Interoffice

National Radio Astronomy Observatory

Charlottesville, Virginia

To: Addressee

June 21, 1976

25 Meter - Millimeter Wave Telescope
Memo #49

From: S. Weinreb

Subject: Millimeter-Wave Developments

The status of Charlottesville millimeter-wave developments and a task plan for the next several months is attached.

I am pleased to announce the appointment of Dr. D. Richard Decker as leader of the Charlottesville Millimeter Wave Development Group.

Attachment:

Addressees:

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I. STATUS OF DEVELOPMENTS

A. Noise in Cooled Schottky Diodes

The noise generated in these diodes (used as mixers in NRAO 15 GHz and 23 GHz VLA receivers, 33-50 and 80-120 GHz 36' receivers) is 5 to 10 times thermal noise at a diode temperature of 18°K. This problem has been studied by Mattauch and Kerr for the past four years and it is now fairly certain that the noise generation mechanisms are:

1) Tunneling of carriers through the Fermi barrier. This will produce a limiting diode noise temperature (∿80°K) which is independent of physical temperature but is dependent upon semiconductor doping. The noise can be modeled as a "hot" barrier resistance and can be measured by applying small DC bias current. The noise may be only weakly coupled to a mixer under high L.O. drive since the barrier resistance is either very low or very high during the L.O. cycle.

2) Gunn-effect noise. This is an effect in bulk gallium-arsenide under high field conditions where carriers may jump into a high momentum state. The noise is modeled as a "hot" series resistance which occurs under the high forward current portion of the L.O. cycle. It is probably the dominant source of noise in cooled mixers and can be reduced by reducing the bulk series resistance.

B. Josephson Junction

The NRAO effort of the past two years has been to produce reliable and reproducible thin-film niobium junctions. For the past several months we have been close to having junctions worth testing as mixers and it appears that this milestone will be reached soon. The junction fabrication task has been shifted into the UVA Semiconductor Lab contract

A small contract has been given to Prof. Ray Y. Chiao at U. of California to develop a 31 GHz Josephson Junction paramp for use as a preamp to our 31 GHz receiver at the 36' telescope. Chiao will use mechanically-scratched, tin junctions and has had good laboratory success with this project. It has potential for higher frequency paramps since the configuration is simple and very small pump power is required.

C. Varactor Mixer

Millimeter wave varactor down-converters with an 18-25 GHz maser I.F. have the potential of producing receivers with $\leq$100°K noise temperature in the 50-150 GHz range using presently available solid-state devices. The planned NRAO development of 26-40 GHz masers will increase the applicable frequency range of varactor mixers and increase the tuning range of a particular unit with a fixed-frequency L.O.

A mixer converting 109-116 GHz to 18-25 GHz is presently being designed. Initial measurements of the thermal resistance and microwave characteristics of UVA diodes has been favorable.

D. 127-174 GHz Mixer

An L.O. injection cavity and mixer has been designed and prototyped by Wojtowicz (no longer with NRAO). The injection cavity has been tested in the 140 GHz range and has excellent performance; there is no reason to expect it will not work well over the entire range. A few tests at 140 GHz have been made of the mixer block with promising results. However, diodes are very fragile and difficult to fabricate.

A major obstacle has been the failure of Varian to deliver the three klystrons which will provide local oscillator power for the 127-174 GHz RF range. Two of three have been received but returned because of inadequate performance.

II. SPECIFIC TASKS

A. Evaluate Lower Noise Diodes

Diodes which should have lower Gunn-effect noise are being fabricated by UVA. These diodes have potential of greatly reducing the noise temperature of several NRAO receivers. Evaluate diodes in an 80-120 GHz mount at 300°, 77°, and 18°K.

B. Extend 80-120 GHz Mixer to 70 GHz

The present mixer diode choke causes poor performance below 80 GHz whereas some important new spectral lines have been found between 70 and 80 GHz. Evaluate slightly longer chokes in the 70-80 GHz range and supply Tucson with a mixer optimized for this range.

C. Varactor Mixer Support

The following Charlottesville support is required for Weinreb's varactor mixer work at U. of California:

Machine Shop - approximately 30 hours/month

Diode Fabrication - approximately 30 hours/month

On a longer time schedule (by June 1977) an 18-25 GHz maser and 4°K refrigerator should be provided in Charlottesville for testing of varactor mixers, Josephson Junction mixers, and VLA up-converters.

D. Spare 33-50 GHz Mixers

As soon as the 33-50 GHz mixers shipped to Tucson June 7, 1976, have been tested satisfactorily, two more mounts with diodes and two spare diodes should be fabricated and shipped to Tucson.

E. 127-174 GHz Mixer

This should be a co-operative development with Tucson. A suggested plan is as follows:

1) Charlottesville should fabricate a second mixer block and ship it with three diodes to Tucson. The diodes should be tested to operate at 77°K and give $\leq$1500° SSB mixer temperature at 300°K and 140 GHz.

2) Tucson should develope the L.O. injection method (either a cavity or a quasi-optics approach) and test this method along with the above mixer over the 127-174 GHz range.

3) The klystron situation should be reviewed with Varian. Are Extended-Interaction Klystrons preferable? If the klystron picture is too unfavorable we should consider a second-harmonic mixer approach.

F. Test Josephson Junctions

When a promising junction has been fabricated it should be evaluated as a 115 GHz mixer.

G. Radome Fabric Tests

During the summer several samples of radome fabric will be evaluated at 140 GHz by J. Findlay and S. Hansen (a summer student). Some space and assistance should be provided.