Attempts at Obtaining Excitation of an Atomic Beam of Monatomic Hydrogen

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ABOUT ten years ago, in an endeavor to observe differences in excitation phenomena, a push-pull, oscillating tube circuit was constructed to give approximately 100 watts at λ5.2 meters. When this oscillator was connected to a highly exhausted Pyrex tube (200×4 cm) containing a trace of mercury, extremely well-defined sinusoidal standing waves were obtained of half-wave-lengths from roughly 3 cm and upwards. The wave-length could not be varied continuously, but apparently changed according to the pressure in the tube and the degree of coupling with the oscillator, the longer wave-lengths being given with higher pressure and closer coupling. Later it was discovered that the oscillator was acting as a multivibrator because a defective grid leak caused it to operate on a curved portion of the voltage characteristic curve.

The experiment showed, however, that long mercury discharge tubes could be excited with pressures of the order of 10^{-6} mm, provided the frequency was sufficiently high.

Unfortunately, the mercury is rapidly driven into the glass and can only be freed by washing with dilute hydrofluoric acid. Doctors Tillyer and Pincus of American Optical Company, Southbridge Massachusetts, have recently pointed out to the writer that by choice of a more suitable glass than Pyrex, a glass with "holes" smaller than the ionized mercury atom, most of this trouble could be avoided.

This has an important bearing on the practicability of the use of a low pressure tube containing a small amount of Hg^{198} that Wiens and Alvarez[1] have produced at the writer's request for excitation in this manner. It will be obvious that such a source and the use of a single even isotope of high atomic weight, excited at relatively low temperature, would give a standard line of far greater homogeneity and symmetry than the present red cadmium standard.

The explanation of the phenomenon of discharge at such low pressures is that the effective path length of stray electrons in the tube has been enormously increased by the spiralling action of the high frequency field, so that the chance of collision with a neutral atom is proportionately increased.

By experiment, it was found that a small discharge tube of hydrogen could be excited by a 3-meter oscillator at a pressure of 10^{-5} mm, and it was hoped that an atomic beam of this order of pressure could be similarly excited. As has been reported,[2] in an investigation of the wave-lengths and fine structure of $H\alpha$ and $D\alpha$ we were unable to excite by high frequency oscillations an atomic beam of the same order of pressure as was possible in a relatively larger discharge tube.

A multiple slit was then constructed, to allow a greater hydrogen flow from the Wood discharge tube without the turbulence caused by a wider single slit. The part of the Wood tube projecting into the first pumping chamber consisted of a double tube, the discharge passing along the inner and returning along the outer tube which was slightly longer. The latter was closed by a glass disk with a 1-cm diameter hole in the center. In order to avoid hydrogen recombination, the slits were made of drawn rectangles of Pyrex. After very little practice it is possible to make these of considerable ellipticity and remarkable uniformity. The strips were pushed into successive coils of two closely wound steel springs of slightly smaller diameter than the long axis of each strip. These springs held the strips in position against the glass disk, so that the width of the slits was fixed by the gauge of the wire. Two pieces of cover glass fixed in a frame and adjusted under a microscope provided the outside edges of the outer slits. Only a low degree of collimation was needed to reduce the Doppler width of the components to the order of the instrumental half-width, so that the second slit could be relatively broad.

With this arrangement of five fore slits in parallel and by using mercury diffusion pumps of

[1] J. Wiens and L. W. Alvarez, Phys. Rev. **58**, 1005 (1940).

[2] Drinkwater, Richardson, and Williams, Proc. Roy. Soc. **A174**, 164 (1940).

1000 liters per second pumping speed, the atomic beam was excited with the first described oscillator and with difficulty and irregularly with the second. With the first oscillator, the beam was only slightly brighter than the background. In spite of using efficient liquid-air traps, the mercury spectrum was present. Furthermore, recombination of hydrogen ions must have occurred since secondary spectrum lines could now be seen.

From Richardson's analysis of the molecular spectrum, secondary lines are expected to fall within the Hα complex; with reluctance this method had to be abandoned in favor of the one described.

It is very probable that the very efficient method of electronic bombardment described by Dr. Mack, coupled with this multiple slit method, will succeed where the ultra-high frequency method of excitation has failed.