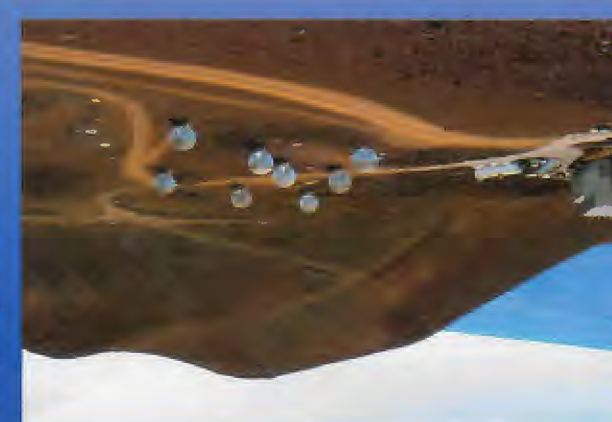
# The Submillimeter Array

## Mauna Kea, Hawai'i

## The SMA on Mauna Kea



The SMA is located at the foot of Pu'u Poli'ahu at 4,080 m (13,386 feet), 400 feet below the summit of Mauna Kea. The submillimeter emission from astronomical objects is partially absorbed by water vapor in the Earth's atmosphere. At sea level, none of the submillimeter radiation reaches the Earth's surface and submillimeter astronomical observations are impossible. By building the SMA on a high and dry site the radiation can be detected and measured through this atmospheric window. Mauna Kea is one of the world's best sites for telescopes.

The Submillimeter Array is a collaborative project of the Smithsonian Astrophysical Observatory (SAO) and the Academia Sinica Institute of Astronomy and Astrophysics (ASIAA).

The SAO is a research institute of the Smithsonian Institution headquarters in Cambridge, MA, where it is joined with the Harvard College Observatory (HCO) to form the Harvard-Smithsonian Center for Astrophysics (CfA). More than 300 scientists at the CfA are engaged in a broad program of research in astronomy, astrophysics, earth and space sciences, and in science education.

The ASIAA was established in 1993 in Taipei, Taiwan. It has already developed a reputation as an internationally competitive astronomical research institute. The ASIAA chose to join the SMA and to pursue sub-millimeter astronomy as one of its key research directions. The institute currently employs more than 70 researchers, technical and support staff.

For more information on the partners:
**SAO:** http://cfa-www.harvard.edu/sao-home.html
**ASIAA:** http://www.asiaa.sinica.edu.tw/


**Contact information:**

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**Hilo, Hawaii 96720**
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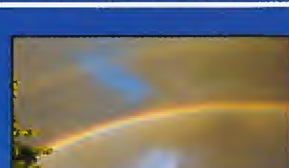
**Web page:**
**http://sma-www.harvard.edu/**


All scientific pictures provided by the SMA staff unless stated otherwise.

Design: J. Baumann

## What is Submillimeter Astronomy ?

The Submillimeter Array (SMA) explores the universe by detecting light of colors which are not visible to the human eye. It receives millimeter and submillimeter radiation, so named because its wavelength ranges from 0.3 - 1.7 millimeter (that is 0.01 – 0.07 inches).

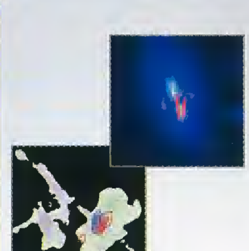


Humans can just see the colors visible in a rainbow. We perceive the world around us in light of those colors. But there is light in "colors" the human eye can not see (e.g. infrared, ultraviolet, X-ray, radio). Astronomers use a number called "*wavelength*" or "*frequency*" to describe these colors.

The left picture shows the galaxy M51 as seen with the Hubble Space Telescope in optical light. On the right, an SMA observation of the same galaxy, translated into so-called 'false colors' to represent different intensities. While the galactic spiral structure is clearly visible in both pictures, the SMA observations reveal gas, dust and regions of active star formation at exactly the positions of the dark regions in the optical image. By revealing such complementary information and examining the features of the gas and dust that are not visible in optical light, the SMA will further our understanding of the galaxy M51 and many other interesting astronomical objects.
(optical picture credits: N. Scoville, T. Rector et al., Hubble Heritage Team, NASA)

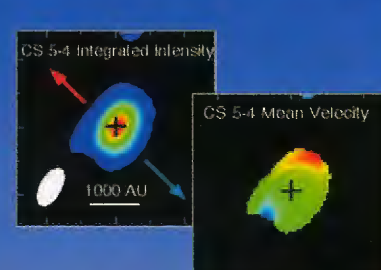
### Submillimeter Radiation – Where does it come from?

The main source of submillimeter radiation is cold interstellar material. It consists of gas, dust and small rock-like bodies. This material is also the substance out of which stars are formed. Detecting submillimeter emission therefore plays a vital role for studying the birth and death of stars. For example, when stars are born out of dense interstellar clouds their first visible light is trapped within them. But the SMA can 'see' into those clouds and detect the submillimeter light and thereby witness the birth of a star where optical telescopes – or the human eye – can just see darkness.



## Current Research

The Submillimeter Array was completed and dedicated in November 2003. It has already been able to make many interesting observations. Now in full operation, it can study newly-forming planetary systems, asteroids, comets, planets in our own Solar System, dying as well as new-born stars, red-shifted radiation from the most distant (and therefore oldest) objects in our universe and even radiation from the Big Bang. Below you can see a small sample of the current research results.

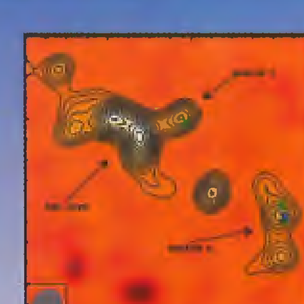


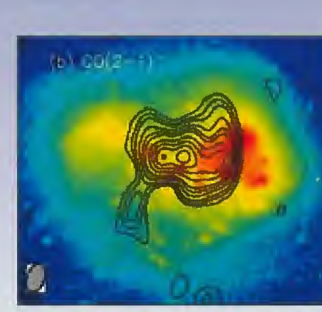

### Are we Alone ?

We live in a planetary system, but are there others? The SMA has observed a disk of material surrounding the star L1551-IRS5. It's comparable in mass and size to our Solar System. The Submillimeter Array could also detect signs of a rotating disc motion (right panel). It could very well be that we are witnessing the beginning of a new planetary system. Our ability to study planetary systems in the making around other stars will be greatly increased by the SMA.

### Zooming in

Like the zoom on a digital camera, the array structure enables the SMA to resolve details much finer than those visible with single dish telescopes. This picture of a star forming region in the Orion constellation is the first submillimeter continuum image with subarcsecond resolution. The SMA detects 8 distinct objects which were previously known as a single source. The additional information is crucial to understanding the mechanisms of star formation.



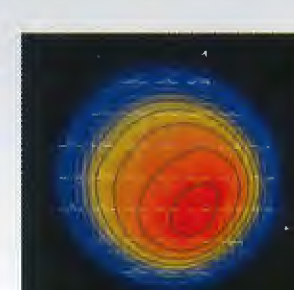


### Worlds in Collision

The SMA probes the region where two galaxies are colliding (yellow and red areas to the left and right of the center). The point of interaction is obscured in optical light but the SMA reveals 4 billion solar masses in the form of carbon monoxide gas (contour lines) that fuels star forming activity triggered by the shock waves of the collision.

### How's the Weather on Mars?

With the SMA it is possible to have a detailed look at the conditions on the planets in the Solar System. This image shows the surface temperature of Mars using color coding. It's warmer (red) on the side facing the sun. The overlaid graphs show the distribution of carbon monoxide in the atmosphere of Mars, which tells us about the temperature of the Martian atmosphere.



The Submillimeter Array is a joint venture of the Smithsonian Astrophysical Observatory and the Academia Sinica Institute of Astronomy and Astrophysics (ASIAA). The interferometer has been under development and construction since the early 1990s. First observations on Mauna Kea were obtained with a single baseline in September of 1999 at 230 GHz. The James Clerk Maxwell Telescope (JCMT) and the Caltech Submillimeter Observatory (CSO) will be incorporated in the array periodically starting in 2005, further increasing the sensitivity and resolving power.

## The Submillimeter Array

The SMA is the world's first interferometer dedicated to submillimeter astronomy. It consists of 8 antennas, each one with a diameter of 6 meter (19.7 feet). There are 24 different locations ('pads') between which the antennas can be moved with the aid of a special transporter. This makes the array-structure highly flexible to carry out different kinds of observations. The astronomical signals from each of the antennas are transmitted over fiber optics to the Control Building, where they are compared to each other in a supercomputer called a "Correlator".

The performance of the SMA is unique because it observes with a maximal resolution of 0.1 arcseconds. This is equivalent to the size of the period at the end of this sentence at a distance of 1 mile. At 0.85 mm wavelength its resolution is 30 times greater than that of the biggest single dish submillimeter telescope.

### THE SMA IN NUMBERS

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|---|---|
| LOCATION: | Mauna Kea, Hawai'i; elevation 4,080 m (13,386 feet) |
| NUMBER OF ANTENNAS: | 8 |
| ANTENNA DIAMETER: | 6 m (19.7 feet) |
| ANTENNA WEIGHT: | 42,910 Kg (94,600 pounds) |
| REFLECTOR SURFACE ACCURACY: | 12 μm (0.0005 inch) |
| NUMBER OF PADS: | 24 |
| NUMBER OF BASELINES: | 28 |
| SHORTEST BASELINE: | 8 m (26.2 feet) |
| LONGEST BASELINE: | 508 m (1,667 feet) |
| OPERATING WAVELENGTHS: | 0.3 – 1.7 mm (0.01 inch – 0.07 inch) (180 – 900 GHz) |
| POINTING ACCURACY: | 1 arcsec |
| MAXIMUM RESOLUTION: | 0.1 – 0.5 arcsec |
| FIELD OF VIEW: | 14 – 70 arcsec |
| CORRELATOR: | highly flexible hybrid, analog/digital design, up to 2GHz bandwidth, 2 receivers, 8 stations |