The Terahertz Intensity Mapper (TIM): Far-infrared Balloon Mission for Spectroscopic Galaxy Evolution Studies

R.M.J. Janssen[1,2], J.E. Aguirre[3], P.S. Barry[4,5], J. Bracks[3], C.M. Bradford[1,2], B. Bumble[1], A.J. Corso[3], J.P. Filippini[6], C.E. Groppi[7], D.P. Marrone[8], M. Bethermin[9], T.-C. Chang[1,2], M.J. Devlin[3], O.P. Dore[1,2], J. Fu[6], S. Hailey-Dunsheath[2], J. Hoh[7], G.P. Holder[6], G. Keating[10], H.G. LeDuc[1], R.P. Keenan[7], E.D. Kovetz[11], G. Lagache[9], L. Liu[2], H. Mani[7], J. Mathewson[7], R. Nie[6], P. Mauskopf[7], D. Narayanan[12], G. Popping[13], J. Redford[2], E. Shirokoff[14], A.K. Sinclair[7], R.S. Somerville[15], I. Trumper[16], M. Underhill[7], B. Uzgil[13], J.D. Vieira[6], and J. Zmuidzinas[2]

Understanding the formation and evolution of galaxies over cosmic time is one of the foremost goals of astrophysics and cosmology today. The cosmic star formation rate has undergone a dramatic evolution over the course of the last 14 billion years, and dust obscured star forming galaxies (DSFGs) are a crucial component of this evolution. A variety of important, bright, and unextincted diagnostic lines are present in the far-infrared (FIR) which can provide crucial insight into the physical conditions of galaxy evolution, including the instantaneous star formation rate, the effect of AGN feedback on star formation, the mass function of the stars, metallicities, and the spectrum of their ionizing radiation.

TIM, the Terahertz Intensity Mapper, is a NASA balloon mission that will observe the universe in the crucial gap between the spectroscopic coverage of the Atacama Large Millimeter/submillimeter Array (ALMA) in the sub/mm, and the James Webb Space Telescope (JWST) in the mid-IR; something which is impossible to from the ground. TIM will survey two 0.1 square degree fields centered on GOODS-S and the South Pole Telescope (SPT) Deep Field. TIM will produce deep maps of the 3D structure of the Universe by redshift tomography ("intensity mapping") with [CI], and [CII] X [NII] cross-spectra, to constrain the cosmic star formation history at cosmic noon. In addition, it is expected to achieve spectroscopic line detections of ~100 galaxies in the atomic fine structure lines of C, N, and O, as well as establish mean galaxy properties such as star formation rate, metallicity and AGN content, using a stacking analysis of known sources and the wealth of ancillary data available in the GOODS-S and SPT Deep Field.

To achieve these science goals, TIM will fly two longslit (1 degree slit length) grating spectrometers, which cover the 240-317 um and 317-420 um wavelength bands at R~250. Each of these spectrometers is serviced by a ~4000 pixel array of horn-coupled kinetic inductance detectors (KIDs). The KIDs, lumped-element resonator of superconducting Al, are designed to achieve a photon noise limited performance at 100 fW of loading with an absorption efficiency of >80%. They will be read out using an RFSoC based readout system.

The TIM gondola and cryogenics will be based upon proved BLAST hardware. However, a new 2-meter low-emissivity high-throughput carbon fiber telescope will be used to achieve maximum mapping speed.

The in-flight demonstration of both the high-sensitivity and scalable KID arrays as well as the low-emissivity high-throughput mirror are key technical milestones to future space-borne instrumentation such as the Origins Space Telescope (OST, formerly the Far-IR Surveyor) or Probe mission.

We will present the design of these key components for TIM as well as summarize the planned route for experimental development and testing, which will conclude with a launch from Antarctica in 2024.

[1] NASA Jet Propulsion Laboratory, Pasadena, CA 91109 USA
[2] Department of Astronomy, California Institute of Technology, Pasadena, CA 91125 USA
[3] Department of Physics and Astronomy, University of Pennsylvania, Philadelphia, PA 19104 USA
[4] High-Energy Physics Division, Argonne National Laboratory, Argonne, IL 60439 USA
[5] Kavli Institute for Cosmological Physics, University of Chicago, Chicago, IL 60637 USA
[6] Department of Astronomy, University of Illinois Urbana-Champaign, Urbana IL 61801 USA
[7] School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287 USA
[8] Steward Observatory, University of Arizona, Tucson, AZ 85721 USA
[9] Laboratoire d'astrophysique de Marseille, 13388 Marseille FRANCE
[10] Harvard Smithsonian Center for Astrophysics, Cambridge, MA 02138 USA
[11] Department of Physics and Astronomy, Johns Hopkins University, Baltimore, MD 21218 USA
[12] Department of Astronomy, University of Florida, Gainsville, FL 32611 USA
[13] Max Planck Institute for Astronomy, 69117 Heidelberg, Germany
[14] Department of Astronomy and Astrophysics, University of Chicago, Chicago, IL 60637 USA
[15] Department of Physics and Astronomy, Rutgers University, Piscataway, NJ 08854 USA
[16] Intuitive Optical Design Lab LLC, Tucson, AZ, USA

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