Research on atomic time algorithm of Cs fountain NTSC-F2

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The 'Paper time scale' calculated by multiple atomic clocks is an important reference for the generation of high-precision time signals, so improving the performance of the time scale is of great significance for timing system. Cesium fountain NTSC-F2 developed by NTSC has high accuracy. Commercial hydrogen clocks have good short-term frequency stability. The atomic time algorithm of Cs fountain NTSC-F2 is studied and the short stability advantage of hydrogen clocks are combined to improve the atomic time performance. The Vondrak-Cepek method is a combined smoothing algorithm that uses two independent data sequences to obtain the advantages of both. Based on Vondrak-Cepek method, the joint time scale of the NTSC-F2 and the hydrogen masers is proposed in this paper. Firstly, hydrogen masers time scale and NTSC-F2 are respectively calculated. Then, the joint time scale based on the NTSC-F2 and the masers time scale is calculated by the Vondrak-Cepek algorithm. The results show that the short-term stability of the joint time scale is better than that of the cesium fountain, Allan deviation of the joint time scale is 5.3E-15 at 3600s, which is 28% higher than that of the cesium fountain. Meanwhile, the long-term stability of the joint time scale is better than that of masers time scale, Allan deviation of the joint time scale is1.28E-15 at 10 days, which is 69% higher than that of the masers time scale. The root mean square error of joint time scale is 0.29ns, which is 86% higher than that of the masers time scale, and 12% higher than that of the cesium fountain.

The international time reference Coordinated Universal Time (UTC) is the most stable time scale. But UTC is only available with a latency that can reach 40 days. For the safety of the time application, the independent, stable and accurate local time scale play an important role in generating a physical signal, available in real time.

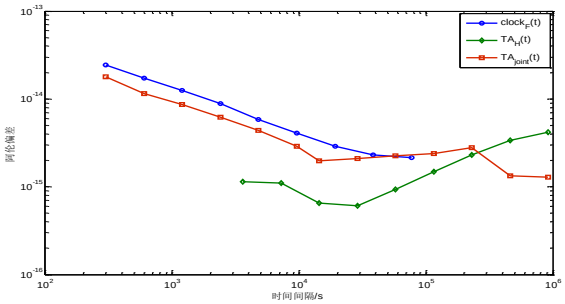

Fig. 1: The frequency instability of different time scales.

The cesium fountain serves as a primary frequency reference for reproducing the definition of "second", and it almost has no drift, so it has good long-term stability. Commercial hydrogen masers have good short-term stability, and it can operate continuously. Therefore, combining the advantages of NTSC-F2 and hydrogen masers, a joint time scale can be generated.

Vondrak-Cepek is a more general method of smoothing in which the estimation is done from two available independent series. Both series are combined to yield two smooth curves tied by the constraints assuring that he latter is the time derivative of the former. The first one curves fits well to the first series and the second one fits well to the second series. The goal is to make use of advantages of both series (Such as, long-term stability of the former and short-term stability of the latter) in one solution.

Firstly, the masers time scale was calculated with the ALGOS algorithm. Then the Vondrak-Cepek smoothing algorithm was used in combining the NTSC-F2 and the hydrogen clock time scale. On the one hand, the fidelity of the joint time scale is close to the cesium fountain NTSC-F2, and on the other hand, the smoothness is close to the hydrogen time scale. Therefore the stability of the joint time scale was improved. The results are shown in the figure 1.