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研究简讯

上海天文台氢脉泽在澳大利亚帕凯斯天文台试验

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1993 年 11 月 4 日 —12 月 15 日，上海天文台氢脉泽安装在澳大利亚帕凯斯天文台。本文给出在此期间这台氢脉泽的试验结果。这次试验的主要目的是测定这台氢脉泽作为 VLBI 频率标准的性能。

Shanghai Maser Tests at Parkes

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A Shanghai Observatory hydrogen maser was installed at the Parkes Observatory from 4 November to 15 December 1993. This report presents the results of tests performed on the maser during this period. The tests were mainly aimed at determining the performance of the maser as a VLBI frequency standard.

The Shanghai maser was installed in the " maser hut ", alongside the observatory frequency standard, a Smithsonian hydrogen maser type VLG -10-1. The maser hut is a small building located approximately 70M to the north of the 64M radiotelescope. It has its own air-conditioning system which is designed to maintain a constant ambient temperature for the maser, to within a few tenths of a degree C.

There were two types of tests performed. The short to medium term stability (1 sec. to around 1000 sec.) was measured by comparing two 800MHz signals, one locked to the Parkes (Smithsonian) maser and the other locked to the Shanghai maser. The long term stability was measured by including the 1Hz signal from the Shanghai maser in the standard Parkes time calibration system. This allowed comparison with 1Hz signals from the Parkes maser, GPS and the Tidbinbilla maser, whose 1Hz signal is transferred to Parkes via a microwave link.

Installation–Reliability

The maser was installed by Mr Lin and Mr He from Shanghai, assisted by Harry Fagg. It was operating within 48 hours of arriving at Parkes. There were some intitial problems with the air-conditioning of the maser hut, particularly during a spell of very hot weather, where the temperature within the hut rose well above the normal operating point of 25C to above 30C. At this point the Shanghai maser failed while the Parkes maser continued operating. Mr Lin thought this was probably due to a problem with the gas flow level. He stated that flow adjustment was made for a particular ambient temperature and a subsequent large change in temperature could lead to failure in the gas flow of the type encountered. Following maintenance on the air-conditioning, the ambient temperature was brought under much closer control and thereafter the maser operated normally.

Short to medium term stability measurements

The comparison was made at 800MHz. The 100MHz reference signal from the Shanghai maser was fed to a frequency multiplier and thence through an 800MHz bandpass filter (5% bandwidth) and amplifier. The 5MHz reference from the Parkes maser was used to synchronise an HP8663A synthesiser which was set to 800MHz. The two 800 MHz signals were fed to a HP8405A vector voltmeter whose phase output was logged via a digital voltmeter connected via IEEE-488 bus with a PC. The integration time of the voltmeter was set to 0.8 seconds.

A typical data set is shown in figure 1. In this case a phase measurement was taken every 1 second for 50 minutes. The top diagram shows the measured phase against elapsed time, while the bottom diagram shows the Allan variance computed from these data. The crosses on the Allan variance plot have been derived from the published Shanghai maser datasheets and show the performance one might expect from comparing two " nominal " Shanghai masers.

Figure 2 shows a dataset where a phase measurement was made every 10 seconds for over two hours.

As a test of the measurement system, the 100MHz signal from the Shanghai maser was replaced by a 100MHz signal from a Rhode & Shwarz synthesiser which was synchronised to the Parkes maser. The results of 1 second samples taken over 50 minutes are shown in figure 3 and demonstrate that significant phase noise is added by the R&S synthesiser.

Figure 4 shows an estimation of the amount of coherence loss due to instrumental phase noise-not including the atmosphere-that one might expect in a VLBI experiment which used the two masers as frequency standards. The observing frequency was assumed to be 40GHz and an integration time of 50 seconds was chosen. The loss of coherence at the beginning and end of the 16 hour dataset is probably an indication of the inadequacy of the linear clock model which was subtracted from the data.

Long term stability measurements

The standard Parkes time calibration system uses a time interval counter to compare 1 Hz signals from various sources. The Shanghai maser was included as one of the sources and the results are shown in figure 5. The time interval between the Parkes and Shanghai 1Hz signals is plotted against time over a period of 12 days.

Conclusion

The short term stability measurements have shown that the Shanghai maser would be a very good VLBI frequency standard. Taking into account the nature of the test setup and the short period over which the measurements were made, and considering the time required for the maser to settle after turn-on, little can be concluded on the long term stability. It would however appear to be adequate for VLBI use. The maser would seem to require a closely controlled temperature environment.

Acknowledgements

We are grateful to Mr Lin and Mr He from the Shanghai Observatory for their efforts in installing and maintaining the maser during its time at Parkes. Thanks also to Harry Fagg for looking after all aspects of the tests at Parkes.

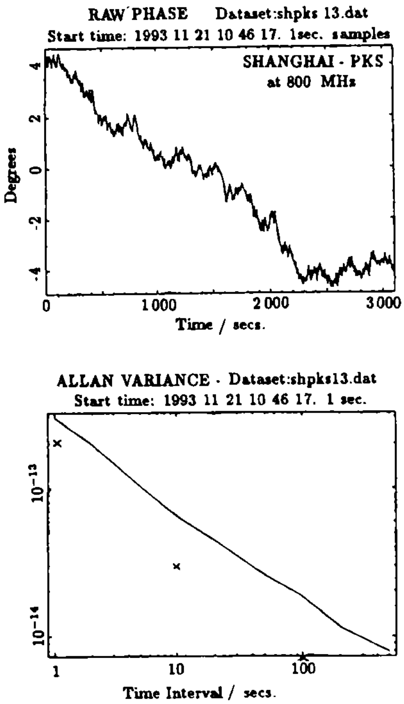

Fig.1

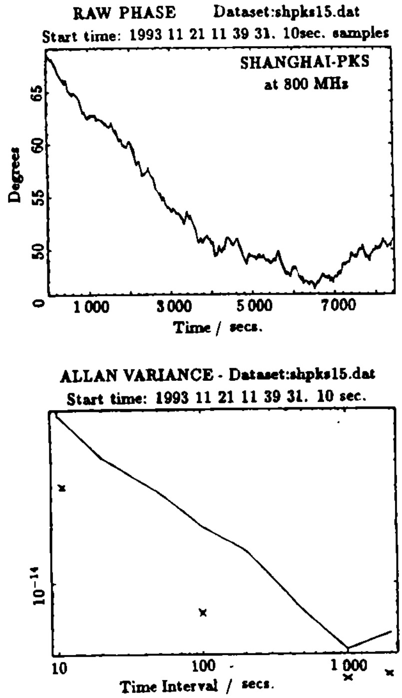

Fig.2

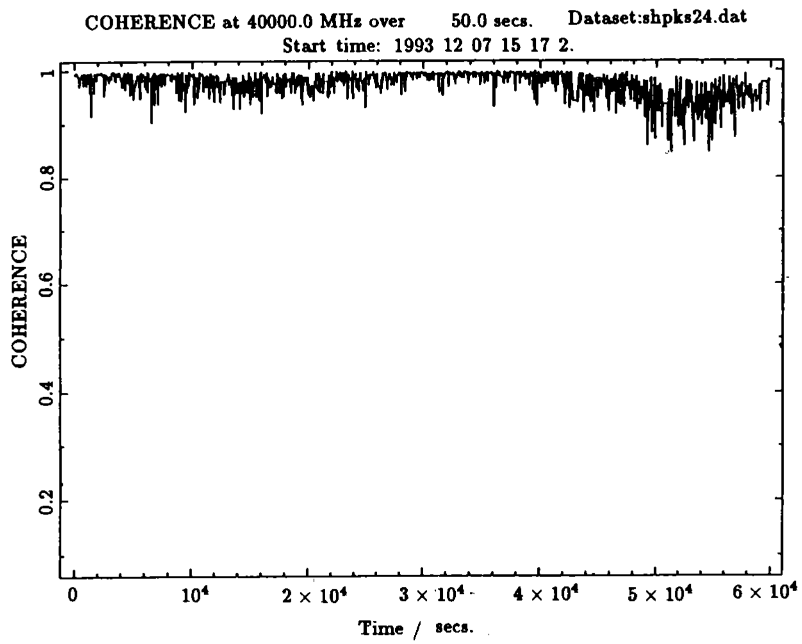

Fig.4

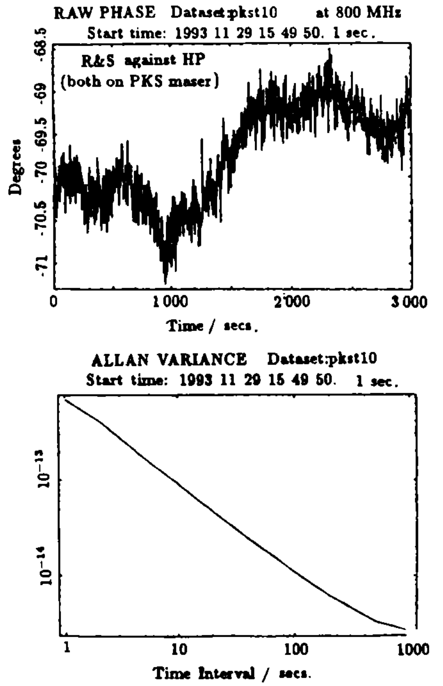
RAW PHASE Dataset:pkst10 at 800 MHz
Start time: 1993 11 29 15 49 50. 1 sec.
R&S against HP
(both on PKS maser)
Degrees
-68.5
-69
-69.5
-70
-70.5
-71
0
1000
2000
3000
Time / secs.
ALLAN VARIANCE Dataset:pkst10
Start time: 1993 11 29 15 49 50. 1 sec.
10^{-13}
10^{-14}
1
10
100
1000
Time Interval / secs.

Fig.3

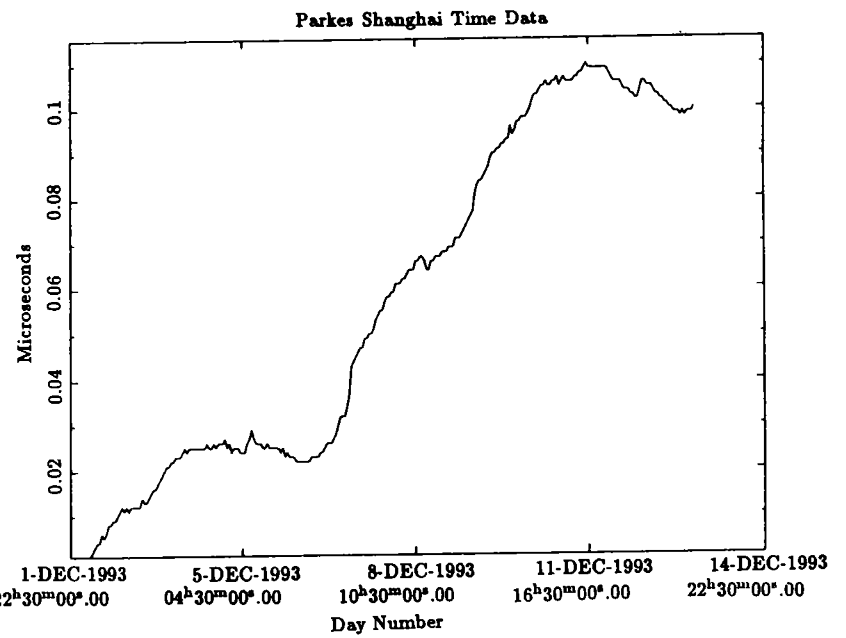
Parkes Shanghai Time Data
Microseconds
0.1
0.08
0.06
0.04
0.02
1-DEC-1993 22h30m00s.00
5-DEC-1993 04h30m00s.00
8-DEC-1993 10h30m00s.00
11-DEC-1993 16h30m00s.00
14-DEC-1993 22h30m00s.00
Day Number

Fig.5