Proposal for 2017 China-CONICYT Postdoc Fellows

Title: Molecular Gas Properties in Low Metallicity Local Group Dwarf Galaxies

Abstract:

The local group dwarf galaxies are perfect laboratories to study the gas, dust, and star formation in a low metallicity environment that resembles the early phases of galaxy formation. A key yet poorly explored aspect of the metal poor interstellar medium is its gas and dust properties. Characterizing them is crucial to use CO or [CI] as tracers of gas mass, and to understand the gas heating, the interstellar medium thermodynamics, the dust-to-gas ratio. The successful candidate will work on the ALMA data (CO 1–0, 2–1 and 1mm for Magellanic Bridge clouds and CO1–0 for local dwarfs as WLM, DDO75, DDO70)) and APEX data (^{13}CO 2–1, CO 4-3 and [CI] for SMC).

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Scientific Justification

The Magellanic Bridge is a filamentary structure of about 15 to 21 kpc seen in neutral hydrogen (HI) lying between the LMC and the SMC. It represent the nearest tidally interaction between these two galaxies some 200 Myr ago. It has a lower metallicity than the SMC and therefore allow to study the ISM in extreme conditions. Recent studies have revealed the presence of young ($<$ 200 Myr) massive stars and CO molecular clouds. The latter are barely resolved in single-dish observations and are spatially related to warm dust emission sources, as recently established by the Spitzer SMC-SAGE and Herschel HERITAGE studies. We have obtained 870 micron images of three these sources in the Magellanic Bridge. Surprisingly, their dust emission shows a large sub-millimeter excess indicative of either very cold dust or a dramatically different sub-millimeter emissivity. Source A was observed in ALMA c1 and shows an excess at 1mm and several CO cores. Two additional sources are observed in ALMA c3 in CO (1–0) and (2–1) and the associated continuum at arcsecond resolution to determine the physical properties of molecular cloud which are in a different evolutionary stage than Source A.

The Small Magellanic Cloud is an ideal laboratory to study the gas, dust, and star formation in a low metallicity environment that resembles the early phases of galaxy formation. We have been undertaking a complete study of the ISM in the SMC, combining CO, 870 μm continuum, Herschel HERSCHEL, Spitzer SMC-SAGE and HI observations to determine the gas and dust properties, such as the relationship between CO, total gas and dust including gas to dust ratio, the CO conversion factor, the sub-millimeter excess of dust emission and recently the transition of CO-bright to CO dark gas, in order to understand the effects of metallicity in the star formation process in low metallicity molecular clouds. To determine the kinetic temperature and densities of the SMC molecular clouds, sensitive observations in the optically thin ^{13}CO 2–1 and CO 4–3 are performed towards selected molecular clouds in the SMC.

The ALMA 12CO 1–0 maps for the local dwarfs as, DDO70, DDO75, DDO69 will allow us to measure the size and mass of the CO cores, and with our PDR line maps,

determine directly the structure of the star-forming molecular cloud. Together with WLM, these molecular clouds form are a sequence of metallicities that have never been mapped at this detail before. Thus, with the work that has been done in the SMC, Magellanic Bridge, NGC 1569, and the LMC at the higher metallicity end, we will have a sequence of cloud structures as a function of metallicity and can test the prediction that the CO core shrinks and the PDR grows as metallicity drops.

Observations and numerical models show that in the metal poor interstellar medium (ISM) there is an important fraction of H_2 gas that resides in the translucent part of clouds where CO has been dissociated (commonly referred as "CO-faint" gas). The goal of this project is to quantify the total reservoir of the molecular, star-forming gas at low metallicities by using neutral carbon as a tracer. At a distance of 60 kpc and 1/5 solar metallicity, the Small Magellanic Cloud (SMC) is an ideal target to explore various aspects of the metal poor ISM. We observed [CI] 1–0 in 8 star-forming regions in the SMC using APEX/FLASH. In combination with the ancillary data in hand (SOFIA/[CII] 158 μm and ALMA/APEX CO spectrally resolved observations), and HERSCHEL 158 μm for the local dwarfs, and the ISM modeling expertise present in the team, these data will provide key insights into total amount of molecular gas at low metallicities, which is crucial to interpret observations of high-z galaxies and to the understanding star formation in the low metallicity early universe.

Chile-China connection

The leaders of this proposal have close collaboration in the past years.

Implementation

This project is expected for two years. The schedule is present as follows,

Year 1: Reducing and analyzing previous data we have obtained. Publishing paper based on previous observations. Submitting observation proposals to ALMA, APEX and other telescopes in the world.

Year 2: Data reduction and analysis of new obtained data. Publishing paper based on new observations.