with the others even during wall collisions. However there is a small disturbing effect, "the wall shift" which shifts the frequency from its unperturbed value. In addition, if the cavity is not tuned exactly to resonance, the maser frequency will be shifted a small amount. The maser frequency also depends on the magnetic field in which the atoms radiate, as well as on the atomic velocities. However, although all these effects can cause hydrogen masers to oscillate at slightly different frequencies, each maser once set up, will continue to oscillate extremely stably at its own frequency.

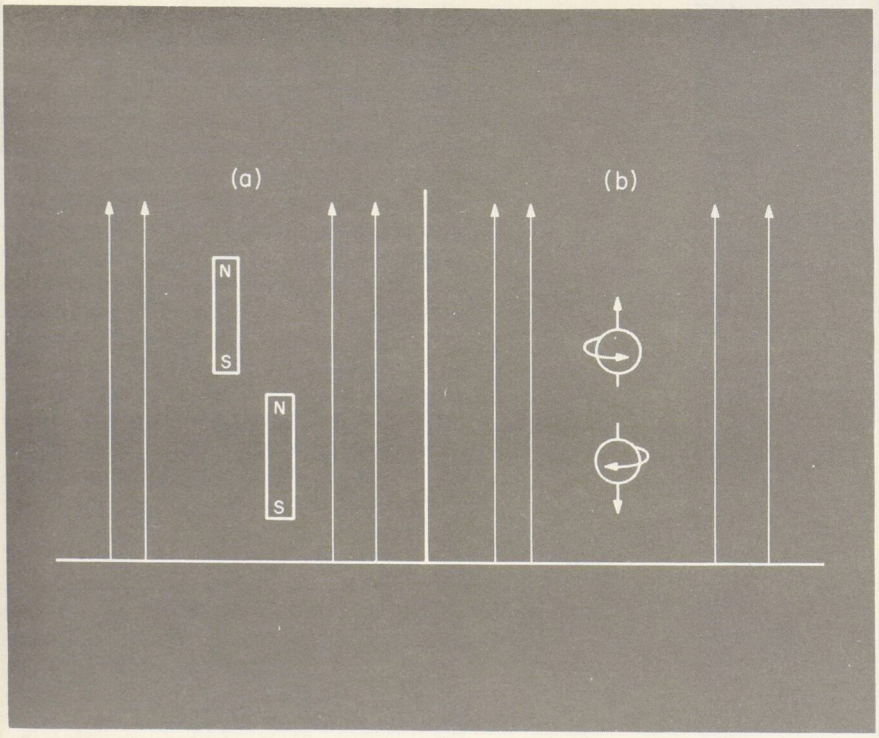
The two NRC hydrogen masers agree with each other to within two parts in 10^{12} (a million million). This performance approaches that observed for the best caesium beam frequency standards, which currently agree to about one part in 10^{13} (ten million million) over a period of several months.

Hydrogen masers possess certain extremely valuable characteristics, which make them as useful as the caesium standards, but for quite different reasons. Although each maser may oscillate at a slightly different frequency, this frequency remains more constant than that from any other known source including the caesium beam clock. Because of this unequalled stability, the hydrogen maser has proven invaluable for assessing the performance and the basic errors characteristic of the caesium standards. The two NRC masers have resulted in an improvement of the NRC caesium clock by almost an order of magnitude.

It is possible that work now underway at NRC and other laboratories may improve the predictability of the wall shift so that the present frequency uncertainties may be essentially eliminated. In such a case the hydrogen maser could well supplant the cesium beam as the primary international standard of physical time.

In other areas of scientific work, hydrogen masers are currently being used in radio astronomy to determine the diameters of 'quasars' (star-like bodies, capable of radiating disproportionately large amounts of energy); a further knowledge of these may materially affect our concepts of cosmology. A somewhat similar experiment may also be applied to determining continental drift. A third application concerns the use of hydrogen masers in satellites in order to verify experimentally some of the predictions of Einstein's theories of relativity.

Although NRC's masers may not participate directly in such experiments, the work done contributes to the general pool of scientific knowledge which makes such fascinating experiments possible.



Mainspring of the caesium clock and hydrogen maser: unlike ordinary magnets (a) always aligned in a magnetic field, electrons, which can act like tiny magnets, can set themselves either with or against a strong magnetic field (b) and a change from one state to the other occurs with the absorption of emission of microwave energy possessing an extremely precise frequency.

Cheville ouvrière de l'horloge à jet de césium et du maser à hydrogène: contrairement aux aimants ordinaires (a) qui s'alignent tous suivant un fort champ magnétique, les électrons, véritables petits aimants, s'alignent tantôt selon la direction du champ magnétique, tantôt en sens inverse (b). Chaque changement de l'état magnétique de l'électron entraîne l'absorption ou l'émission d'énergie (en microondes) de fréquence extrêmement précise.