

Very Large Array (VLA) 1980, 27座25m天線

增加解析度 天線做多，散開成陣列 (array)

=> 干涉儀 (interferometer)! $D \sim 36\text{km}$



New Mexico, 海拔: $\sim 2124\text{ m}$, upto 50GHz, 7mm, 0.05''

干涉儀 (interferometer)--望遠鏡陣列 (array)

PdBI 6 座15m天線D~0.7km



NMA 5座10m天線



CARMA

9座6m天線+ 6座10m天線 D~2km



SubMillimeter Array (SMA) 次毫米波陣列

8座6m天線 D~0.5km



- eight 6-m antennas
- wavelength bands 1.3, 0.85, and 0.45 mm (span 186–696 GHz)-switchable waveplate
- maximum baseline ~500 m -angular resolutions (potentially) as high as $0''.4$ at 1.3 mm and $0''.15$ at 0.45 mm
- located on Mauna Kea, Hawaii, USA

AMiBA (2004) ASIAA+NTU

Array for Microwave Background Anisotropy

7-13座0.6m-1.2m天線 D~6m



Mauna Loa at 3400 m. 94 GHz. Synthesized Beam 10' to 2'

Very Long Baseline Array (VLBA)



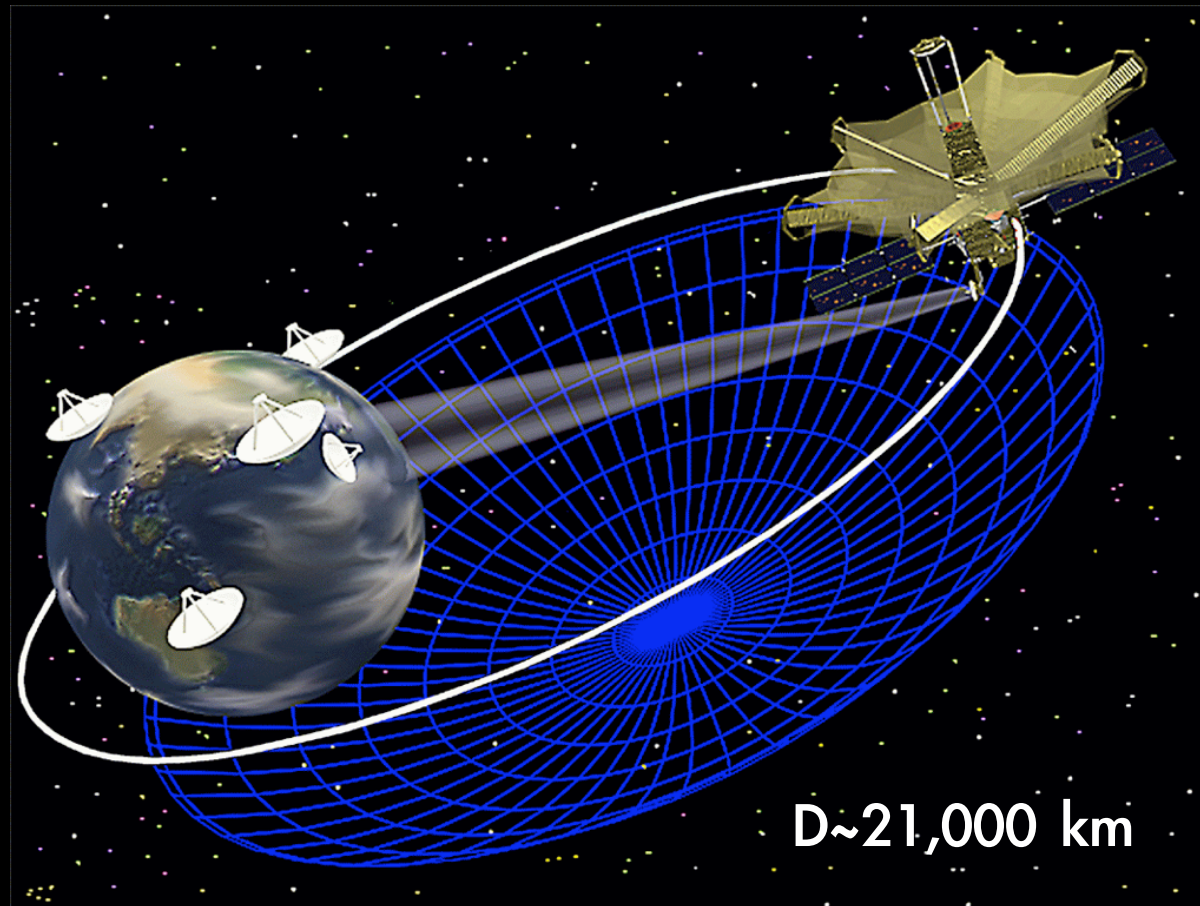
- ten 25-m antennas
- wavelength bands 90, 50, 21, 13, 6, 4, 2, 1, 0.7 and 0.3 cm (0.3-90 GHz) -dual polarizations -
- maximum baselines of 8611 km-angular resolutions as high as ~ 22 μ arcs at 90 cm to 72 μ arcs at ~ 0.3 cm-signals received at each antenna recorded on hard disk and later correlated (VLBI) at Array Operations Center in Socorro, New Mexico -
- located USA territories

European VLBI Network (EVN)

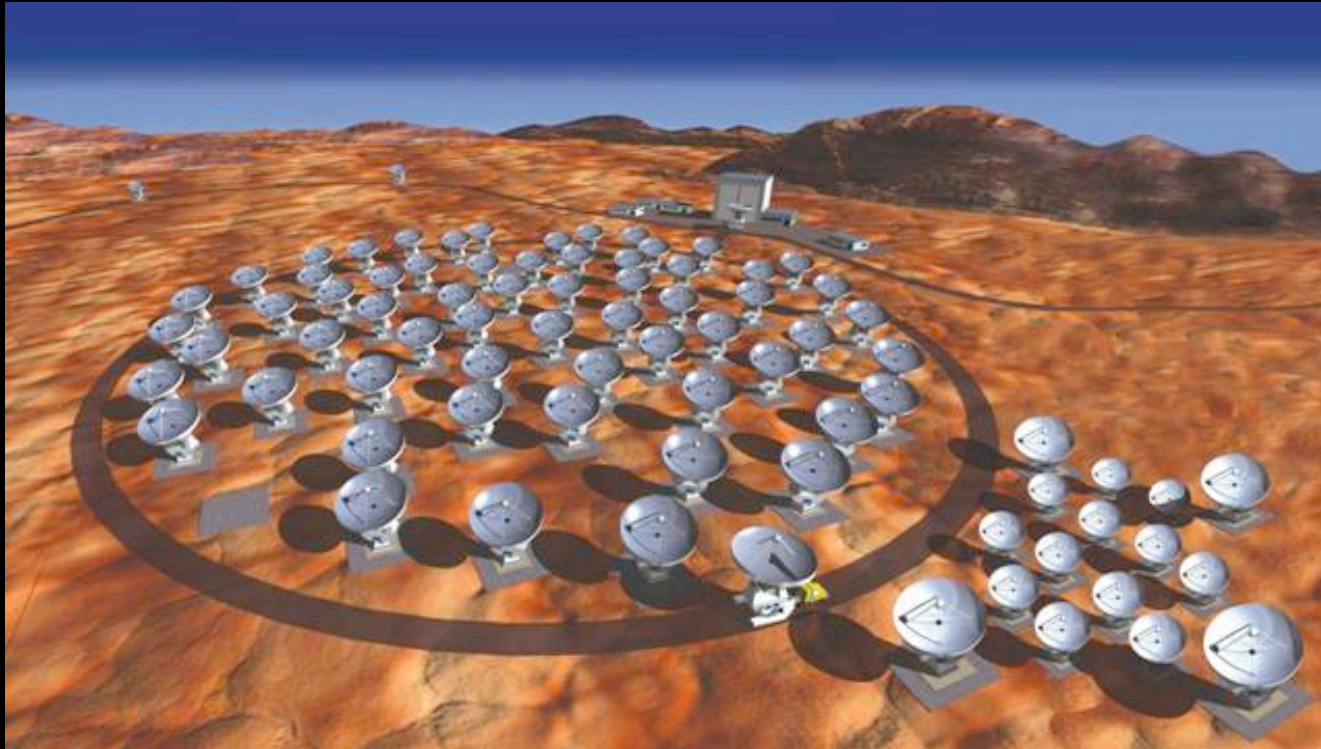


15+ 座天線

VLBI Space Observatory Programme (VSOP) 8m dish
in space, 1997, Japan



The Atacama Large Millimeter/Submillimeter Array (ALMA)



- ALMA is the largest ground based, international astronomical observational facility ever built.
- It is currently under construction in the Chajnantor area in the Atacama desert in northern Chile
- wavelength range from 0.3mm to 9mm with an angular resolution of up to 0.004 arcsec. The baseline project consists of the 12-m array of up to 64 12-m telescopes, and the Atacama Compact Array (ACA) of 4 12-m telescopes and 12 7-m telescopes. Maximum baseline ~ 15 km.
- ALMA will be studying a broad range of exciting science, such as weather patterns on solar system planets, the formation of planets and stars in our galaxy, the motions within active galactic nuclei, and the formation of the earliest galaxies at $z \sim 10$.

Comparison of Resolutions

Resolution

0.1"



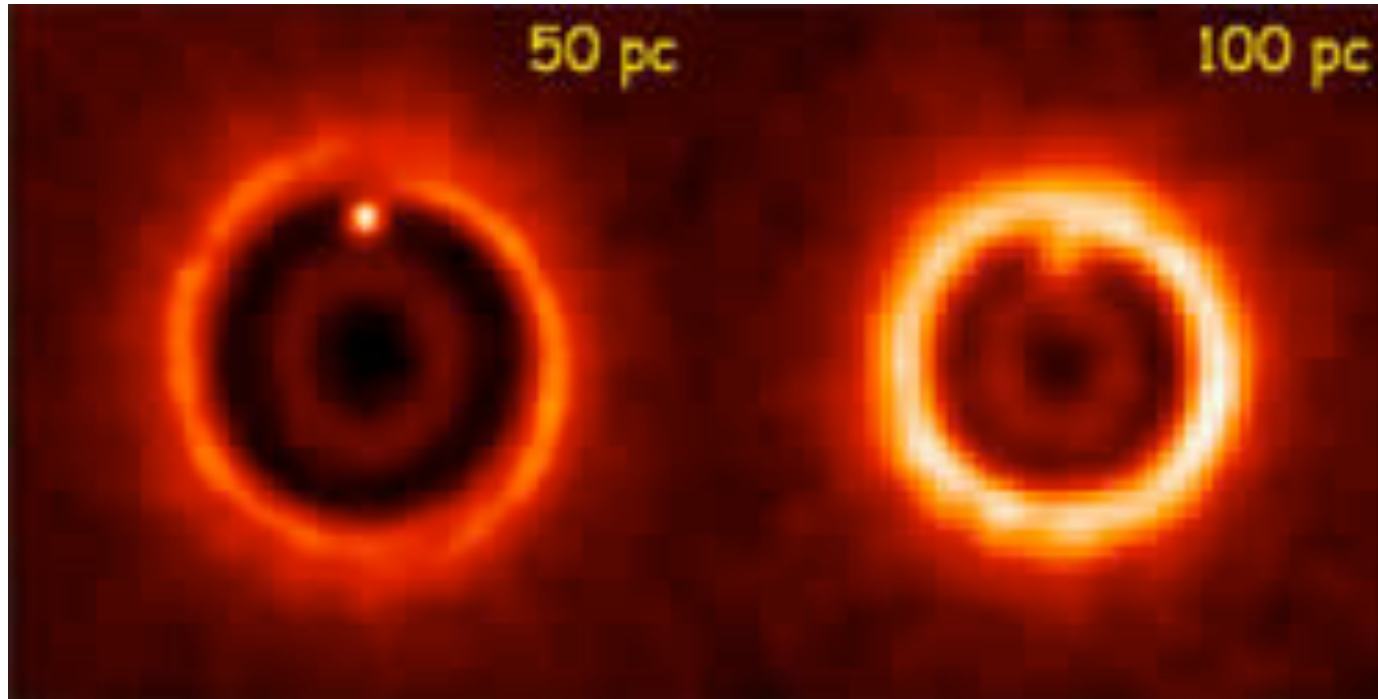
0.05"



0.004"

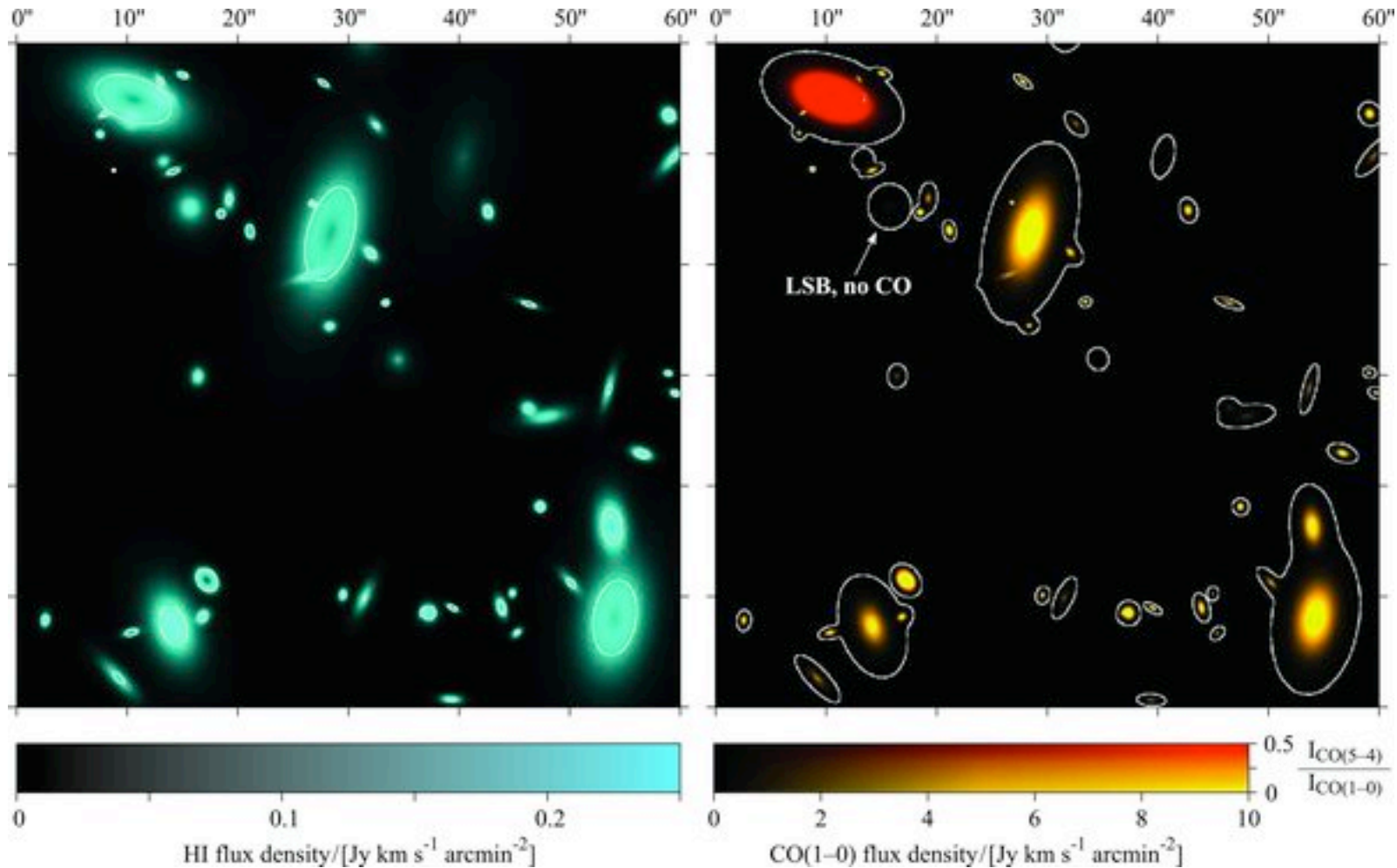


High Resolution: Protoplanetary Disks



A simulation (Wolf & D'Angelo 2005) of ALMA observations at 950 GHz of a disc showing an embedded protoplanet of 1 Jupiter Mass around a 0.5 Solar Mass star (orbital radius: 5AU). The assumed distance is 50 pc or 100 pc as labeled. The disc mass is set to that of the Butterfly Star (IRAS 04302+2247) in Taurus. Note the reproduced shape of the spiral wave near the planet and the slightly shadowed region behind the planet in the left image. Image courtesy S. Wolf.

High Sensitivity: CO gas in High z galaxies



Obreschkow et. al. (2009) made simulations of CO and HI emission at high redshifts. This image shows the integrated line emission of CO (1-0) in the right panel and HI in the left one, for $z=1.0-1.1$ in 1 arcmin^2 . For CO, the colors represent the ratio $I_{\text{CO}(5-4)}/I_{\text{CO}(1-0)}$. The white contours around HI sources represent iso-density curves of CO at 50 percent level of the full CO density scale and vice versa.