中央研究院新聞稿

成功的連結天線使 ALMA 計畫邁向新里程

Atacama 大型毫米及次毫米波陣列(ALMA)是一個正在南美洲智利北邊建構的跨國性超大型望遠鏡興建計畫。今年四月三十日，兩座 ALMA 天線，連結整合成一套系統，並首次對天體進行觀測，此次成功測試為該計畫又樹立了一項主要的里程碑。

位於海拔兩千九百公尺的後勤支援基地，首次接收到火星的干涉訊號，這一刻的來到，宣告了此一階段性目標的達成！

ALMA 計畫的主任 Thijs de Graauw 表示：「對 ALMA 計畫來說，我們向前踏出了重要的另一步，這證明了各種硬體元件間能良好的協力運作。在所有工作同仁的努力下，此一首次整合展現了我們全球性合作的能量，也讓我們有信心能夠讓 ALMA 全面運轉，並成為一座偉大的天文台 」

來自火星的微弱電波，先透過兩座直徑 12 米 ALMA 天線進行收集，然後經過最先進電子設備的處理，兩座天線就被轉化成一套高解析度的望遠鏡系統(被稱為干涉儀)。

成對的天線是干涉儀系統的組成單元，干涉儀系統能將電波轉成影像，並使其解析度趨近或甚至超過光學望遠鏡。在這樣的系統中，每座天線都以電子的方式和另一座天線相連，從而形成一大群的成對天線。每對天線都能提供獨特的訊息，把這些資訊整合起來，便能建構出細節豐富的天體影像。

值得一提的是，用於本次成功測試的電子設備，包括了一組由台灣負責整合，測試的前端接收機系統。前端接收機系統是來自天體的訊號首先會通過的電子元件。

兩座直徑 12 米的 ALMA 天線，正指向火星。圖片提供 Lewis Knee

ALMA 計畫預計在 2010 年代的初期完工，屆時 66 座天線間會有上千個兩兩配對組合的訊號，而天線間的距離最長會超過十六公里。這使得 ALMA 能達到的解析度，會比最好的太空望遠鏡還要好。智利 Atacama 沙漠上的 Chajnantor Plateau 山區是將來天線陣列之運作地點，其海拔高達五千公尺，比後勤支援基

地所在地更高，是地球上進行毫米波天文觀測的最佳地點之一。

四月底成功完成觀測的天體是火星，天線所接收到的頻率為 104.2 GHz 的訊號，是火星運動透過干涉儀的偵測所產生的。

「該訊號的取得條件十分嚴苛，要求天線和電子設備間要達到完美的同步：相距數公里的設備間，其時間上的精度需求高達百萬分之一秒的百萬分之一。此外，智利山區的地理環境極嚴苛，強風、高海拔、溫差大等惡劣的自然環境，在在增加天文台運作的複雜度和工程挑戰的極限性。」ALMA 計畫工程師 Richard Murowinski 做了上述的評論。

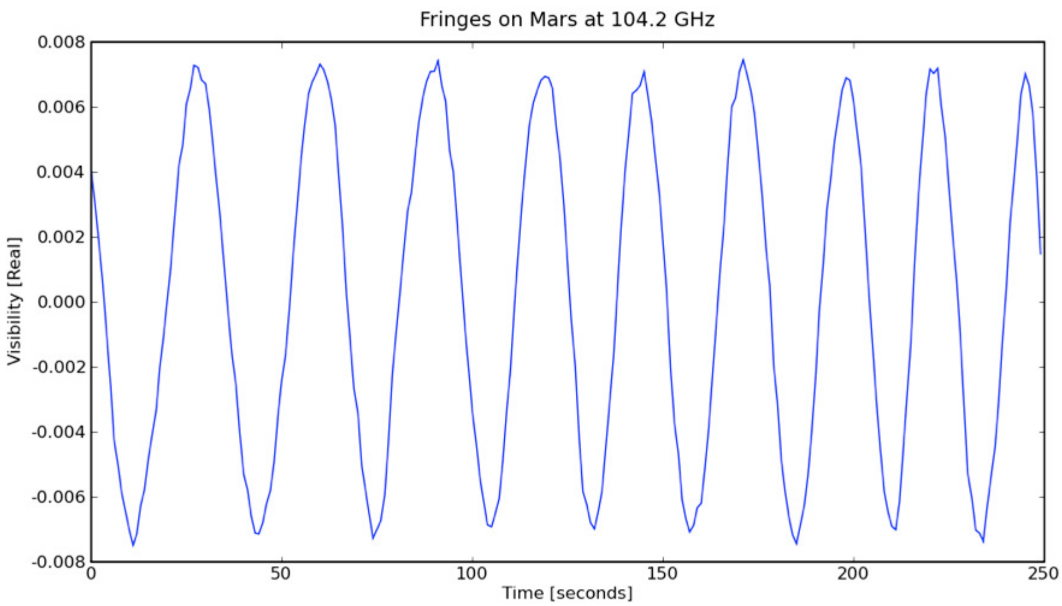
在毫米與次毫米波段上，ALMA 計畫將會是天文學家探索宇宙的最先進探測工具。與過去所有望遠鏡系統相較，ALMA 在上述波段能看到的天體更暗，能得到的影像解析度也更高。科學家們渴望利用 ALMA 的這些優點來研究形成於宇宙初期的恆星與星系、了解更多恆星誕生過程中的未知細節、追蹤新生恆星與行星週遭的氣體與塵之運動軌跡。

ALMA 計畫的主任 Thijs de Graauw 表示：「今年年底前，我們希望能首次在海拔五千公尺的基地，完成干涉儀測試，並於 2011 年底前，至少能同時運作至少十六座天線來模擬單一巨大口徑的望遠鏡」。

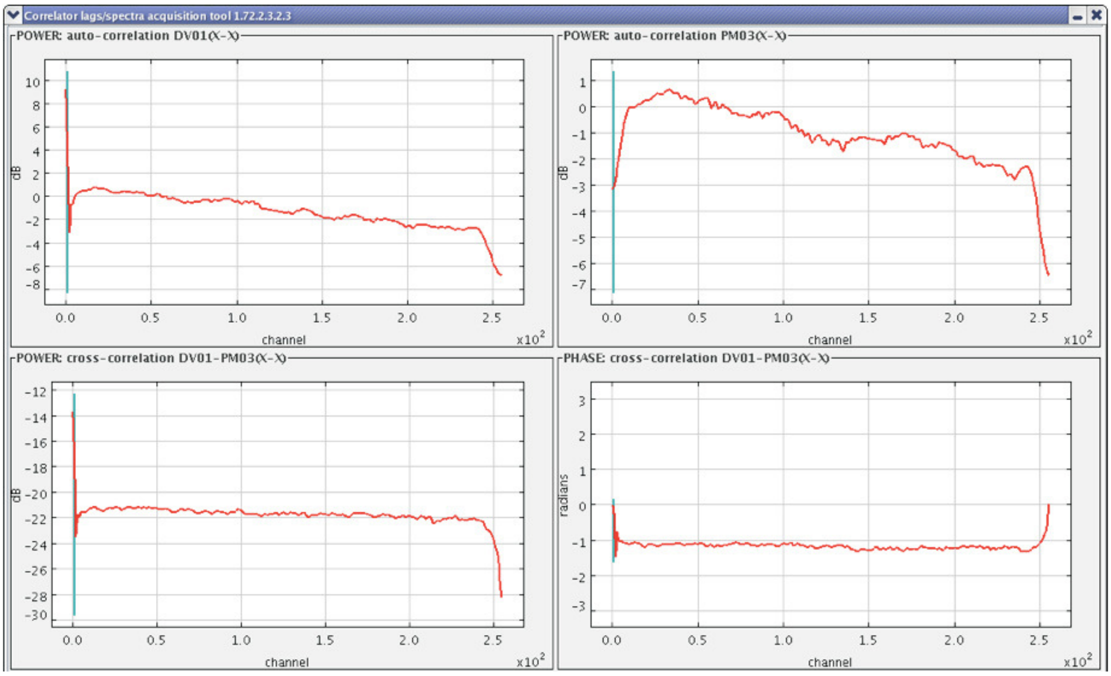
ALMA 計畫係由東亞、歐洲、北美三地投注精銳天文研究人力與資源，並與智利合作興建。行政院國家科學委員會與本院亦挹注研究經費。

附圖:

- 下圖所示為當對火星進行觀測時，相關器輸出頻道中的訊號對時間的函數。



•下圖所示為相關器所有輸出頻道的螢幕畫面，其中每個單一頻道都以 1 秒為單位積分。上方兩個視窗展示來自兩座個別接收天線的訊號譜線圖。下右展示的為相位，下左顯示的為「相關訊號功率(cross-correlated power)」。



•用於本次首波測試的兩座直徑 12 米的天線，座落於海拔兩千九百公尺高的後勤支援基地。版權所有：ALMA (ESO/NAOJ/NRAO) 。

補充資料：

ALMA計畫是革命性的電波天文望遠鏡，由直徑12米及直徑7米、總數66座的天線所組成，觀測波段為毫米與次毫米波。ALMA預計將於2011年開始進行科學觀測，是用來研究宇宙低溫的一面(分子雲與塵相當於大霹靂的殘存輻射)之最有力工具。ALMA將用來研究形成恆星的原料、行星系統、星系、甚至生命本身，並將對我們這個宇宙起源的最深入問題做定位。

ALMA 望遠鏡所觀測的波長是 0.3 毫米至 9.6 毫米。要在這個波段做觀測，高海拔且乾燥是觀測基地必備的條件，如此才不會受到地球大氣的阻撓。這也就是為

何 ALMA 會建在海拔五千公尺的智利 Atacama 沙漠上的 Chajnantor Plateau 山區了，這裡也是全球最高的天文觀測基地。ALMA 的靈敏度與解析能力都是史無前例得高，直徑 12 米天線的基線是可以任意調整的，範圍從十五公尺到十六公里。ALMA 的解析能力是哈伯望遠鏡的十倍。

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Academia Sinica Press Release

ALMA Telescope passes major milestone with successful antenna link

The Atacama Large Millimeter/submillimeter Array (ALMA), an immense international telescope project under construction in northern Chile, reached a major milestone on April 30, when two ALMA antennas were linked together as an integrated system to observe an astronomical object for the first time.

The milestone achievement, technically termed "First Fringes," came at ALMA's Operations Support Facility, 2900 metres above sea level.

"This is another important step forward for ALMA as it proves that the various hardware components can work well together. The efforts of all the staff involved in this first antenna integration show the strength of our global collaboration and give much confidence that we can get to full operations with ALMA as one great astronomical observatory," says Thijs de Graauw, ALMA Director.

Faint radio waves emitted by the planet Mars were collected by the two 12-metre diameter ALMA antennas, then processed by state-of-the-art electronics to turn the two antennas into a single, high-resolution telescope system, called an interferometer.

Such pairs of antennas are the basic building blocks of imaging systems that enable radio telescopes to deliver pictures that approach or even exceed the resolving power of visible light telescopes. In such a system, each antenna is combined electronically with every other antenna to form a multitude of antenna pairs. Each pair contributes unique information that is used to build a highly-detailed image of the astronomical object under observation.

The hardware used in this successful test included, in particular, one Front End that was integrated, tested, and delivered by the Taiwan arm of the project. Front End is the first electronic element through which the signals from the sky are received.

The two ALMA antennas pointing at Mars. Image courtesy of Lewis Knee (ALMA)

When completed in early in the next decade, ALMA's 66 antennas will provide over a thousand such antenna pairings, with distances between antennas exceeding sixteen kilometres. This will enable ALMA to see with a sharpness surpassing that of the best space telescopes. The antennas will operate at an altitude of 5000 metres, high above the OSF, in one of the best locations on Earth for millimetre-wavelength astronomy, the Chajnantor Plateau in Chile's Atacama Desert.

Last week's successful Mars observation was conducted at an observing frequency of 104.2 GHz. Astronomers measured the distinctive varying "fringes" detected by the interferometer as the planet moved across the sky.

"This can only be achieved with the perfect synchronisation of the antennas and the electronic equipment: a precision much better than one millionth of a millionth of a second between equipment located many kilometres apart. The extreme environment where the ALMA observatory is located, with its strong winds, high altitude, and wide range of temperatures, just adds to the complexity of the observatory and to the fascinating engineering challenges we face", comments Richard Murowinski, ALMA Project Engineer.

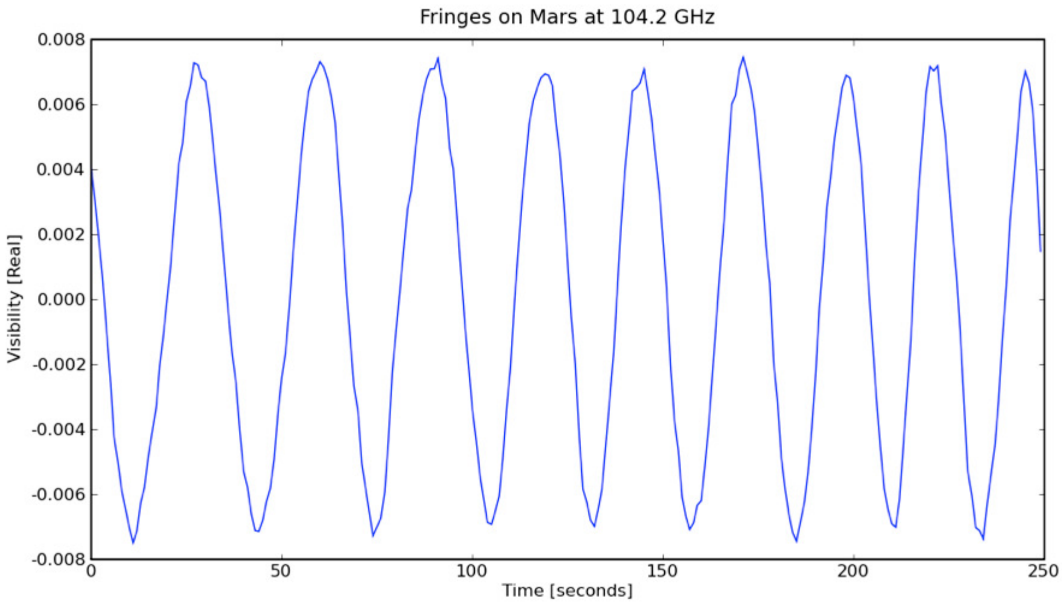
ALMA will provide astronomers with the world's most advanced tool for exploring the Universe at millimetre and submillimetre wavelengths. It will detect fainter objects and be able to produce much higher-quality images at these wavelengths than any previous telescope system. Scientists are eager to use this transformational capability to study stars and galaxies that formed in the early Universe, to learn long-sought details about how stars are born, and to trace the motion of gas and dust as it whirls toward the surface of newly-formed stars and planets.

“We are on target to do the first interferometry tests at the 5000-metre high-altitude site by the end of this year, and by the end of 2011 we plan to have at least 16 antennas working together as a single giant telescope,” says Thijs de Graauw.

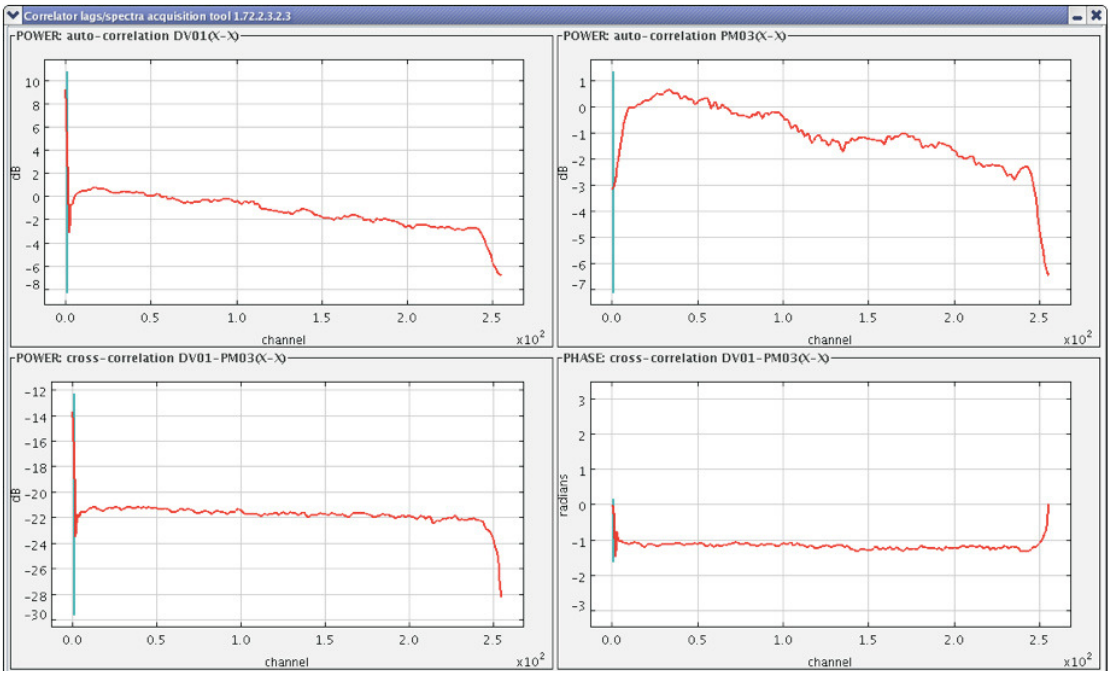
The ALMA Project is a partnership between the scientific communities of East Asia, Europe and North America with Chile.

Images:

• This graph shows a plot of a single channel of the correlator output as a function of time, when observing Mars.



• In the next caption, we see a screenshot of the full correlator output for a single one-second integration. The top two windows are the spectral shapes of the signals from the two individual antennas. The bottom ones are the phase (right) and cross-correlated power (left), which is a little less than one percent of the total.



• The two antennas used in this first and successful test observation of "first astronomical fringes", at the Operations Support Facility at an altitude of 2900 metres.

Credit: ALMA (ESO/NAOJ/NRAO)

Notes for editors:

ALMA is a revolutionary astronomical telescope, comprising an array of 66 giant 12-metre and 7-metre diameter antennas observing at millimetre and submillimetre wavelengths. ALMA, which will start scientific observations in 2011, is the most powerful telescope for observing the cool Universe — molecular gas and dust as well as the relic radiation of the Big Bang. ALMA will study the building blocks of stars, planetary systems, galaxies and life itself, and will address some of the deepest questions of our cosmic origins.

ALMA will operate at wavelengths of 0.3 to 9.6 mm. At these wavelengths, a high, dry site is needed for the telescope to be able to see through the Earth's atmosphere. This is why ALMA is being built on the breathtaking 5000-metre-high plateau of Chajnantor in the Atacama region of Chile, the highest astronomy site in the world. ALMA will offer unprecedented sensitivity and resolution. The 12-metre antennas will have reconfigurable baselines ranging from 15 m to 16 km. ALMA will have a resolution ten times better than the Hubble Space Telescope.

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