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Backgrounder

Canadian Hydrogen Intensity Mapping Experiment (CHIME)

Canada's newest radio astronomy telescope begins the largest volume survey of the universe ever undertaken

Dark energy

The universe is expanding, and the rate of expansion is accelerating. The discovery of dark energy was made in the 1990's and was surprising to astronomers, who expected to find that the cosmic expansion would slow down as gravity pulls the matter in the universe back in on itself, much as a ball thrown in the air would eventually reverse course and fall to the ground.

A mysterious effect appears to be counteracting gravity and pushing matter apart. This is attributed to "dark energy" which is estimated to make up 68 percent of all energy in the universe. Despite its prevalence, very little is known about dark energy. CHIME has been designed to learn more about dark energy by measuring the expansion of the universe over a period in the distant past when its effects first became apparent.

Because the universe is so large, it has taken many years for the radio light to arrive at CHIME. CHIME will see light that left the most distant cosmic structures over 11 billion years ago. By studying these distant structures, CHIME is able to peer into this period in the universe's history, to see if the dark energy is changing with time as the universe expands.

Fast radio bursts and pulsars

Recently, scientists have discovered fast radio bursts, energetic single pulses of radio emission arriving in random directions from unknown sources well beyond our galaxy, the Milky Way. The origin of these pulses is a major puzzle in high energy astrophysics. With its huge field of view and broad frequency coverage, CHIME is a nearly ideal instrument for finding and studying many of these bursts.

Radio pulses traveling through our galaxy and through the space between galaxies change shape, much as ocean waves change shape as they travel. Sharp features and smooth general shapes travel at different speeds. In fact, the pulses only last 1/1,000 seconds at their source, but are spread out over many seconds by the time they reach CHIME. By analyzing the signals to put them back to their original spiked shapes, CHIME will learn the distance to the source of each burst.

Neutron stars in our galaxy spin, and the radio waves they emit pierce the sky like the beam from a lighthouse. These radio waves are seen as repetitive pulses and called sources pulsars. These sources act like cosmic clocks and CHIME will monitor the pulses from all known pulsars visible from Penticton, nearly every day. Among other things, this information will aid in the search for gravitational waves—travelling ripples in space-time—passing through our galaxy. It will also lead to new insights into the structure and magnetic fields on neutron stars, and enable other tests of Einstein's theory of general relativity.

CHIME telescope: infrastructure and technology

CHIME is a highly sensitive radio telescope which collects very faint radio signals that arrive from space. It is a novel instrument with no moving parts that does not look or operate like most other radio telescopes.

CHIME is composed of four large reflectors that are curved like a half-pipe. Each reflector collects radio waves and focuses them onto 512 inputs located along the focal line, directly underneath each walkway. As the Earth turns, each input scans a North-South strip of sky so that each day, the telescope scans the entire sky visible from its Penticton location.

CHIME is cost effective for a telescope of this scale, due in large part to the technology it employs. By drawing on mass-produced signal amplifiers developed for use in cell phones and on high-end graphics cards developed for video game processors, CHIME exploits consumer technologies to scan the cosmos.

The amount of data flowing through the telescope is comparable to the entire world's mobile data network traffic. To process these data, CHIME's computers perform seven quadrillion multiplications per second, equivalent to everyone on earth performing one million multiplication problems every second.

Radio-free zone

CHIME was built at the NRC's Dominion Radio Astrophysical Observatory (DRAO). Located south of Penticton in the White Lake Basin, the site provides a radio-quiet zone, which is imperative for radio astronomy instruments like CHIME. The site is physically protected from Radio Frequency Interference (RFI) by the surrounding hills. In addition, legislation at the federal, provincial and local level restricts activities which would interfere with radio astronomy research. Even the buildings at DRAO are regularly scanned for possible sources of RFI, and computers must be surrounded by metal screening. Cell phones must be turned off while on site as CHIME is very sensitive to radio frequencies and could detect a single cell phone located 20 times as far away as the moon.

CHIME operates in a relatively quiet radio band, from 400 to 800 MHz, between the frequencies used by analogue TV stations and cell phones. This is an ideal frequency range for CHIME because it seeks to measure the location of hydrogen gas in the universe (hence CHIME's name: the Canadian Hydrogen Intensity Mapping Experiment) and this gas emits a line whose frequency is shifted into this range by the expansion of the universe. This frequency range is also excellent for studying fast radio bursts and radio pulsars.

CHIME Team

The CHIME team consists of researchers from across Canada and the United States:

- J. Richard Bond, University of Toronto
- Paul Demorest, National Radio Astronomy Observatory
- Matt Dobbs, McGill University
- Bryan Gaensler, University of Toronto
- Mark Halpern, University of British Columbia
- David Hanna, McGill University
- Gary Hinshaw, University of British Columbia
- Vicky Kaspi, McGill University
- Tom Landecker, National Research Council of Canada
- Ue-Li Pen, University of Toronto
- Scott Ransom, National Radio Astronomy Observatory
- Kris Sigurdson, University of British Columbia
- Kendrick Smith, Perimeter Institute
- Ingrid Stairs, University of British Columbia
- Keith Vanderlinde, University of Toronto

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