a Frequency-temperature Compensated Sapphire Loaded Cavity for Satellite Hydrogen Maser

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To obtain frequency-temperature compensation in a sapphire loaded cavity for hydrogen maser, Dielectrics named $SrTiO_3$ and rutile are adopted whose temperature coefficient of permittivity are opposite to that of sapphire. Based on theoretical analysis and computer simulation, TE_{011} mode of a sapphire loaded cavity associated with two small rings of $SrTiO_3$/rutile with different thickness is solved, and useful parameters that influence temperature coefficient of cavity are calculated. Finally an experiment is brought forward and its results are very close to computing results. When the height of rutile ring is 5 mm,the temperature coefficient of cavity frequency is decreased from -58.8 kHz/K to 28.99kHz/ ℃ ,and the quality facotor is 41648.When the thickness of $SiTiO_3$ dielectric is 7 mm and the diameter is 17 mm in configuration b, the temperature coefficient of cavity is decreased from - 58.8 kHz/K to - 8.2 kHz/K and the quality factor is 40248.

Fig.1 the picture of frequency-temperature compensated sapphire loaded cavity

In experiment, we get a cavity frequency in a temperature point, then we change it and we will get another cavity frequency, so we can calculate the frequency change in one degree. The numerical value is the frequency temperature coefficient of the cavity. In fact, when we change temperature point, it needs about 6 hours to reach temperature balance. To keep precision, we experiment several times in each temperature point. Due to slowly changing and long-time stabilizing of temperature, the experimental period must last over one month.

In this paper, we will also report the latest experiment results of hydrogen maser with frequency-temperature compensated sapphire loaded cavity, The compact hydrogen maser has a total volume of 80L and fractional frequency stabilities of about 10^{-16} over internals of 10^{-3} to 10^{-6}s.