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Research on the Frequency Steering Strategy of a Hydrogen Maser† ⋆

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Abstract In the master clock system, the local standard time UTC(k) with a better short-term stability will be generated, if the hydrogen maser is set as a frequency source of the master clock. But the hydrogen maser always exhibits an apparent frequency drift, thus its long-term stability gets poor with the time, therefore the stability and accuracy of UTC(k) become worse. To solve this problem, the performance of hydrogen maser is compared with cesium clocks, and the time scale algorithm is modified when the hydrogen maser is involved, a new steering strategy is proposed when a hydrogen maser is used as the frequency source of the master clock. An experimental system is set up with the programs compiled, and finally the new steering strategy is testified with the laboratory data. The results show that when the hydrogen maser is involved in the atomic time scale calculation, the short-term frequency stability of the reference time scale will be improved. Meanwhile, the local time UTC(k) has a better short-term frequency stability when the frequency source of the master clock uses a hydrogen maser instead of a cesium clock.

Key words astrometry—time—hydrogen maser—time keeping—methods: data analysis

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1. INTRODUCTION

The time conservation system of the National Time Service Center (NTSC) of Chinese Academy of Sciences is composed of hydrogen and cesium atomic frequency standards (32 HP5071A cesium atomic clocks and 6 hydrogen masers of active type), and keeps in contact with the international standard time UTC through the co-visual comparison (GNSS CV) of the Global Navigation Satellite System (GNSS), the GNSS precise single point positioning (GNSS PPP), and the two-way satellite time and frequency comparison (TWSTFT), so as to track down the international origin, and to make a contribution to the time conservation of the International Atomic Time (TAI).

For a long time, in the time conservation work of the basic laboratory of the National Time Service Center, cesium clocks play all along an important role, while hydrogen masers associate themselves rather little with this work, due to the influence of their frequency drift. How to bring the speciality of hydrogen masers into full play is a difficulty in the time conservation work.

To take a panoramic view of the weight assignment of atomic clocks in the time laboratories all over the world[1], before 2014, the total weight of cesium clocks with which TAI is calculated was very high, constituting about 85%, while that of hydrogen masers with which TAI is calculated was too low in proportion, only about 10%. After 2014, in order to give ample scope to the strong point of a hydrogen maser, the Bureau International des Poids et des Mesures (BIPM) altered the computational method of weight[2], to reduce the total weight of cesium clocks with which TAI is calculated from the original 85% to 50%, and to raise the total weight of hydrogen clocks from 10% to 50%, so as to change the situation where the weight of cesium clock is too high, and to enhance the status of hydrogen maser in the calculation of TAI. It means that to the hydrogen masers in the time laboratories of the world more and more importance is attached. Meanwhile, according to the analysis of the BIPM annual reports in recent successive years [1,3−4], the common trait of the disposition of clock groups in the time laboratories which keep rather high precision is: the quantity of atomic clocks increases continuously, in particular, that of hydrogen masers raises rapidly, and the frequency sources of master clocks are changed from cesium clocks into hydrogen clocks in overwhelming majority of laboratories. These facts are enough to prove the importance of hydrogen maser.

In our country, the technique of hydrogen maser is developed with each passing day, and the precision of hydrogen maser raises ceaselessly, the quantity increases year by year. Hence, it is of great importance for improving the stability of time scale and keeping the high accuracy of local standard time UTC(k) to bring the strong point of hydrogen maser to the maximum.

In order to enhance the precision and stability of the local standard time UTC(k), this paper has analyzed and compared the performance of hydrogen masers with that of cesium clocks, improved the algorithm of the time scale in which hydrogen masers are involved, and