106 and IRAS 19132+1035.

| Source        | J2000.0 coord. | gal. coord. |
|---------------|---------------|-------------|
| GRS 1915+105  | $\alpha = 19°15′11″545$ | $l^I = 45°40$ |
|               | $\delta = 10°56′44″80$     | $b^I = −0°29$ |
| IRAS 19124+1106 | $\alpha = 19°14′45″77$    | $l^I = 45°54$ |
|               | $\delta = 11°12′06″4$     | $b^I = −0°007$ |
| IRAS 19132+1035 | $\alpha = 19°15′39″13$    | $l^I = 45°19$ |
|               | $\delta = 10°41′17″1$     | $b^I = −0°44$ |

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#### 2.1. Centimeter wavelength observations

High-resolution maps of the two continuum radio sources have been obtained with the VLA (RM98). These maps are shown in the Figure 2. Concerning the North lobe, the centimeter map shows that it resembles to a common cometary H II region, but it also shows a shockwave structure to the South, e.g. to the direction of GRS 1915 + 105. For the South lobe, the centimeter map shows to the northwest a non-thermal jet, pointing along the direction of GRS 1915 + 105. The flux densities of this jet are $\sim \leq 1$, 2 and 5 mJy respectively at 2, 6 and 20 cm, showing a spectral index of $−0.8$. Furthermore, the South lobe shows a sharp edge to the South, which could be either a bow shock, or an ionization front in the H II region. The following discussion emphasizes these two striking features of the South lobe.

#### 2.2. Millimeter wavelength observations

We used the IRAM (Institut de Radio Astronomie Millimétrique) 30-m radio telescope, located on Pico Veleta, near Granada, Spain. The details of observations are described in C00, and the results for IRAS 19132+1035 are shown in Figure 3. The OFF position (position switching) was chosen at $(\alpha = −500′, \delta = −1200′$) from
GRS 1915 + 105. The main results are that i) the density profile of the cloud exhibits an asymmetric velocity distribution, ii) the maximum of the profile is closer to the counter-jet for high density tracers (compare e.g. $^{12}$CO 2-1 to the CS 2-1 transition), and iii) there are two maxima in the $^{12}$CO 2-1 transition and only one in the others. The other main result is that we detected a 4-$\sigma$ SiO 2-1 line, localized on the position of the counter-jet.

All these facts could indicate the presence of an interaction, although they do not constitute a clear proof thereof. Is there an association, or the two H$\text{\textsc{ii}}$ regions are point-symmetric by chance?

3. DISCUSSION AND CONCLUSION

There is a possibility that these two IRAS sources received energy from GRS 1915 + 105 through shocks initiated by plasma clouds ejected by GRS 1915 + 105 and colliding with H$\text{\textsc{ii}}$ regions, creating the non-thermal jet seen in the South lobe. There is also a possibility that the relativistic ejecta have induced star formation, and this could have created the non-thermal jet as a Herbig-Haro-like feature. However, we consider this last possibility as unlikely because of the timescale of the different phenomena.

The other possibility is that these two IRAS sources have nothing to do with GRS 1915 + 105: the alignment could be a background coincidence. It is worthwhile to remember that there are two point-symmetric sources, and furthermore the IRAS fluxes and the molecular lines show that the two IRAS sources are in our Galaxy (RM98). This decreases the probability of a background coincidence.

Although our observations spanned in a large range of wavelengths (C00), and there are some striking facts, we can not clearly prove any association between GRS 1915 + 105 and the two IRAS sources.

ACKNOWLEDGEMENTS

S.C. acknowledges support from grant F/00-180/A from the Leverhulme Trust, and is grateful to C.A. Haswell for improving the language of the manuscript.

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FIGURE 1. Map of the surroundings of GRS 1915 + 105 (VLA-C, λ = 20 cm, half power contour of the beam shown in the bottom right corner). The arrows around GRS 1915 + 105 indicate the position angle of the sub-arcsec relativistic ejecta.

FIGURE 2. Maps of the two continuum radio sources IRAS 19132 + 1035 (left) and IRAS 19124 + 1106 (right), (VLA-D λ = 2 cm (top), C 6 cm (middle) and B 20 cm (bottom), half power contour of the beam shown in the bottom right corner.

FIGURE 3. Observations of IRAS 19132+1035. Offsets are relative to the position of maximum radio emission observed at the VLA. The transitions are, from top to bottom of Figure $^{12}$CO, $^{13}$CO, H$^{13}$CO$^+$ and CS. The black contours are antennae iso-temperature, equal respectively from top to bottom: $^{12}$CO: $T_A^* = -1$, and from 1 to 20$K$ separated by an interval of 1$K$; $^{13}$CO: $T_A^* = -1$, and from 1 to 11$K$ separated by an interval of 1$K$; H$^{13}$CO$^+$: $T_A^* = -1$, and from 0.2 to 2.1$K$ separated by an interval of 0.1$K$; CS: $T_A^* = -1$, and from 0.2 to 2.2$K$ separated by an interval of 0.2$K$. The counter-jet seen in the VLA centimeter continuum is located at $\sim -18''$. 