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Radio Continuum and CO emission in spiral galaxies

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Abstract. We have studied the relationship between the Radio Continuum (RC) and CO emission for a set of galaxies selected from the BIMA SONG sample. By combining new 20 cm VLA B-array observations with BIMA maps it has been possible to investigate the behaviour of the RC/CO correlation at matched resolution down to an angular size of about 6″. Preliminary results indicate that the RC/CO correlation is as tight as (if not better than) the famous RC/FIR one. This may have important consequences on the models proposed to explain them.

Key words. Radio continuum: galaxies – galaxies spiral – ISM: molecules – stars: formation

1. Introduction

The remarkably tight and universal correlation between the global radio continuum at cm wavelengths (RC) and far-infrared (FIR) emissions in external galaxies is at the same time one of the most robust and one of the most puzzling relations in extragalactic astronomy (Condon 1992).

According to the conventional interpretation (e.g. Young & Scoville 1991), the CO emission traces the condensation of the gaseous medium into molecular clouds, where the star-formation process occurs. The RC is, for the most part, synchrotron emission that arises from the interaction of relativistic electrons with the ambient magnetic field in which they diffuse. The relativistic electrons are supposed to be accelerated in the supernova remnants, that is the ultimate phase of the life of massive stars. In this scenario, why the RC emission should be so closely related the CO emission is not so straightforward to understand, given the complexity of the very different processes from which they originate.

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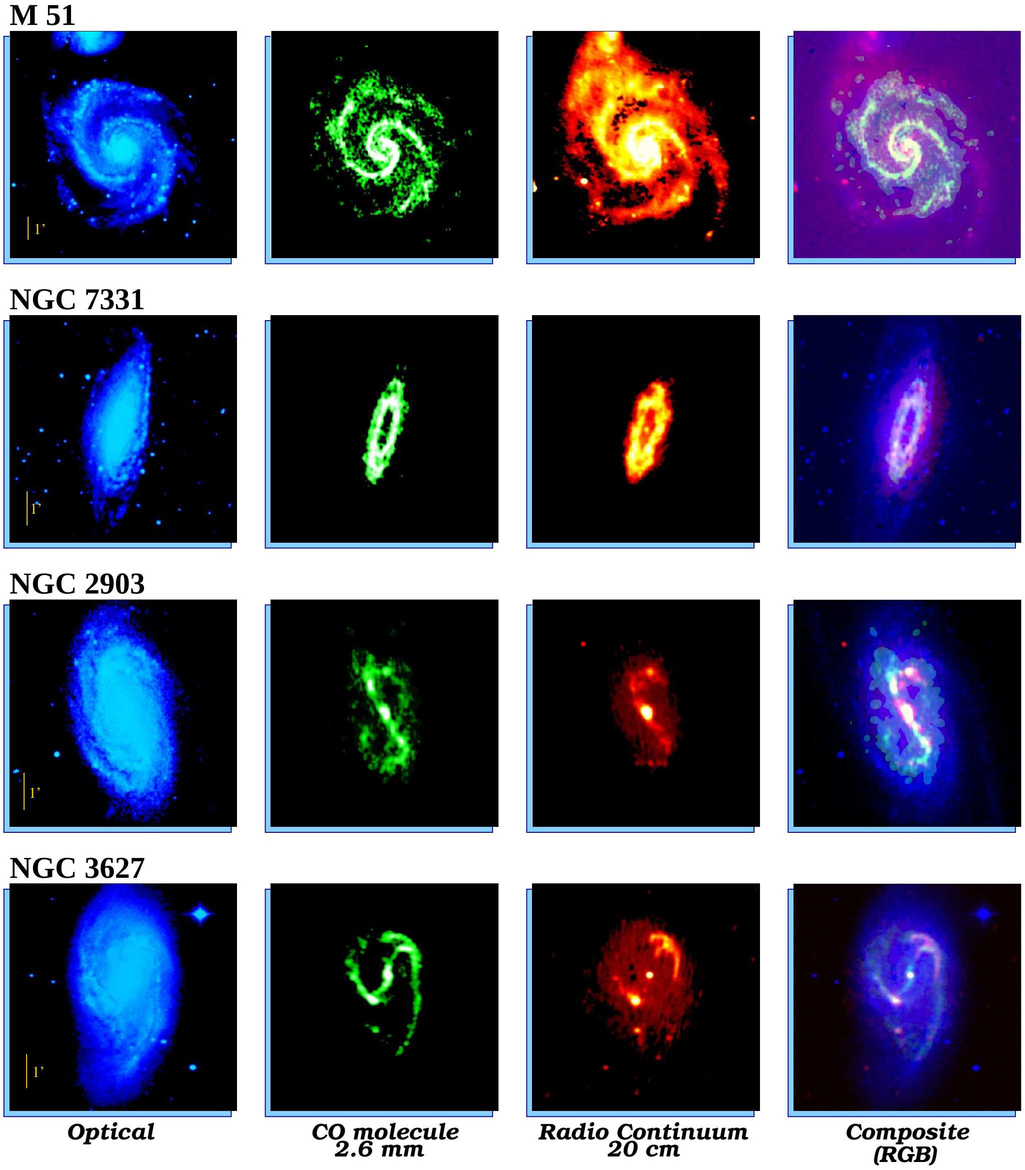

Fig. 1. We present here images on optical (blue), CO (green) and RC (red) bands of four selected galaxies characterized by different morphologies (spiral arms, ring, bar), and the 3-color images (left column panels) obtained by their combination.

2. Spatially resolved RC/CO correlation

So far, except for a few nearby objects, the scarce angular resolution of the FIR observations prevented detailed investigations of this fundamental correlation on sub-kpc scales. Also the local connection with other star formation indicators, such as the CO emission, has been poorly explored. Comparing data from NVSS and the FCRAO survey, with an angular resolution of 45″, Murgia et al. (2002)

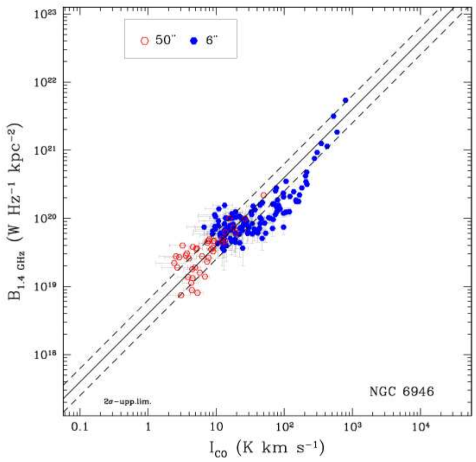

Fig. 2. RC brightness versus the CO integrated intensity at low (red circle) and high (blue circle) resolution for one of the sudied galaxies. The correlation has a dispersion, from galaxy to galaxy, less than a factor of two.

found that RC/CO correlation holds within individual galaxies and that the ratio between the RC and CO emission is constant, both inside and from galaxy to galaxy. It is essential to extend the previous studies in order to investigate which is the lowest scale size at which the RC/CO correlation breaks down, and what are the physical process that leads to this correlation.

The BIMA 3 mm CO Survey of Nearby Galaxies (BIMA SONG; Regan et al. 2001; Helfer et al. 2003) is an ideal sample for this investigation. We have recently completed a RC follow up of 21 BIMA SONG galaxies. By combining our new 20 cm VLA B-array observations with BIMA maps it has been possible to investigate the behaviour of the RC/CO correlation at matched resolution down to an angular size of about 6″. Figure 1 shows four of these galaxies, characterized by different morphologies (spiral arms, ring, bar).

Fig.2 shows the RC brightness versus the CO integrated intensity for one of the studied galaxies from an angular scale of about 50″ down to 6″. We found that, not only the RC/CO correlation is preserved going from ∼ 50″ to ∼ 6″ (in fact, the scatter of the global RC/CO correlation is a factor of about three whilst the local one has a dispersion, from galaxy to galaxy, which is less than a factor of two!), but it also seems to hold down to linear scales as small as ∼ 100-200 pc.

3. Conclusions

We have analyzed the RC/CO correlation at angular scales of 55″ and 6″ (i.e. at a linear scale of ∼ 3 kpc and ∼ 300 pc, respectively) in the framework of the BIMA RC follow-up program. This correlation appears to be linear and extends almost over 3 order of magnitude with a scatter 0.2 dex.

This indicates that the RC/CO correlation is as tight as (if not better than) the famous RC/FIR one. The unprecedented spatial resolution of our study will provide additional clues necessary to discriminate between the different theoretical models proposed to explain these correlations.

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