MAINTAINING HIGHLY ACCURATE GLOBAL SYNTONIZATION USING THE HYDROGEN LINE

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ABSTRACT

The NASA-JPL Deep Space Network (DSN) supports spacecraft navigation requirements through the use of ensembles of atomic frequency standards located in Australia, California, and Spain. The syntonization of these widely separated reference frequency standards is maintained over long periods, >6 months, through use of a technique that exploits the phenomena that: the magnitude of the offset of the output frequency of a particular hydrogen maser (H2M) from the hydrogen line is constant throughout the life of the H2M.

The magnitude of an H2M's frequency offset (F_o) from the hydrogen line is a function of ΔF_m, ΔF_r, ΔF_t, ΔF_w, where m is the ambient magnetic field in the bulb, r is cavity mistuning, t is thermal motion of hydrogen atoms in the bulb and w is wall collision caused shifts. Of these four, ΔF_r is the major contributor to drift of the output frequency. Subsequent to a careful cavity tuning operation any residual frequency offset is due to the other three error sources (ΔF_m, ΔF_t and ΔF_w). This residual F_o is largely a function of the manufacturer's design and the maser's geographic orientation. Thus this residual F_o, for a particular H2M at a fixed location, will be constant throughout the life of the H2M.

In August-September 1980 the F_o of three Smithsonian Institution Astrophysical Observatory (SAO) model VLG-10B hydrogen masers at widely separate locations were measured against a "calibrated" model 5061A cesium beam frequency standard. In April-May 1981 after the three H2M's were returned to the hydrogen line, the F_o values returned to within $<+ 4 \times 10^{-15}$ of the original "calibrated" values. Since the "calibrated" 5061A was calibrated against UTC (NBS), then the syntonization between H2M's and to UTC (NBS) was maintained within a few parts in 10^{13th} over a period of >8 1/2 months. More accurate syntonization may be obtained if the retuning is performed more frequently.

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QUESTIONS AND ANSWERS

QUESTION FROM THE AUDIENCE:

I have a question. What is the reference standard for tuning the maser, particularly in Spain and Australia, and what's the procedure of tuning the maser?

MR. WARD:

Your first question first. The reference standard we use was 5061A, option 4, Hewlett-Packard cesium.

And the second question. In tuning the maser, you measure the Zeeman frequency, then using an independent reference such as a quiet cesium, but preferably a good specially prepared rubidium, such as the 5065, and you use that to tune the cavity over the hydrogen line.

QUESTION FROM THE AUDIENCE:

Yes. What is the standard time for tuning the maser?

MR. WARD:

It is a function of how quiet your source is. If you used another maser, you can do it in a few hours. If you use a rubidium, it perhaps will take you a day. If it's cesium, as we in many cases have to use, it may take five days.

QUESTION FROM THE AUDIENCE:

Okay. Another question. Did you change the orientation of the maser, and how much does the frequency offset change? Because I was wondering even if you didn't change the position of the maser, but the surrounding magnetic would change for some reason?

MR. WARD:

Well, first we have excellent shielding. And we try to put them in magnetically stable environment second, and the results show that nothing has happened in the magnetic domain or we couldn't get those numbers that you just saw.