1) Research subject title and an abstract (<1000 words,)

**Title:** Investigating physical and chemical properties of CO dark gas through multiple-band absorption observations

## Abstract:

The interstellar medium (ISM) hosts star formation. Determining physical environment of the ISM will improve understanding of the lifecycle of ISM and the evolution of galaxies. The common, familiar tracer of molecular hydrogen, the main component of ISM, is CO emission. However, Dark Molecular Gas (DMG), in which hydrogen is molecular but CO is absent, turns out to be abundant from various of observations including dust, gamma-ray, $C^+$ and OH lines. DMG represents the transition between the atomic ISM to the molecule dominated ISM – the initial stage of star formation, which lies at the very heart of modern astrophysics. Nevertheless, it is not well studied. Absorption observations toward continuum source provide excellent method to determine the physical properties of the cloud along the sightline of continuum source. Multiple-band absorption observations of DMG tracers, e.g., OH at 1.6 GHz with FAST telescope and $HCO^+$(1-0) at 89 GHz with ALMA telescope, has potential to answer the crucial questions associated with DMG, abundance, physical/chemical conditions, and roles in ISM evolution.

2) Project proposer, his/her collaborator and host institutions in Chile and/or China

**Project Proposer:**

**Di Li, National Astronomical observatories, CAS**

**Collaborator:**

**Leonardo Bronfman, Universidad de Chile**

3) A brief Scientific Justification, Chile-China connection, and any other relevant information

**Scientific Justification:**

With the completion of the Five-hundred-meter Aperture Spherical radio Telescope (FAST) in September 2016, China will obtain the most sensitive single dish at low frequency (70MHz- 3GHz). The Atacama Large Millimeter/submillimeter Array (ALMA) consisting of 66 single dishes is the most powerful facility for molecular lines and dust emission at millimeter/submillimeter band (84 GHz-950 GHz). The combination of these two telescopes is suitable for investigating target with emissions at multiple frequency range. The project of CO-dark molecular gas (DMG) provides such a chance.

The emissions of the main tracers of DMG, OH and HCO+, are in FAST and ALMA frequency range, respectively. They are generally weak due to minor difference between excitation temperature and background continuum temperature. Absorptions of DMG tracers toward strong continuum sources are easier to be detected. Beside this, DMG tracers are in the transition region between atomic and molecular gas. Observational research of them will provide constraints for physical and chemical theory of interstellar medium.

**Chile-China connection:**

Two parts between leaders of this proposal have close collaboration in the past three years. We have applied two ALMA proposals successfully.

4) Implementation details including expected project duration (two years or three years)

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

Year 1: Make a list and collect data of strong continuum candidates. Submitting observation proposals to ALMA, Arecibo, VLA, GBT and other telescopes in the world. Do trail observations with FAST. Analyzing previous data we have obtained.

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

5) CV(s) of the project's leader(s) and list of their publications relevant to the proposal

See CV files of Dili_CV.pdf and Bronfman_CV.pdf.