Technical Development Center News No.1

(International Earth Rotation Service VLBI Technical Development Center News)

October, 1991
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Introduction

Contribution of the Japanese technology
for the International Earth Rotation Service

Akira Sugiura
Chairman
Committee on Space-Time Measurement Project

Great progress has been made in the science and space geodesy during the past decade. In these circumstances the International Earth Rotation Service (IERS) started its activities in precise observations of the Earth rotation. This work requires a variety of advanced technology, such as Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR), Lunar Laser Ranging (LLR) and Global Positioning System (GPS). These sophisticated observation systems have greatly changed our views of the nature of Earth so far. For further extending our scientific knowledge, it is believed essential to develop and improve the technology of observation systems . Therefore, the IERS designated our laboratory (CRL) and Haystack Observatory (in USA) as the VLBI Technical Development Centers (TDC) in October 1990. It is a great pleasure for us to contribute to the IERS in the technical fields as well as in the experimental ones. We will make every possible effort to improve the relating technology in cooperation with other laboratories in Japan.

Establishment of VLBI Technlcal Development Center

Technical Development Center (hereafter TDC) will work

I. to develop new observation technique and new system for more advanced Earth's rotation observation by VLBI and other space technique,

II. to promote the research of Earth's rotation by supporting the VLBI technology level,

and

III. to distribute new technology of VLBI.

The TDC not only develop new observation system, but also make efforts to apply the products to enhance the knowledge of human being through RD experiments and exchanging scientists.

Organization

Location of the TDC in IERS is shown in Fig.1. In Japan, three Centers are working for IERS, which are VLBI observation center (NAO), analysis center (NAO) and TDC. TDC is organized by the Director General of Communications Research Laboratory. And it is managed under the Space-Time Measurement Project Committee. The President of the Committee is Director of the Standards and Measurement Division, who designate the members of the Comittee. Moreover, Director General requests the special members from the other institutes. The Committee is to be advised concerning the plan of Technical Development by the special member.

Management

TDC chooses the development themes for the future IERS activities. And technical development plan is made in the TDC meeting. Selected theme is studied both in CRL and at other relating study groups. And technical information is exchanged with the other TDC (Haystack Obs.) for the international cooperation.

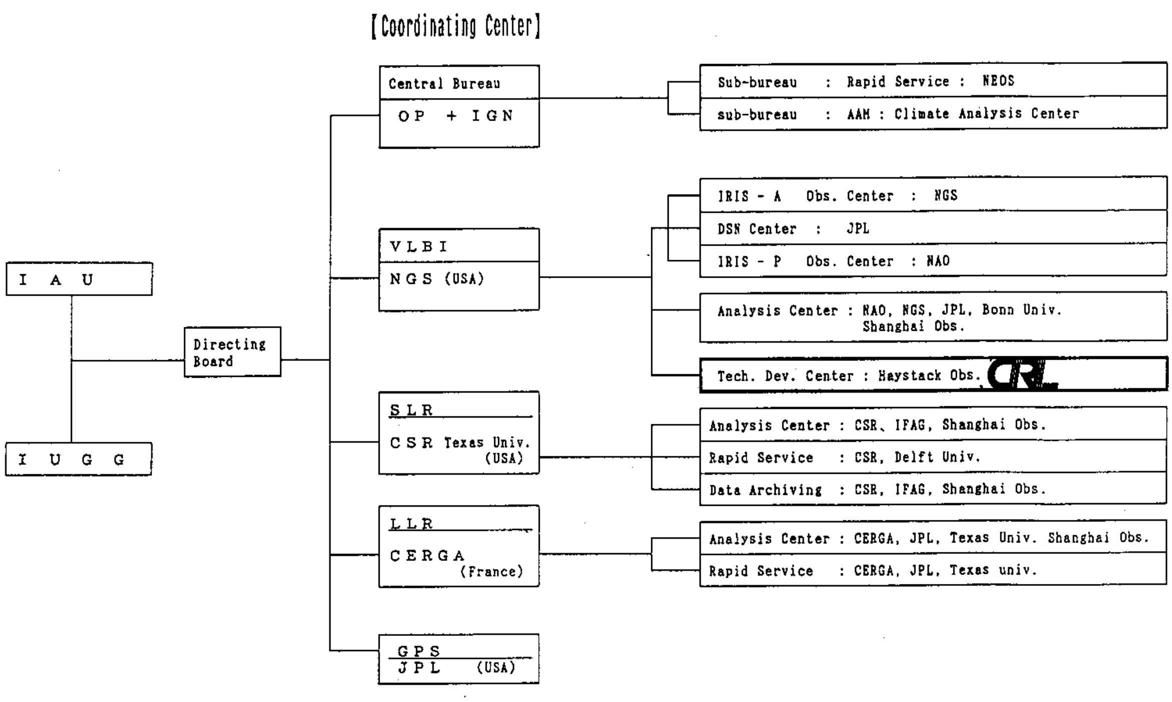


Figure 1. IERS ORGANIZATION.

First TDC Meeting was held

July 25, 1991 at the Conference Room of CRL

Agenda

1. Opening
   Dr.R.Hayashi, Deputy Director General, CRL
   Mr.A.Sugiura, Director of Standards and Measurements Division, CRL
2. Introduction
   Mr.K.Uchida, Director of Kashima Space Research Center
3. Remarks for the TDC program by the special members
4. Organization and Role of the TDC
5. Technical Development Plan
   (1) K-4 system
   (2) Millimeter Wave VLBI
   (3) Antarctic VLBI
   (4) Utilization of Satellite Technique
6. Discussion on the plan for 1990 chaired by Dr.T.Yoshino

Minutes

F.Takahashi : A number of items for development are shown. Priority of the development should be discussed. Suggestions for the development plan are welcome.

Kawaguchi: I hope TDC will develop VLBI observation technique in higher frequency band.

Ejiri: Toward the regular VLBI experiment in Antarctica, cooperation between NIPR and TDC is expected.

Nakahori: Since 1981, GSI has been cooperating with CRL to conduct domestic VLBI experiments. We hope these activity will grow and realize the system for the mean sea level measurement. We are now trying to reduce the error of vertical component at the observing station with schedule optimization.

Kawaguchi: I would like to know the current status of the development plan of data processor for the Earth rotation observation.

F.Takahashi: For the VLBI experiments, we observe with Mark III type DAT in international experiments and with K-4 type DAT in domestic experiments, in most cases. At the moment, data processing for international VLBI experiments is dependent on the correlator in the USA and Germany, while data by domestic experiments is processed by K-3 type correlator in Japan. We are developing the K-4 type correlator to make the best use of its advanced functions.

Kawaguchi : It is planned to develop a new correlator for 20 stations at NAO (Mitaka, Tokyo). Geodetic application is also taken into account in the design of this correlator. For K-4 correlator under development in CRL, what is the relation with Mark IV?

F.Takahashi: Mark IV is under development. We have to complete the K-4 system.

Okihara: As a future VLBI recorder, data recorder with helical scan type is very promising. Furthermore, the cost of the K-4 type data recorder will certainly decrease.

Manabe: I am afraid that the data quality of Kashima station with Mark III HD recording is not good enough. I hope it will be recovered soon . The most important item must be K-4 correlator development. And I prefer the data processing system which is capable of correlation with mixing the K-4 type data and Mark III type data.

Murata: CRL has unique opportunity to have both VLBI and SLR facility. And CRL has conducted VLBI technical development. I hope CRL will make more efforts for the SLR development. And I suggest introducing the SLR analysis software for the efficient development.

Manabe: What kind of computers will be used for the data analysis?

Y.Takahashi: They are HP-IOOO, micro VAX, and FACOM main frame computers.

Sengoku: I hope CRL will make efforts for the collocation experiment with VLBI and SLR to establish reference frame.

Kawaguchi: Are there any plan to commercialize Hydrogen maser? And I hdpe TDC will develop compact and stable oscillator which is also applicable to transportable VLBI station.

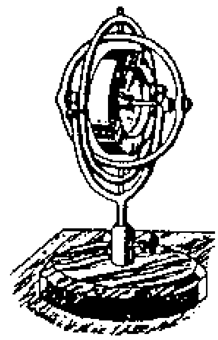
Nakayama: We can contribute to TDC with the integration of many technical aspects.

Attendees :

Risao Hayashi	CRL/Tokyo
Akira Sugiura	CRL/Tokyo
Fujinobu Takahashi	CRL/Tokyo
Taizoh Yoshino	CRL/Tokyo
Hiroo Kunimori	CRL/Tokyo
Kuniaki Uchida	CRL/Kashima
Michito Imae	CRL/Kashima
Tetsuro Kondo	CRL/Kashima
Yukio Takahashi	CRL/Kashima
Hitoshi Kiuchi	CRL/Kashima
Hiroshi Takaba	CRL/Kashima
Seiji Manabe	NAO/Mizusawa
Noriyuki Kawaguchi	NAO/Nobeyama
Yoshiro Nakabori	GSI
Arata Sengoku	JHD
Masaaki Murata	NAL
Masaki Ejiri	NIPR
Daishiro Okihara	SONY
Makoto Nakayama	NEC

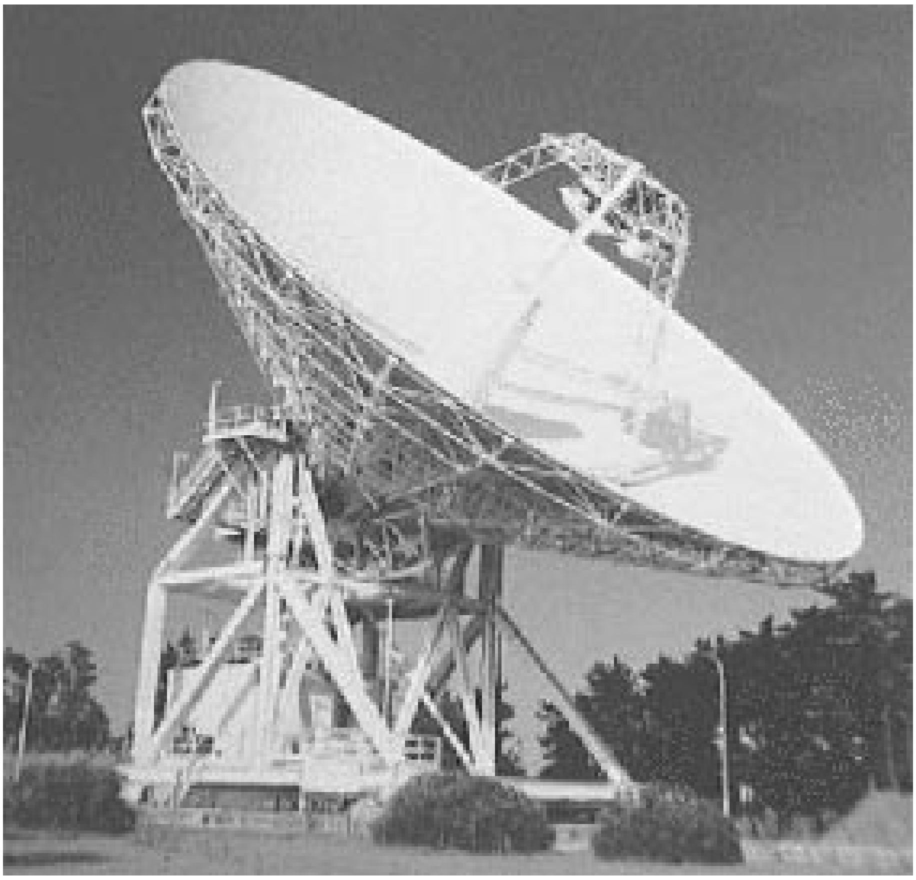
Abbreviation:

CRL:	Communications Research Laboratory
NAO:	National Astronomical Observatory
GSI:	Geographical Survey Institute
JHD:	Hydrographical Survey Department
NAL:	National Aerospace Laboratory
NIPR:	National Institute of Polar Research



Technical Topics

In every issue of the TDC News, topics of technical development is introduced by the researcher in TDC.



Status report of the system developing group

by
H. Kiuchi

The K-4 system

In the Very Long Baseline Interferometer (VLBI), the radio emission from a radio source several billion light years away is received by two stations and the distance between the two stations can be determined with an accuracy of 1-3 cm by measuring the slight difference in arrival times of the signals at the two stations. As the received radio wave is very weak, it is necessary to integrate a very large amount of data. Hence, it is necessary to record a large amount of observational data. A high-recording density high-speed large-capacity data recorder is therefore one of the most important parts of the VLBI system.

The K-4 VLBI system is being developed at CRL as the next-generation system. In this system a rotary-head cassette recorder (American National Standard 19 mm Type ID-1 Instrumentation Digital Cassette Format) is used to make the system smaller and easier to operate. The interfaces are designed to be compatible with that new recorder. Two interface units are used to obtain compatibility with other VLBI equipment: an input interface unit between the video converter and the recorder and an output interface unit between the recorder and the data processing system. We are making a more compact system with observational functions and data processing functions housed in separate units. The K-4 system consists of the following; (1) local oscillator. (2) video converter, (3) input interface unit, (4) output interface unit (5) data recorder.

The block diagrams are shown in Figs. 1 and 2. The local oscillator synthesizes the local frequency signal for the video converter. The video converter converts a window in the IF signal (lOO-500 MHz) input to a video signal (0-2 MHz). The frequency conversion is achieved by the image rejection mixer using single-sideband conversion. These functions are equivalent to the IF distributor, video converters (16ch) and reference distributor of the Mark-III or K-3 VLBI systems.

The input interface unit is used for data acquisition and recording at the VLBI observing station (Fig. 1). It samples the video signal from the video converter, and sends the digital data to the data recorder together with the time data which is derived from the external time standard signal.

The output interface unit is used at the correlation station (Fig. 2). It converts the reproduced data into the appropriate output format, and sends them to the correlator. The format of the output interface unit is compatible with the Mark-III format. Besides this format, another format is also provided for future correlator systems; this provides only digitized raw data signals. When multi-baseline correlation is processed, all the output interface units are daisy-chained through GPIB, so that the tape position data and status data of all the data recorders can be exchanged. The main (reference) output interface supplies the timing clock to sub-output interfaces. The delay bit between the main and sub-output interface units is calculated in each sub-output interface unit, using the time data which is periodically inserted into the recorded data.

It is possible to interface with current VLBI systems through the above-mentioned two interface units. Input and output interface units, when connected together directly, also perform a function equivalent to the formatter of the K-3 VLBI system.

Due to the development of technology, VLBI is now used for more varied purposes and its observing stations are not only fixed ones but mobile ones used in remote islands and in Antarctica

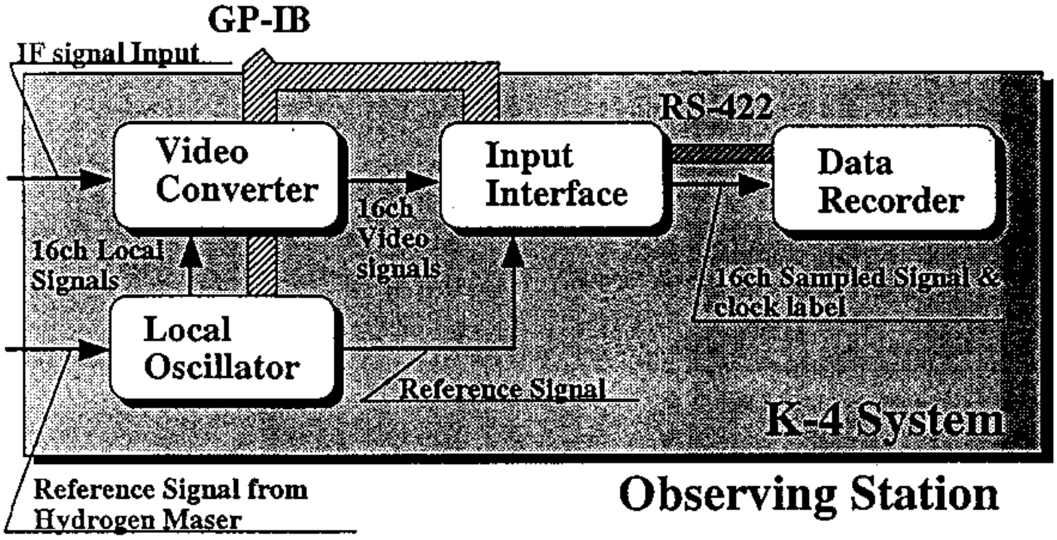


Figure 1. Observing station.

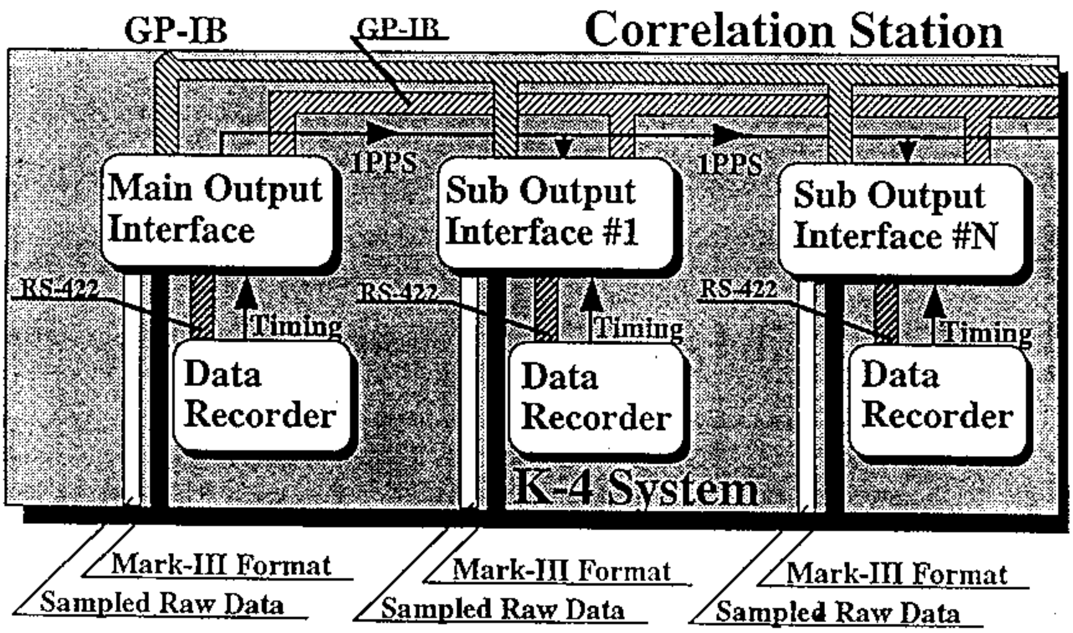


Figure 2. Correlation station.

Geodetic VLBI experiment at 22GHz band

Yukio TAKAHASHI

Current geodetic VLBI experiments are conducted in S/X band. Improvements of precision are desired in the geodetic VLBI. The geodetic VLBI in 22GHz is the one of the solution to this demand, because of following reasons;

(1) The observation bandwidth can be expanded easily. The precision of geodetic VLBI is inversely proportional to the bandwidth.

(2) Ionospheric delay in 22GHz band is smaller than one in X band. The ionospheric delay will be corrected using GPS equipment. All video channels are used for only 22GHz band, so SNR can be improved

(3) Tipping data of the same antenna will be obtained the water vapor data as WVR (Water Vapor Radiometer).

(4) The precision of delay rate becomes better since it is inversely proportional to the observation frequency.

The geodetic VLBI needs the phase calibration (PCAL) data for each channel in the observation band. CRL developed a new PCAL equipment in 22GHz band. At 16th February, the geodetic VLBI experiment in 22GHz band was conducted between the Institute of Radio Astronomy (Bologna, Italy) and CRL (Kashima, Japan). The purposes of the experiment are

(1) to check of the new PCAL equipment for 22GHz in the international geodetic VLBI experiments,

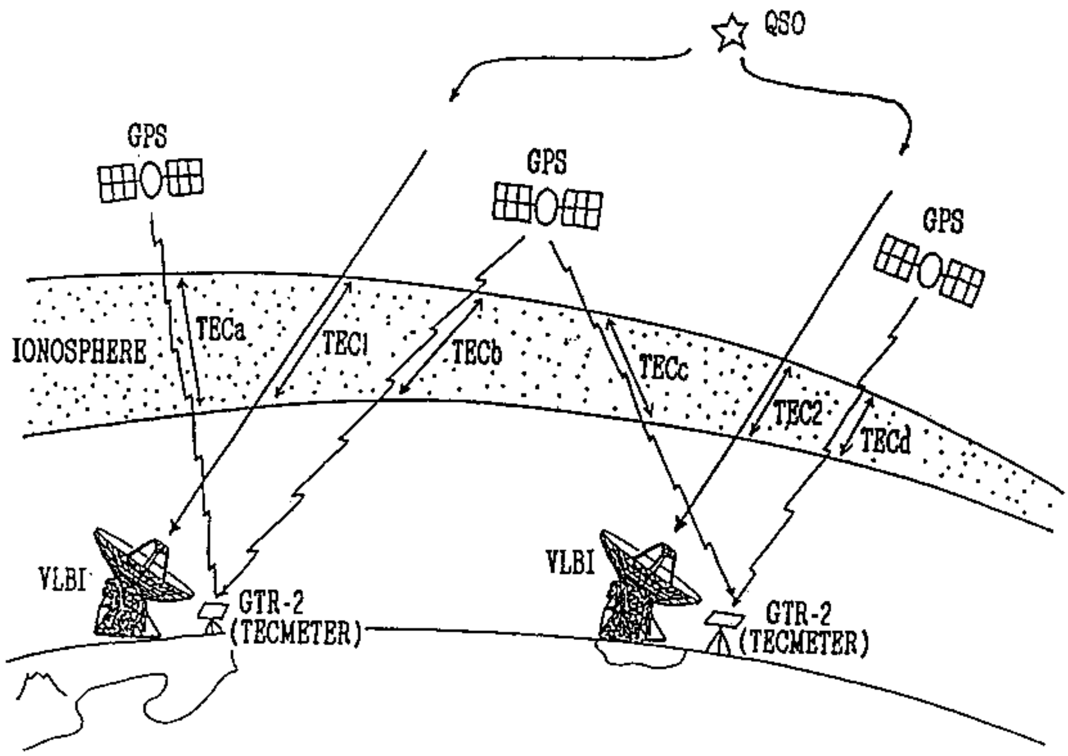
(2) to obtain the basic data of the radio sources and the baseline analysis.

In this experiment, 240 observations were conducted for 40 radio sources. We succeeded in the experiments, band width synthesis and baseline analysis. The r.m.s. values of delay and delay rate residuals were 183ps and 94fs/s respectively. The r.m.s. values were almost the same as the r.m.s. value in standard geodetic VLBI experiments in S/X band because we did not use wide band receiver this time and ionospheric delay corrections. The information of the sources in 22GHz band, such as the correlation flux and the resolution, were obtained on the long baseline (8000km). The relation between the distance (z) and the correlation flux density. The new method to estimate the coherence loss by the atmospheric scintillation is proposed. The data will be useful for the future geodetic VLBI experiments in 22GHz band.

Precise Ionospheric Delay Corrections by GPS for VLBI Geodetic Measurements Made at a Single Frequency Band

by Tetsuro KONDO

In VLBI geodetic measurements excess delays caused by the charged particles existing along the ray paths from a radio star to each antenna, mainly due to the difference in the terrestrial ionospheric total electron content (TEC) along each ray path, are corrected by receiving dual S(2GHz) and X(8GHz) frequency bands. This dual band receiving system, however, makes it difficult to employ a small antenna (less than 3 m in diameter) for a VLBI remote station in spite of the merits of small antennas such as low cost of construction and ease of transportation. On the other hand the GPS signal measurement provides an independent measurement of the TEC applicable for calibration of the excess delays in case of VLBI measurements made at a single frequency band. Consequently the antenna size can be diminished. The directions of GPS satellites from a station are, however, usually different from those of radio stars observed by VLBI. Hence the TEC obtained by GPS measurements have to be mapped to any other directions. S ome models have been proposed as mapping methods on the basis of assumption of the spherical-shell-like and static ionosphere. Simultaneous observations of dual-band VLBI and of GPS enable us to evaluate models, i.e., we can assess validity of each mapping model through a direct comparison of TECs (or excess delay time at same frequency) obtained by both observations. We have already made this kind of observations several times. According to a preliminary result, some mapping model shows coincidence between VLBI and GPS measurements less than 0.18 nsec at 8 GHz. Now mapping method is being refined to accomplish much better coincidence (<0.1 nsec : requirement from a geodetic VLBI).



The evolutlon of water maser spectra in M type stars

Hiroshi Takaba, Radio Astronomy Group

A portable acousto-optical spectrometer (AOS) became available at Kashima. The AOS uses an optical diode laser and had been developed in Nobeyama Radio Observatory (Miyaji 1991). The frequency resolution and the total band width are 40 KHz and 40 MHz, respectively. The AOS is used to check the pointing at the VLBI observation time of maser sources. A new automatic maser survey software was developed by the author and a snapshot 22 GHz H_20 and 43 GHz SiO (J=1-0,v=1) maser survey was made between 1991 April 26 and May 11 using the AOS and with 34 m radio telescope at Kashima. About 200 stars were selected from the catalog of stellar masers by Benson et al. (1990) and about 160 late type stars were observed almost simultaneously with both two maser transitions.

By comparing those spectra, a systematic change of H_20 maser spectra was found in M type stars. In figures' 1-3, H_20 and SiO (J=1-0,v=1) maser spectra toward three stars (a visible Mira variable R LMI, a near infrared source IRC+60169, and a far infrared source OH12.8-1.9) are shown. Double peaked H_20 emissions are seen in IRC/AFGL objects and OH/IR stars and as shown in figure 4, the expansion velocity of the H_20 maser is found to be correlated with the *IRAS* color temperature derived from 12 μm and 25 μm intensities.

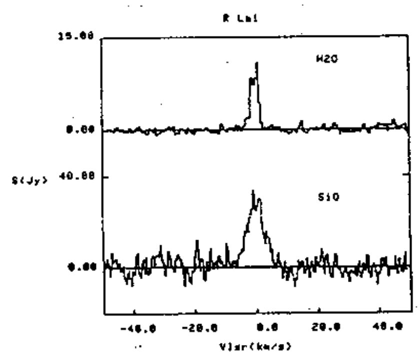


Fig.1

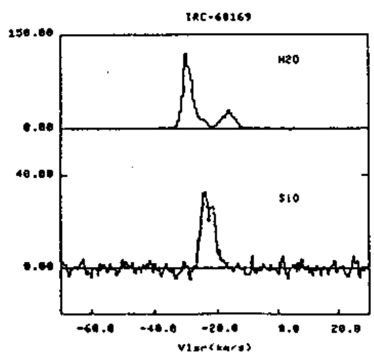


Fig.2

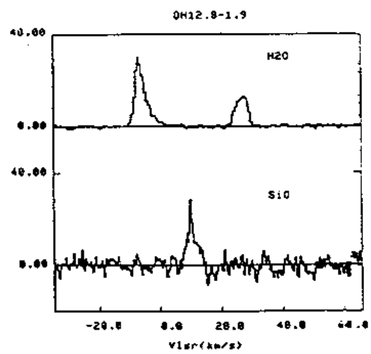


Fig.3

H_20 (Top) and SiO (Bottom) maser spectra of R LMI (Fig. 1), IRC+60169(Fig. 2) and OH12.8-1.9(Fig.3)

The oxygen-rich M type stars are thought to evolve in the sequence of Mira variable, IRC/AFGL objects, and OH/IR stars. In this evolutionary sequence, the mass-loss rate increases and the *IRAS* two colors (12μm and 25μm) becomes cooler (e.g., Van der Veen 1989, Bowen and Willson 1991). Therefore our result shows that the H_2O maser emitting regions are expanding from the star with the evolution of the central star. Since Cooke and Elitzur (1985) calculated that the location of 22 GHz H_20 maser emitting region moves out with the mass-loss rate increase based on the collisional excitation model, our observational result is simply explained by the collisional excitation model. Thus we can say our observation is a strong evidence of the collisional excitation of 22 GHz H_20 maser in late-type stars.

We are planning VLBI observations with KNIFE (Kashima Nobeyama Interferometer) for more detailed study of stellar masers in this and early next year.

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Cooke, B. and Elitzur, M., 1985, Ap.J., 295. 175.

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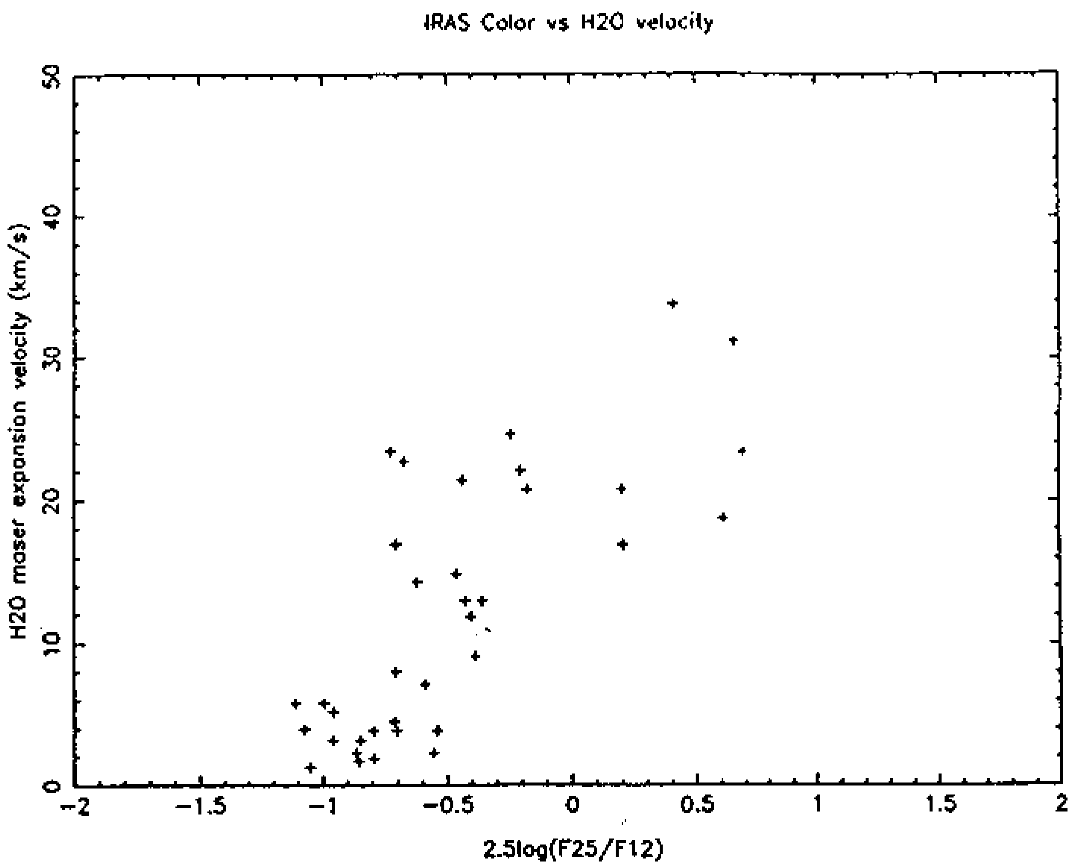

Figure 4. Plot of the H_2O maser velocity width (half intensity width for single peaked sources and differences between two peaks for double peaked sources) versus the IRAS two color ratios.

Determination of global position at Tokyo SLR station

Hiroo Kunimori

Satellite measurement group composed of members in frequency and time measurements section, CRL, have been developing satellite laser ranging (SLR), GPS time receiver and two-way INTELSAT time transfer techniques. With regard to the development of VLBI, we would offer evaluation measures of accuracy in geodetic and time comparison results. We would also contribute the construction of IERS reference frame by their collocation with VLBI.

In January 1990, CRL's new satellite laser ranging (SLR) facility with a 1.5m diameter telescope at Tokyo has started the observations to the major laser satellites. It participated in intensive tracking campaign for Russian satellite, ETALONs, during a period from September to November in 1990. From this campaign, global position of Tokyo SLR station is determined with the precision of several centimeters. The difference of coordinates between SLR and VLBI at Tokyo SLR station are less than 10 cm. Fig.1 shows positions of Tokyo SLR station (CRLLAS) and Kashima VLBI station. Fig.2 presents the estimated precision for each stations during ETALON campaign.

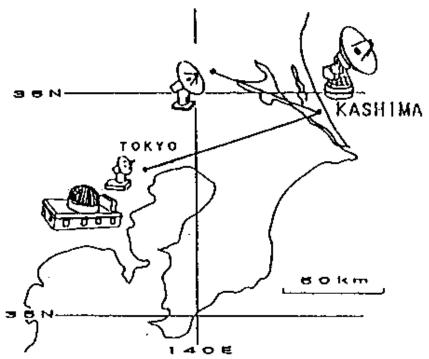

Figure 1. Position of Tokyo SLR and Kashima VLBI station.

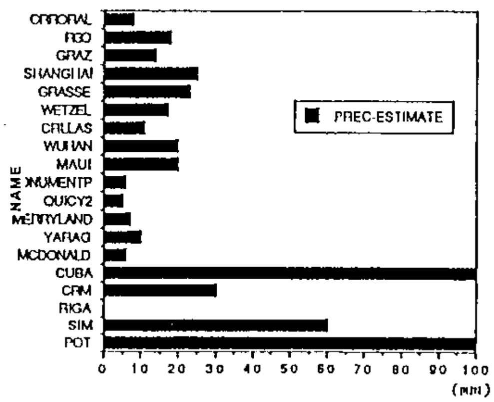

Figure 2. Precision estimated from ETALON1 5 min normal points for each station during ETALON Campaign Sep-Nov,1990.

IRIS President from CRL

During the XXth IUGG Conference in Vienna (August, 1991), the IRIS steering committee was held. It is decided to propose to CSTG that Dr. Taizoh Yoshino of CRL follows Prof. James Campbell as the president of subcommission IRIS for the next four year term.

The TDC News is published biannually. To begin or discontinue the receipt of the TDC News, please send a message to the following address. Comments, questions and/or suggestions can be also sent to the following address.


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Taizoh Yoshino
IERS VLBI Technical Development Center
Communications Research Laboratory

Nukui-kitamachi 4-2-1
Koganei, 184 Tokyo
JAPAN

(FAX) +81-423-21-9899
(MarkIII) CRL
(Internet) yosh@frex.cc.crl.go.jp
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COMMUNICATIONS RESEARCH LABORATORY