Forecast for **HEAT** on Dome A, Antarctica
The **H**igh **E**levation **A**ntarctic **T**erahertz Telescope

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Together with collaborators in Australia (John Storey-UNSW), the Netherlands (J. R. Gao-SRON), and Germany (Juergen Stutzki-Univ. of Cologne), we have proposed to the NSF Office of Polar Programs to construct a fully automated, 0.5-meter far-infrared observatory for remote operation from the summit of Dome A in Antarctica. The extreme cold, stability, dryness, and low wind make Dome A a ground-based site without equal for astronomy at infrared and submillimeter wavelengths. HEAT, the High Elevation Antarctic Terahertz Telescope, will operate in the atmospheric windows between 150 and 400 μm, in which the most crucial astrophysical spectral diagnostics of the formation of galaxies, stars, planets, and life are found. At these wavelengths, HEAT will have high aperture efficiency and excellent atmospheric transmission most of the year. HEAT's superheterodyne receiver system is designed to simultaneously observe the pivotal J=7→6 line of CO (806 GHz), the J=2→1 line of atomic carbon (809 GHz), and the far-infrared fine structure lines of N^+ (1.4 THz) and C^+ (1.9 THz), the brightest emission lines in the entire Milky Way Galaxy. When combined with the HEAT telescope, the receiver system represents the most powerful instrument for reconstructing the history of star formation in our Galaxy, with application to the distant Universe. The receiver system will be constructed from leading-edge components developed by NASA-JPL, the Space Research Organization of the Netherlands (SRON), the University of Cologne, and Ball Aerospace. The proposed study will pave the way for future astronomical investigations from Dome A. HEAT is a true international pioneering effort in keeping with the spirit of the International Polar Year 2007-2008.

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1 Scientific Justification

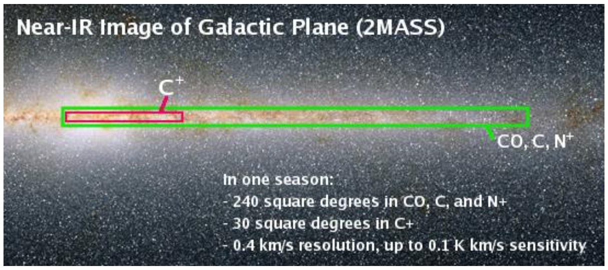

Figure 1: The power of HEAT: a definitive survey of the interstellar medium and star-forming clouds over 240 square degrees of the sky can be performed in 6 months in the spectral lines of atomic carbon and N^+. Over 30 square degrees of sky can be mapped in two months of the best winter weather in the pivotal 158 μm C^+ line. No other ground-based site is capable of routine observations at these highest frequencies.

Although great progress in understanding star and planet formation has resulted from the technological advent of sensitive (sub)millimeter wave detectors, many fundamental aspects of the formation and evolution of galaxies, stars, planets, and life remain shrouded in uncertainty. The common element of these mysteries is the evolution of interstellar clouds of dust and gas, from which stars and planets are born, and to which stars return enriched material at the end of their lives. These clouds sculpt the evolution of entire galaxies. The far-infrared (FIR) contains the brightest and most diagnostic spectral lines of the entire electromagnetic spectrum; in particular the pivotal fine structure lines of C, N^+ and C^+ at 0.8, 1.4 and 1.9 THz (370, 205 and 158 μm), respectively. Only on the high Antarctic plateau is the atmosphere dry, cold and stable enough to permit survey observations at all three wavelengths. In performing a Galactic Plane survey of these spectral lines, fundamental new insights into Galactic evolution, and star formation will be pioneered (Figure 1). In particular, HEAT will:

1. **Directly witness the formation of interstellar molecular clouds for the first time**, and answer where and how cloud formation takes place in the context of the Galaxy as a whole, with direct impact on star formation and Galaxy evolution.
2. **Derive a definitive star formation rate as a function of radius in the plane of the Milky Way**, providing an optimum set of data to calculate the Schmidt Law in the Galaxy.
3. **Provide the first map of warm dense molecular gas** via CO emission in the CO J=7→6 line at 0.8 THz, which can be observed simultaneously with the J=2→1 fine structure line of carbon.

The adoption of heterodyne receivers for HEAT naturally provides the high spectral resolution needed to disentangle the many cloud components along any particular line of sight through the Galactic Plane. The angular resolution provided by the 0.5-meter clear aperture (Figure 2) is optimized for resolving individual cloud components throughout the Galaxy while providing adequate mapping speed to perform a substantial survey of the Galaxy in a single observing season (Figure 1).

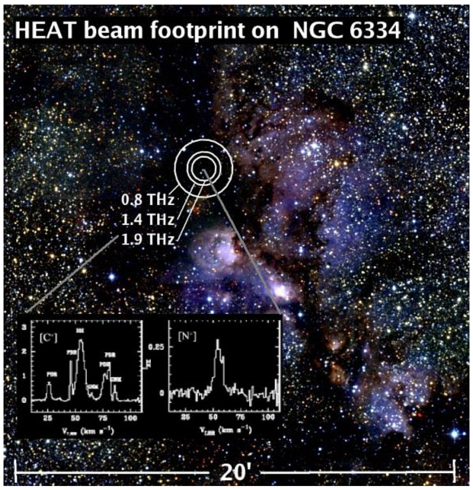

Figure 2: The 3 beams of HEAT overlaid upon a 2MASS image of NGC 6334. The size of the cospatial 0.8, 1.4, and 1.9 THz beams is 3, 1.7, and 1.3 arcminutes, respectively.

2 Observatory Description & Logistics

A conceptual drawing of HEAT is shown in Figure 3. HEAT will be mounted on top of a University of New South Wales AASTINO (Automated Astrophysical Site-Testing InterNational Observatory). The AASTINO provides power and communications for the HEAT telescope and Instrument (Figure 4). The total power budget for HEAT (including cryogenics, telescope drive system, and instrument control system is ~ 550 W, which can be readily provided by Stirling engines within the AASTINO. Data transfer and command and control of HEAT will occur daily via satellite (Iridium and/or TDRSS-1). The University of New South Wales will provide an AASTINO specifically for HEAT and participate in all aspects of design, integration, deployment, and operation. The HEAT/AASTINO facility is functionally equivalent to a space-based observatory. Indeed, many of the key components used in the instrument were originally developed for space applications.

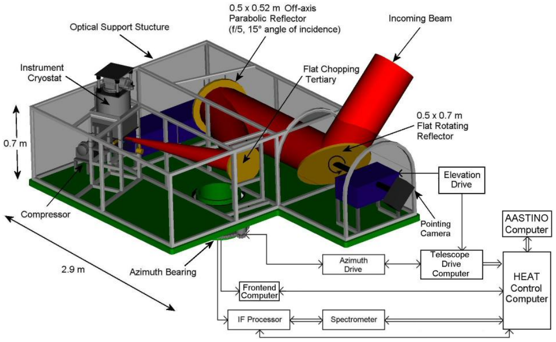

Figure 3: HEAT 0.5-meter concept: The HEB and SIS mixers used in the instrument package are cooled to ~ 4 K using closed-cycle cryocooler technology developed for space-based applications.

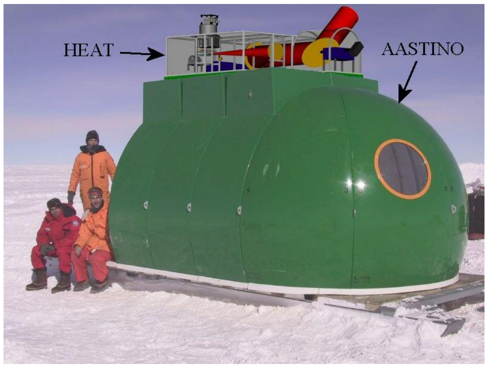

Figure 4: Rendering of HEAT atop a UNSW AASTINO

The design and construction of HEAT will occur from 01/05 through 05/06. Integration with the AASTINO module will take place at the University of New South Wales from 06/06 to 09/06. From 11/06 to 04/07 HEAT will be field tested at the Amundsen-Scott South Pole Base. In 12/07 HEAT and its commissioning team will be flown to Dome A from South Pole by an Australian CASA 212 transport. The team will set-up camp, prepare HEAT for remote operation, and fly back to South Pole approximately a week later. HEAT will then begin its survey of the Galaxy. We will return to the summit of Dome A in 12/08 to retrieve the raw data files and perform maintenance as needed for the next year of operation.

With the implementation of HEAT, the astronomical community will have a new, powerful capability for exploring the origin of stars, galaxies, and planetary systems like our own. It will serve as a model for future Antarctic observatories and the first step toward realizing the research potential of Dome A. We look forward both to the exciting science that will come from HEAT and the challenge of making it a reality.