Unveiling the Hidden Supernova Population in Local LIRGs with NIR/Radio Observations

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The dust enshrouded environments of Luminous Infrared Galaxies (LIRGs), and especially of their nuclear regions, prevents the direct detection of supernovae in the optical. Radio observations are unaffected by dust extinction, allowing for the detection of most of these supernovae, thus probing their massive star formation rate. In addition, complementary observations in the near IR can help us to understand the nature of these phenomena and derive properties of the regions where they occur.

Motivation

The bulk of the energy radiated by Luminous Infrared Galaxies (LIRGs, $10^{11}L_\odot < L_{IR} < 10^{12}L_\odot$) is due to infrared emission from warm dust grains heated by a central power source. The fundamental question is whether these dust grains are heated by an active galactic nucleus (AGN) (e.g. Yuan et al. 2010), by a nuclear massive starburst (e.g. Farrah et al. 2003) or both.

Radio interferometric observations of LIRGs are crucial to disentangle a putative AGN from nuclear (50~100 pc) or circumnuclear (500~1000 pc) starburst, since these observations yield the necessary high angular resolution and are unaffected by dust extinction.

LIRGs have star formation rates one to two orders of magnitude higher than normal galaxies, making them ideal scenarios to study the recent ($t < 40$ Myr) massive ($M > 8\ M_\odot$) star formation, by directly detecting radio supernovae.

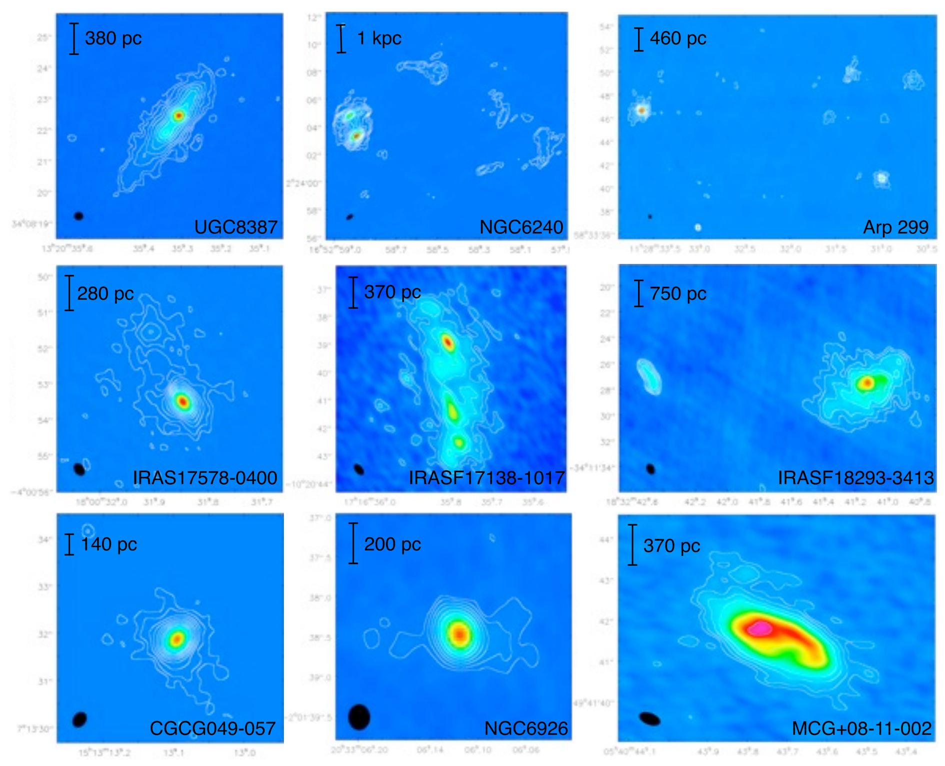

Fig. 1 - Images from our first JVLA observing epoch at 8.4 GHz of nine of the sources from our sample, taken during 2011. Note the typical radio structure consisting of a compact nuclear region surrounded by a low surface brightness extended region. We have NACO-VLT images of these sources, whose analysis is ongoing. Herrero-Illana et al. (2012, in prep.).

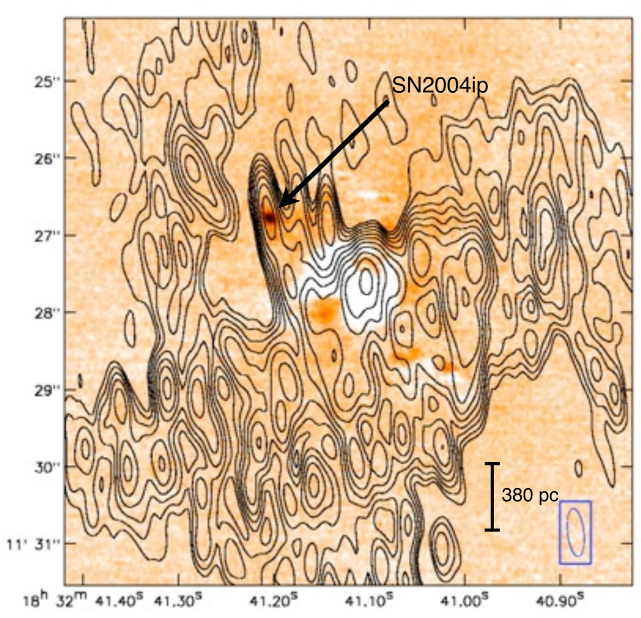

Fig. 2 - Contours of 8.4 GHz observations of IRAS 18293-3413 made on 11 June 2007 with the VLA, overlaid on a NACO-VLT 2.2 μm image. Note the clear detection of SN2004ip at both wavelengths. From Pérez-Torres et al. (2007).

Radio observations of a sample of LIRGs

We have performed X-band observations with the JVLA in A configuration of a sample of 11 LIRGs. The resolution achieved is around 0.25". We show nine of the sources in Figure 1.

Our aim is to obtain three epochs of observations within a period of two years. Based on the relationship between the far IR luminosity and the core collapse supernova rate (Mattila & Meikle, 2001), we expect around 20 of these events to happen in the whole period, from which we should be able to detect around a 70%, i.e., 14 SNe. Significant variations on these numbers would give us precious information about the circumstellar medium, the mass of the progenitors and the upper end of the IMF in local LIRGs.

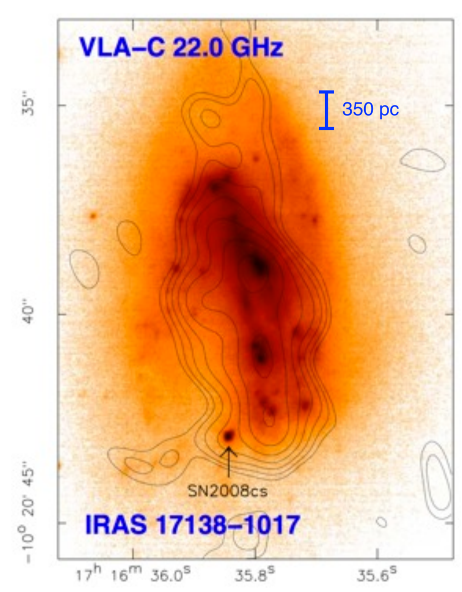

Fig. 3 - Contours of 22 GHz VLA observations made on 19 May 2008, overlaid on 2.2 μm Gemini-North observations of IRAS 17138-1017 obtained on 21 April 2008. Note the local maximum of NIR emission, which has been identified as SN2008cs (Kankare et al. 2008), and whose position coincides within 50 miliarcseconds with a local maximum of radio emission. From Kankare et al. (2008).

Radio - NIR synergies

The introduction of adaptive optics for 8-meter class telescopes now enables near-IR searches for SNe at an angular resolution of ~ 0.1", comparable or even better than obtained with some of the radio studies carried out with the VLA (Mattila et al. 2007). Also, near IR observations are much less affected by dust obscuration than in the optical, and are therefore a promising way to detect supernovae (see Figs. 2 and 3).

However, both core collapse and thermonuclear supernovae show similar near IR peaks of brightness. This degeneracy in their classification can be broken by using radio interferometric observations. Indeed, thermonuclear supernovae (type Ia) are extremely faint in radio, such that a clear radio detection of a counterpart to a near IR supernova allows to unambiguously classify it as a core collapse supernova.

Our combined observations at both radio and NIR will allow us to estimate the complete core collapse supernova rate in local LIRGs, essential to derive the recent massive star formation history in the local Universe.

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