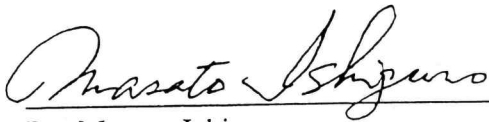


MEMORANDUM OF AGREEMENT

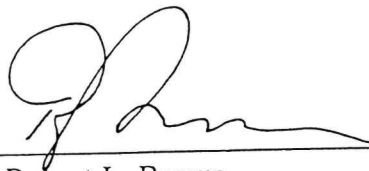
THE NATIONAL ASTRONOMICAL OBSERVATORY, JAPAN
AND
THE NATIONAL RADIO ASTRONOMY OBSERVATORY, USA

Cooperative Studies for
The Large Millimeter and Submillimeter Array
and
The Millimeter Array

March, 1998



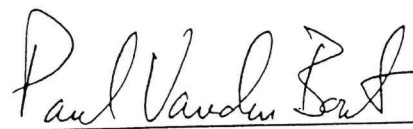
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1. Background

Astronomers in Japan and the United States are planning major astronomical instruments capable of making images of celestial objects at millimeter and submillimeter wavelengths. In Japan the planning is being done at the National Astronomical Observatory of Japan (NAOJ); in the United States the planning is led by the National Radio Astronomy Observatory (NRAO).

The NAOJ instrument is the Large Millimeter and Submillimeter Array (LMSA), an aperture synthesis telescope comprised of 50 antennas of 10 meters diameter designed for the study of distant and faint astronomical objects. The NRAO instrument is the Millimeter Array (MMA), an aperture synthesis telescope of 36 antennas of 10 meters diameter designed for wide field imaging. Each of these synthesis arrays will be equipped with superconducting mixer receivers for operation at wavelengths of 3 mm to 0.3 mm, and each anticipates employing array configurations with antenna separations greater than 2-3 km to achieve sub-arcsecond angular resolution.

There is a long history of discussion and growing joint activity between the NAOJ and NRAO concerning the MMA and LMSA. That activity has resulted in the idea that were these two arrays to be built on nearby adjacent sites with compatible equipment, not only would there be a saving of construction costs, but also an entire new area of science would be possible. Under the cooperative research program supported by JSPS (Japan Society for the Promotion of Science) in Japan and NSF (National Science Foundation) in the United States, the first of proposed series of joint workshops was held in March 1997 in Tokyo to examine the prospects for science at 10 milli-arcsecond resolution that will be realized by combining both arrays as the Atacama Array. The implications for the technology and design for the Atacama Array were also discussed.

Optimum performance of the MMA and the LMSA depends on locating the instruments on a site with dry and stable atmospheric conditions. Cooperative site studies done by the groups in Japan and in the United States have led both groups to focus their site evaluation on the Chajnantor/Pampa la Bola area in northern Chile that offer exceptionally favorable atmospheric conditions and sufficiently wide area to construct large arrays for millimeter and submillimeter astronomy.

Since 12 June 1995 there has been a Memorandum of Understanding between the NAOJ and the NRAO with respect to the joint activities on site studies. This document renews that agreement, expanding the areas of cooperation and replacing the earlier agreement in its entirety.

2. Cooperative Studies for Partnership

Since the effort involved in the site-testing activities and studies for site development and operational structure is very large, particularly in the remote area of northern Chile, both the NAOJ and the NRAO groups recognize the value of working together. More extensive site studies are needed: the atmospheric conditions to evaluate the performance of the LMSA and the MMA at submillimeter wavelengths, the effects on telescope pointing, and issues in interferometric phase/amplitude calibration.

Considering that the Chajnantor/Pampa la Bola area is being identified as the potential site for the MMA and the LMSA, both groups will explore the feasibility of a closer partnership between the LMSA and the MMA projects in that area. Recognizing also that the European astronomical community is planning the Large Southern Array (LSA) and has organized a partnership that will

explore the union of the LSA and the MMA into a single project, both the NAOJ and the NRAO will encourage studies with the Europeans of how a three-way partnership could be realized as an extension of Atacama Array concept in collaboration with the LSA project.

3. Agreement

Recognizing that the LMSA and the MMA projects share common goals, we agree to cooperate on the following:

- We will jointly conduct site-testing activities in Chajnantor/Pampa la Bola area by integrating all the available site-testing equipments, facilities, and personnel;
- We will make a joint effort to protect the site by working collaboratively with our Chilean collaborators;
- We will jointly conduct studies on site development and operational structure;
- We will share technology developments for the arrays via reports and visits of engineering and scientific personnel;
- We will develop a common set of safety procedure for work on the Chile site;
- We will explore the possible partnership among the LSA, MMA, and LMSA projects.

4. Term

This agreement is for a term of three years and can be renewed or amended, as necessary, by mutual agreement.