ACCURACY EVALUATION AND STABILITY OF THE NBS PRIMARY FREQUENCY STANDARDS

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The NBS primary frequency standards NBS-4 and NBS-5, both cesium beam devices, will be described. The NBS-4 beam tube (1.5 meter long) has an interaction length of about 50 cm, and a transition linewidth of about 130 Hz. NBS-4 was designed and constructed jointly by the Hewlett-Packard Co. and NBS as a device which would demonstrate high stability and reliability with some special experimental features.

NBS-5, also designed for high stability, is intended to reach an accuracy goal of 1×10^{-13}. The NBS-5 beam tube (6 meters long) has an interaction length of about 3.7 m, and a transition linewidth of 30 Hz.

Accuracy evaluations to date have been completed which yield accuracies for NBS-5 of 2×10^{-13}. New accuracy evaluations of NBS-5 (with NBS-4 as a reference) and of NBS-4 (with NBS-5 as a reference) will be described and results given. Special features of accuracy evaluations, i.e., comparisons of the pulse and power shift method with the beam reversal method for evaluation of the cavity phase shift will be discussed. Both the pulse method and analysis of the Ramsey pattern have been used for determination of the velocity distribution of the operating beam. A comparison of these two methods will be discussed. The derivation, from these data, of the second-order Doppler shift will be discussed.

Discussion of important aspects of the electronics systems will be described with special attention given to phase-noise levels and the resultant system frequency stability.

Frequency stability measurements have been made by comparisons of NBS-4 and NBS-5. From those measurements the stability, $\sigma_y(\tau)$ has been determined for one standard (assuming equal contributions from each one) to be about 2×10^{-14} for $\tau = 2$ hours. These data are shown in Fig. 1.

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FIG. 1 FREQUENCY STABILITY, $\sigma_y(\tau)$, FOR THE COMPARISON OF NBS-4 AND NBS-5. ASSUMING EQUAL NOISE CONTRIBUTIONS FROM EACH STANDARD, THE STABILITY FOR EITHER ONE WOULD BE GIVEN APPROXIMATELY BY THE DASHED LINE.