ALMA PHOTONICS MEETING – TOKYO

7/8 November 2000

Agenda:

7 November AM

09.00	Welcome Remarks	Masato Ishiguro
09.15	Summary of work at NRAO	Bill Shillue (NRAO)
10.00	Summary of work at RAL	R. Wade, B. Ellison (RAL)
10.45	Coffee Break	
11.15	Summary of work at Duisburg	Andreas Stöhr (Duisburg U.)
11.45	Systems Aspects of Photonic LO	Horst Stüer (MPIfR, Bonn)
12.00	Lunch	

7 November PM

13.30	Summary of work at NAOJ	M. Ishiguro (NAOJ)
14.0	Photoresponse Characteristics of InP/InGaAs Uni-traveling-Carrier Photodiodes	T. Ishibashi (NTT)
14.30	Generation and Transmission of >100-GHz Millimeter-Waves Using Uni-traveling-Carrier Photodiode	T. Nagatsuma (NTT)
15.00	Coffee Break	
15.30	100 GHz waveguide mounted photonic LO	T. Noguchi (NAOJ)
16.00	LTG GaAs photomixer	S. Matsuura (ISAS)
16.30	Interfacing photonic LO to SIS mixers	Y. Sekimoto (NAOJ)
17.00	Adjourn	
18.00	Group Dinner	

8 November AM

09.00	Collaborative issues	J. Payne, R. Wade, M. Ishiguro
12.00	Lunch	

8 November PM

13.00 Lab visits:
1) Gravitational wave laser interferometer
2) R&D Center for Subaru at Mitaka

15.00 Adjourn

ALMA PHOTONICS MEETING
Tokyo, Japan
7/8 November 2000

Attendees —

Europe:

Andreas Stöhr (Duisburg University)
Horst Stüer (MPIfR, Bonn)
Richard Wade (RAL)
Wolfgang Wild (RUG)

Japan:

Tetsuo Hasegawa (Univ. of Tokyo)
Masato Ishiguro (NAOJ)
Satoki Kawanishi (NTT)
Shuji Matsuura (ISAS)
Takashi Noguchi (NAOJ)
Seiichi Sakamoto (NAOJ)
Shuro Takano (NAOJ)
Tadao Ishibashi (NTT)
Hiroshi Ito (NTT)
Hiroshi Matsuo (NAOJ)
Tadao Nagatsuma (NTT)
Hideo Ogawa (Osaka Prefecture Univ.)
Yutaro Sekimoto (NAOJ)
Akitoshi Ueda (NAOJ)

Taiwan:

Yuh-Jing Hwang (ASIAA)

U.S.:

John Payne (NRAO/Tucson)
Darrel Emerson (NRAO/Tucson)

Masato Ishiguro opened the meeting with words of welcome.

Summary of work at NRAO

John Payne (standing in for Bill Shillue) gave a summary of the work being done at NRAO. The requirements of the photonic LO were outlined. It was mentioned that the following have been collaborating: NRAO Tucson, Max-Planck-Institut für Radioastronomie, Rutherford Appleton Laboratory, Nobeyama Radio Observatory, University of Duisburg, University of Kent, and NTT. The broad requirements were stated as enough power to act as the LO for an SIS mixer over the frequency range 30 GHz to 1 THz together with a path length stability between the different antennas of 17 microns over a period of around 20 mins with a maximum transmission distance of 25 Km. The crucial technologies for this effort were outlined as follows. It was explained that, due to the lack of photomixers at high frequencies at present, a compromise solution has been worked out in which a frequency of up to 120 GHz is transmitted as the difference between two optical frequencies with subsequent multiplication up to the required frequency taking place at the various antennas. The required technology for this solution was outlined and was seen to consist mainly of COTS (commercial off the shelf) components. Results were presented of the various measurements that have taken place in Tucson and it seems that the proposed scheme is viable. Then the various elements needed for realizing the so-called "direct photonic" system were outlined and it was clear that there are several potential show stoppers. These included the noise

generated by the photo mixing process and Brouillon scattering preventing the delivery of adequate optical power at the longest transmission distances.

Summary of work in the UK

Richard Wade (standing in for Brian Ellison) outlined the objectives of the UK effort:

1) Produce a waveguide mounted photomixer for 75-110 GHz for the test interferometer.
2) Produce direct photonic LO power up to 400 GHz.
3) At UKC produce an optical comb generator.

Richard then outlined progress towards meeting these goals:

1) PPARC funding has been obtained.
2) A preliminary study of the U2T equivalent circuit indicates that much RF power is lost due to a large mis-match. There is some agreement between measurement and prediction, particularly in the way in which power falls off with frequency.
3) A conceptual design for the mounting of the photodiode in the waveguide has been completed.
4) Preparatory work has been completed for a study of the direct illumination of an SIS mixer.

Additional work included the evaluation of the performance of optical fiber at cryogenic temperatures. No degradation in performance was detected.

Summary of work at Duisburg University

Andreas Stöhr reported that work on photodetectors for ALMA started in May 2000. Simulations of traveling-wave photodetectors suggest output powers 20 dB down at 650 GHz with existing detectors. Optimization should improve this to 10 db down. The heterodyne measurement set up was described and can now measure up to 220 GHz. Various coupling structures have been examined including coplanar single slot, double slots, microstrip slots and ring slots. New improved devices have been designed and the delivery of the first devices is expected early next year. Some of the older devices have already been shipped to RAL. The best result to date is 100 microwatts at 110 GHz with 16 dBm optical power input.

Systems aspects for the photonic LO

Horst Stüer outlined goals in the development of a 650 GHz photonic LO for ALMA. He gave a description of the test set-up for evaluating the photodetector output. The schedule anticipates that testing at 490 GHz would start early in 2001.

Summary of work at NAOJ

Masato Ishiguro described the goal of generating an LO signal with a power of 100 microwatts at frequencies ranging from 30-950 GHz. The frequency resolution quoted was 1 KHz. The results obtained by Ishibashi were outlined and the result of a continuous-wave generation of 0.5 mW at 120 GHz was presented along with the expected power level at THz range suggested by a pulse measurement. These results indicate that useful power should be obtained up to 1 THz (-15 dB down) with the output power

down 3 dB at 370 GHz. The schedule was outlined; a waveguide-mounted photomixer to produce 0.5mW at 100 GHz by the end of December 2000 and a demonstration of sufficient power for an SIS mixer at frequencies of up to 1 THz by the end of February 2001. A system diagram and preliminary experimental results were presented in which an optical phase shifter was used to achieve the necessary frequency and phase manipulation at the LO frequency. Both Darrel Emerson and John Payne expressed concerns on the open-loop stability of such an arrangement. Masato Ishiguro emphasized a possibility to attain a necessary stability by careful control of the ambient temperature. If this system works, fringe tracking and phase switching can be greatly simplified.

Work at NTT

T. Ishibashi presented a description of the principals involved in the Uni-traveling carrier photodiode. Results were presented on a 120 GHz mmw source. An 8 micron diameter diode was described that gave 1mW at 120 GHz. An experiment that succeeded in transmitting video signals impressed on the 120 GHz carrier was described. A goal of 1mW at 300 GHz was felt to be realizable. The point was made that the frequency response of a photodiode can be determined by the carrier lifetime and not so much by the circuit parameters.

Generation and transmission of >100 GHz millimeter waves using Uni-traveling photodiodes

T. Nagatsuma described a transmission experiment at 120 GHz. A Uni-traveling carrier photodiode was used to generate millimeter power at a frequency of 120 GHz. He noted that an 8-micon diameter diode generated more power at 120 GHz than a 5-micron diameter diode although the smaller diode had better response at lower power levels. After transmission by a horn antenna, a received signal of 100 microwatts was measured. A video signal was transmitted using this system. Power levels were measured with a calibrated Schottky diode.

100 GHz waveguide mounted photonic LO

T Noguchi reported on the requirements of a waveguide mount in 75-110 GHz waveguide. Greater than 15 dB return loss was specified. A new waveguide-stripline transition was described along with a 3-section quarter-wave transformer. The opinion was expressed that, at frequencies above 400 GHz, a quasi-optical mount should be preferred over waveguide. The point was made that a waveguide mount requires a very thin substrate at the higher frequencies. Hopes were expressed for several milliwatts of power at 100 GHz and the suggestion was made that a useful experiment might be to study the amount of power available at higher frequencies by using the output waveguide in over-moded operation.

LTG GaAs photomixer

S. Matsuura talked about stabilizing 0.8 micron lasers and described techniques for linewidth reduction. The laser frequency was stabilized by a resonant optical cavity.

Interfacing photonic LO to SIS mixers

Yutaro Sekimoto discussed the possibilities for coupling the LO signal into the mixer, which included:

1) A balanced mixer.
2) Martin Puplett or Fabry-Perot.
3) Single ended mixer with -20 dB coupler.

It was mentioned that at 900 GHz, using a conventional single-ended mixer, 200 microwatts would be needed. The point was made that, for the photonic LO, it is very important to compare noise temperatures with both conventional and photonic LOs.

Meeting of 7 November adjourned.

Collaborative issues (8 November)

1) Initial test result of the NAOJ 3mm WG photomixer will be available before the end of December 2000 and the estimation of power up to 1 THz before the end of February.

2) A model for the phase 1 three-way WBS is discussed and the following model is proposed:

<Frequency independent part>

LASER synthesizer, Round-trip phase correction, optical fiber	=> Tucson (+Kent, RAL, NAOJ)

<Frequency dependent part>

Photodiode	=> NTT, Duisburg U
Photomixer units	=> NAOJ, RAL

3) It was agreed to modify the Phase 1 agreement on photonics LO to include Japan.

4) The above model will be discussed in the next ALMA Photonics Meeting (MPI, end of March 2001).

Minutes distributed 20 December 2000 by J. Neighbours/NRAO