The IR-Radio Correlation in High-Mass Young Stellar Objects

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FOREWORD

Hi-GAL is a survey of the galactic plane in the range 8-60 and 360-1000 GHz, making use of PACS & SPIRE in parallel mode.

Images of the continuum emission at 70, 160, 250, 350, and 500 μm are obtained, with angular resolutions from 5'' to 36'', corresponding to ~0.1 and ~1 pc, at a distance of 5 kpc.

The existence of analogous surveys at shorter (GLIMPSE & MIPSGLASS, MSX) and longer (BOLOCAM, ATLASGAL, CORNISH) wavelengths provides us with the unique opportunity to determine crucial physical parameters of the deeply embedded stellar population in star forming regions.

GOAL

We wish to study the earliest stages of the formation of OB-type stars through a comparison of their radio and IR properties.

Here we present a preliminary analysis based on the two galactic fields (2° x 2° centered at -3° and -5°) observed in the Science Demonstration Phase (SDP).

STRATEGY

Using the CORNISH survey of the galactic plane at 5 GHz (Purcell et al. 2008, ASP Conf. Series, 387, 389), we searched for the radio counterparts of the compact IR sources identified in the two SDP fields (Ella et al. 2010, A&A, in press). The corresponding 5 GHz spectral energy distributions (SEDs) were reconstructed using also the MSX, MIPSGLASS, 24 μm, and BOLOCAM 1.1 mm continuum data (see e.g. Fig. 1).

RESULTS

90% of CORNISH sources do not have a HI-GAL counterpart: their radio fluxes and spectral indices indicate that they are extragalactic objects (see Fig. 2).

A total of 15 sources are found, in only 1 HI-GAL band.

Out of the remaining 25 sources, 7 are known Planetary Nebulae (PNe) and 3 have too complex, extended IR emission.

15 useful radio + IR sources (14 with known distance – Russell et al. in prep.). For these we reconstructed the SEDs as previously explained in Fig. 3. The mean size at 5 GHz is 5 arcsec.

METHOD

We estimated four fundamental physical parameters.

Lmm The bolometric luminosity, obtained by integrating the emission under the SED.

Lradio = Lμm - μd Lmic = μd Lmic The radio luminosity Lradio = μd Lmic, where the 5 GHz flux density has been measured in the CORNISH maps.

Tgas The dust (gas) temperature, from the peak of the SED.

Mgas The mass of the parental molecular clumps, from the 500 μm flux measured with Herschel, assuming Tdust = 26 K.

DISCUSSION

Lmic vs Lradio (Fig. 4). 85% of the sources fall in the region of the plot where the radio flux is due to a single OB star or to a cluster of stars with total luminosity equal to Lmic (we assume a Salpeter IMF). No point should fall above the red solid line, as this is a robust upper limit to Lmic obtainable from a single star with luminosity Lmic. The sources with “radio excess” could lie at a larger distance than adopted by us, but might also be different types of objects deserving further investigation.

CONCLUSIONS

Our preliminary analysis based on a very limited number of sources provides us with three indications:

3. Most Herschel-radio sources are compact HH regions powered by one or a cluster of OB stars.

4. A handful of objects present a “radio excess” which cannot be explained as free-free emission from an HH region. These could be located at a larger distance than assumed by us or belong to a new class of objects.

5. We find a correlation between Lradio/Lmic and μd/Lmic that can be reproduced with an evolutionary model of a (proto)star accreting mass from the parental core.

FUTURE PERSPECTIVES

The results obtained have limited statistical reliability, due to the low number of sources. Extrapolation to the whole region covered by the Hi-GAL survey suggests that ~1000 compact sources with radio counterparts should be detected, providing us with an excellent benchmark for our study of the radio emission from high-mass young stellar objects.