CCAT: Project Overview, Science & Instrumentation Plans

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What is CCAT?

- A 25-meter FIR/submillimeter telescope that will operate at wavelengths as short as \( \lambda = 200 \, \mu m \), an atmospheric limit.
- To be located in a high (5617m) desert environment.
- It will take advantage of one of the now fastest-developing detector technologies of any spectral region, opening up for surveys one of the last, largely untapped frontiers of ground-based astronomical research.

Why 25m?
- Match ALMA sensitivity in submm regime.
- Integration time to confusion (?) at 350 \( \mu m \) \( \sim 1 \) hr or to fully resolve the FIR/submm CBR.
- Better than 0.5” source positioning.

Beam size: \( \lambda [\mu m]/100 \) arcsec
  e.g. 2” @ 200 \( \mu m \)

FoV: 1 sq. deg.

@ 350 \( \mu m \)

First-light short \( \lambda \) camera: 50 kpix

Several instruments in Nasmith foci, some simultaneously accessible in very large FoV.
What is CCAT?

CCAT is not intended to be a “national” observatory: a consortium of mostly academic partners, it is intended to be run – inasmuch as possible – as an academic facility, training ground for the instrumentalists, observers, telescope makers of tomorrow; nimble in rapidly responding to new discoveries as in testing new technologies; with “lean & mean” bureaucracy and eager to release its data with short “proprietary periods”, in order to maximize science fall-out.
What’s CCAT for...
Main CCAT Science Themes

• Measuring the History of Star Formation in Galaxies from the Epoch of Reionization, Through the Peak of Activity, to today
• Advancing the Resolution of the Cosmic FIR Background Radiation Field
• Characterizing the Atomic, Molecular, and Solid-State Interstellar Media of Nearby Galaxies
• Probing the Formation of Galaxy Clusters with the Sunyaev-Zel’dovich Effect (SZE)
• Characterizing the Formation of Molecular Clouds and the Clump Mass Function
• Dust reprocesses starlight into FIR
• Cosmic expansion shifts light of early galaxies further into submm and mm bands

Lagache, Puget, & Dole 2005
Galaxy Counts and the Cosmic FIRB at Submm Wavelengths

- ~10% of CFIRB resolved directly with Herschel
- ~50% inferred statistically, yielding estimated number count models to a depth of 2 mJy/beam
- CCAT will resolve (directly) sources to 0.5-1 mJy, likely resolving the totality of the CFIRB
- → Large Scale surveys into the most active epoch of assembly of cosmic structures

Modeling and Physical Characterization of Cluster Formation via the SZE
Structure of Molecular Clouds

Molinari et al. 2010
Herschel 70μm, 160μm, and 350μm image at longitude = 59°
Filaments are pervasive ...

Filtered Herschel 250um image  Molinari et al. 2010
... and are where stars form

Molinari et al. 2010
Synergy with ALMA

ALMA will deliver very high spatial resolution, but only over a very small Field of View:

» Will reveal fine detail, ONE SOURCE AT A TIME

CCAT will not match ALMA in angular resolution (beam 2”-5” will not yield morphological info); it will however match it in continuum sensitivity and will have a Field of View 30,000 times larger

» FAST SURVEYOR (many objects at a time)
Where CCAT ?...
At the driest, high altitude site you can drive a truck to....
Median 350 µm atm. Transparency at CCAT site is 1.64x higher than at ALMA Plateau.
Who is CCAT?

- Cornell University (*)
- California Institute of Technology(*)/Jet Propulsion Laboratory
- University of Colorado(*)
- University of Cologne(*) + University of Bonn
- Canadian consortium(**):
- Associated Universities, Inc.
- U.S. National Science Foundation

(*) Signers of CCAT Consortium Agreement and members of CCAT Corp.
(**) Members of Canada Corp., which is in process of joining CCAT Corp.
Friday the 13th of August 2010 brings good news from Astro2010

**New Worlds, New Horizons in Astronomy and Astrophysics**

Committee for a Decadal Survey of Astronomy and Astrophysics
(a.k.a. “Astro2010”)

National Research Council
**Project Timeline**

- **October 2003**: Partnership Workshop in Pasadena
- **Feb 2004**: MOU signed by Caltech, JPL and Cornell
- **2006-2010**: Feasibility Study Review, Consortium consolidation, Site selection completed
- **2010**: First-ranked mid-scale project by Astro2010
- **2011 Jun**: NSF Award of $4.5M toward CCAT Engineering Design, UKoeln/Bonn awarded $9M by German Research Foundation
- **2011-2013**: Detailed Engineering Design (EDP) underway
- **mid-2013**: Design Review
- **2013-2017**: Construction and First Light

"Patience, n. A minor form of despair, disguised as a virtue."  
Ambrose Bierce
Instrumentation Plans
Four instruments are in preliminary design phase, all multi-institutional:

- Short Wavelength Camera (PI: G. Stacey, Cornell) (*)
- Long Wavelength Camera (PI: S. Golwala, Caltech) (*)
- Direct Detection MOS (PI: M. Bradford, JPL) (*)
- Heterodyne Feed Array (PI: J. Stutzki, Koeln)

Instrument prioritization w.r.t. first light will be decided in mid-2013

(*) Direct detection instruments
MKIDs are technology of choice: they are intrinsically multiplexable, and can be implemented into large format arrays with relatively simple readout electronics.
Back view of the Carbon Fiber Reinforced Plastic (CFRP) Truss
Short Wavelength Camera (SWC) : MKIDs

• A superconducting resonator at temperature $< \text{T}_c$ has a supercurrent carried by pairs of electrons - Cooper Pairs (CP) -, which are bound together by an energy $\Delta = k_B T_c$.

• An incoming photon of energy $> \Delta$ can break a CP; as a result

• the change in kinetic inductance shifts the resonator frequency

• In addition, the resonator internal dissipation ($1/Q$) increases, causing the resonance width to increase and the transmission depth to decrease
CCAT is a groundbreaking submillimeter telescope that will be located at 5600 m altitude on Cerro Chajnantor in the Andes mountains of northern Chile. CCAT will combine high sensitivity, a wide field of view, and a broad wavelength range to provide an unprecedented capability for deep, large area multicolor submillimeter surveys. Science objectives include galaxy formation and evolution throughout the history of the Universe; the hot gas pervading clusters of galaxies; star formation, protoplanetary disks, and planets; and testing general relativity.

ccatobservatory.org

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