HYDROGEN MASER CLOCKS AND DEEP SPACE SYSTEMS INVOLVING CLOCKS:
Ultra-Long Baseline Interferometry Definition of an Inertial Frame, Searches for Pulsed Gravitational Radiation

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The present status of research and development in atomic hydrogen maser clocks gives stability of 3×10^{-16} in $\Delta f/f$ for intervals of several hours. Long-term drift rates are in the order of 1×10^{-15}/day and uninterrupted operating lifetimes of more than 4 years are fairly common with SAO's VLG-series masers. Experiments with improved techniques for separating atoms in the desired state confirm that stability can be achieved with existing technology at levels below 1×10^{-16}. A four-fold improvement beyond this level appears feasible with more smoothly applied storage volume coatings of fluorinated materials. A recent breakthrough in technology has been made by SAO/Harvard, M.I.T. and, University of British Columbia, by operating hydrogen masers at 0.4K using storage coatings of superfluid liquid helium. This promises stability better than 1×10^{-17} in $\Delta f/f$ for intervals longer than 30 seconds. Features of a hydrogen maser operating at room temperature, developed at SAO for long-term ($\sim$7 years) unattended operation in space, are described. Possible applications of such masers with stability $\sim1\times10^{-16}$ for intervals 10^4-10^5 seconds in a deep space network of 4 (or more) radio astronomy antennas interconnected by time correlated one-way and two-way Doppler systems are discussed. By comparing the phase of signals propagated in both senses around the four (or more) closed triangular paths, changes in the magnitude and direction of the baselines can be determined with reference to inertial space defined by the constancy and isotropy of the velocity of light. The system is also sensitive to pulsed gravitational radiation at wavelengths less than the inter-terminal distances. Sensitivity is limited by the stability of the clocks and the fluctuations of ionization in the paths between stations. Multiple station time correlation of Doppler fluctuation in the signals between the six (or more) inter-terminal paths can be used to determine the direction and polarization of the pulsed gravitational radiation.

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