Molecular Gas Properties of Galaxies: The SMA CO(2-1) B0DEGA Legacy Project

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Abstract In the last two decades high-resolution (< 5″) CO observations for ~ 150 galaxies have provided a wealth of information about the molecular gas morphologies in the circumnuclear regions. While in samples of “normal” galaxies the molecular gas does not seem to peak toward the nuclear regions for about 50% of the galaxies, barred galaxies and mergers show larger concentrations. However, we do not exactly know from an observational point of view how the molecular gas properties of a galaxy evolve as a result of an interaction. Here we present the SMA CO(2–1) B0DEGA (Below 0 DEgree GAaxies) legacy project (http://b0dega.iaa.es) in which we are imaging the CO(2–1) line of the circumnuclear regions (1′) of a large (~ 70) sample of nearby IR-bright spiral galaxies, likely interacting, and that still remained unexplored due to its location in the southern hemisphere. We find different molecular gas morphologies, such as rings, nuclear arms, nuclear bars, and asymmetries. We find a centrally peaked concentration in about 85% of the galaxies with typical size scales of about 0.5–1 kpc. This might be related to perturbations produced by recent interactions.

1 Introduction

The molecular gas is one of the dominant components of the interstellar medium (ISM) in the inner few kiloparsecs of spiral galaxies. It is not only an essential ingredient to understand the structure and kinematics of the ISM there but also constitutes the fuel for future star formation (SF). Molecular gas, due to its dissipative nature, efficiently loses angular momentum via gravitational torques and may fall into the central hundreds of parsec. This gaseous component is eventually one of the main drivers for the existence of a central starburst and/or the fueling an active galactic nuclei (AGN) [8]. As a result, the concentration index in barred galaxies
is seen to be larger than in non-barred galaxies [6, 7]. Galaxy–galaxy interactions are expected to play a major role in triggering the formation of bars, resulting in larger central gas concentrations in each individual galaxy. Then, the merging of two galaxies can lead to a violent starburst episode [1, 9].

We aim to study the circumnuclear morphologies of the bulk of the molecular gas and its relation with both intrinsic (i.e., stellar morphology) and external variables (i.e., environment). High-resolution molecular gas studies are needed. However, the limited number of observed galaxies to date (∼150) and large number of variables at play seem insufficient to understand how they affect the general properties of the bulk of the molecular gas. The most numerous high-resolution CO studies (best tracer at our disposal to trace the bulk of the molecular gas) of nearby spiral galaxies performed to date are NRT-OVRO (N = 20 galaxies [6]), BIMA-SONG (N = 44 [4]), and the NUGA projects (N = 28 [3] and references therein). These images reveal a wide variety of morphologies in the circumnuclear molecular disks. BIMA-SONG is one of the largest compilations of CO interferometric data to date for “normal” galaxies and shows that molecular gas is not centrally peaked in 55% of the galaxies [4]. However, this result is not likely valid for other samples of galaxies with other environmental properties. We aim to enlarge the number of observed galaxies that are likely suffering recent interactions (although not mergers), which in addition to previously studied samples will allow us to study how interactions modify the molecular gas concentration.

2 The B0DEGA Sample

We focus on a sample of: (i) nearby galaxies, with recession velocities \( V < 7,000 \text{ km s}^{-1} \), being the bulk of galaxies at about 2,000 km s\(^{-1}\); (ii) IR-bright, following the criterion: \( 2.58 \times S_{60\mu m} + S_{100\mu m} > 31.5 \text{ Jy} \) (\( S_{60\mu m} \) and \( S_{100\mu m} \) are the IRAS flux densities in the IRAS Point Source Catalog [5]) so that CO(2–1) fluxes are high enough to be easily detected with the Submillimeter Array (SMA) in a reasonable amount of time of about 2–3 h and with resolutions better than \( \sim 5'' \); (iii) located in the southern hemisphere and observable from SMA (\( -45^\circ < \delta < 0^\circ \)). We use the latter criterion because the lack of millimeter/submillimeter interferometers in the southern hemisphere has prevented to study detailed molecular gas properties of many southern galaxies. The SMA can observe sources down to \( \delta = -45^\circ \), and it is revealing the molecular gas properties of many unique southern sources (for example, Centaurus A [2]).

With these criteria it yields a total of \( N = 134 \) galaxies, out of which only 14 had high-resolution CO(2–1) maps in the literature. Here we present data for a subsample of the IR brightest \( N = 30 \) B0DEGA galaxies. Further observations for other galaxies in the sample are being carried out at the SMA as a legacy project.

The galaxies reside in mid-density regions in the local Universe, usually members of pairs, triplets, or groups, thus representing the galaxies that have suffered a recent interaction. In most cases they have peculiarities in the optical, such as