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Introduction: The Gal/Xgal Ultra-Long Duration Balloon-borne Spectroscopic THz Observatory (GUSTO) will dramatically improve our understanding of the Universe by probing the topology and ecology of interstellar gas throughout the Milky Way and Large Magellanic Cloud (LMC). GUSTO consists of a semi-autonomous 0.9 m Cassegrain telescope and cryogenic detection system designed to stay aloft for 100 days or more (Fig. 1). During this time GUSTO will use its heterodyne array receivers to survey 124 square degrees of the Milky Way and all of the LMC in three important interstellar lines: [CII], [OI], and [NII] at 158, 63, and 205 μm, respectively. GUSTO will map the structure, dynamics, energy balance, pressure, and evolution of the Interstellar Medium (ISM) within the Milky Way and LMC.

GUSTO is an Explorer Mission of Opportunity led by the University of Arizona (UofA) in partnership with the Johns Hopkins University Applied Physics Laboratory (APL). The mission will utilize the 100+ day flight potential of the Super Pressure Balloon, also known as the Ultra Long Duration Balloon (ULDB), provided by NASA's Balloon Program Office. GUSTO features a proven measurement approach, a high-heritage payload, and a simple, repeatable observing strategy that, combined with the ultra-long duration capability of the SPB, enables these important new galactic/extragalactic observations at a fraction of the cost of a comparable orbital mission.

Science Objectives: Observations with *Herschel* and *Spitzer* underscore the considerable range of cloud types that coexist in the ISM, some differing in density by more than a factor of 10^4. Since the ages of these clouds are much less than that of the Galaxy, the processes governing their ongoing formation and destruction are fundamental to understanding the life cycle of gas in the plane of our Galaxy and other galaxies. The best means of tracing these processes lies in information contained in lines that occur at terahertz (THz) frequencies.

The GUSTO science goals (see below) directly address NASA Strategic Goal 2.4: *Discover how the universe works, explore how it began and evolved, and search for Earth-like planets.* They also address a key aim from the National Research Council's Decadal Survey (p. 53): *Beginning near home, detailed spectroscopic measurements at short radio wavelengths will track the internal dynamics of the dust-enshrouded molecular clouds that fragment and seed star-forming cores within a few hundred light-years of our Sun.*

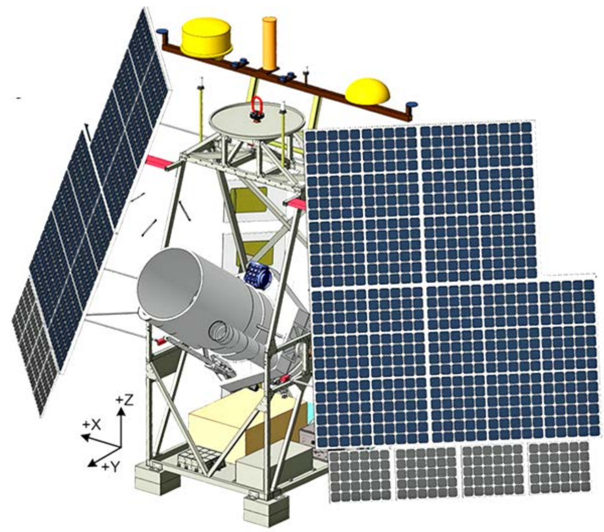

Figure 1. GUSTO ballooncraft and payload include a 0.9 m telescope, cryogenic THz receivers, and a gyro stabilized pointing system to provide an unparalleled galactic-extragalactic survey capability.

Goal 1: Determine the constituents and life cycle of interstellar gas in the Milky Way

Goal 2: Witness the formation and destruction of star-forming clouds

Goal 3: Understand the dynamics and gas flow to and in the Galactic Center

Goal 4: Understand the interplay between star formation, stellar winds and radiation, and the structure of the interstellar medium (ISM) in the Large Magellanic Cloud (LMC)

Goal 5: Construct Milky Way and LMC templates for comparison to distant galaxies

The data products will consist of data cubes of spectral line maps, a standard radio astronomy product. These data are produced in three surveys:

1. A Galactic Plane Survey (GPS): $-25^o < l < 28^o$; $|b| < 1.1^o$
2. LMC Survey (LMCS): 25 sq. deg. map covering the whole LMC.
3. Targeted Deep Surveys (TDS): 0.1-1.5 sq. deg. maps of a dozen selected regions in the Galaxy and LMC.

GUSTO is scheduled for an Antarctic launch in December 2021.