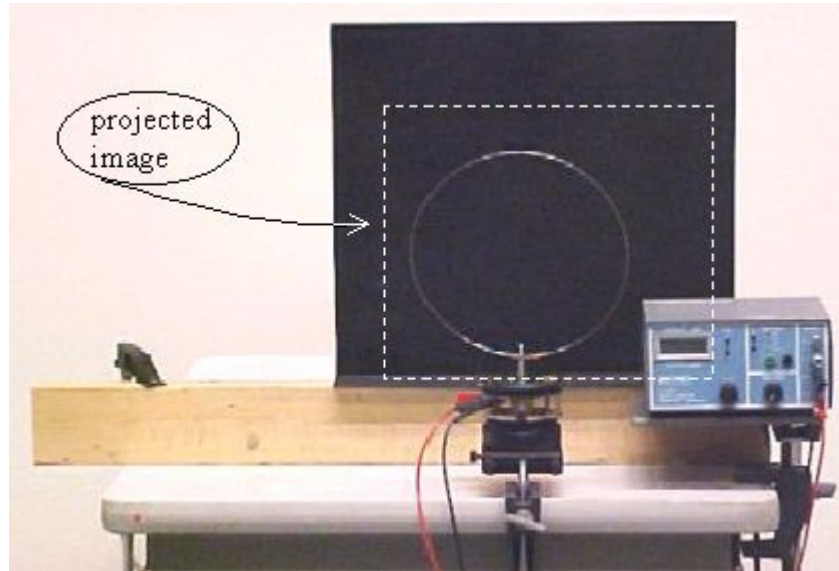# deBroglie applied to Bohr

Aim: To introduce how matter waves can be associated to Bohr's model of an atom; a classical analogy.

Subjects: 3B22 (Standing Waves)
7A50 (Wave Mechanics)
7B50 (Atomic Models)

Diagram:

Equipment:
- Wire loop of spring steel (round, 1mm), bend into a circular loop with a diameter of around 25 cm, and fixed to a banana plug (Pasco SF-9405).
- Mechanical wave driver (Pasco SF-9324), actually an adapted loudspeaker.
- Signal generator.
- Black screen.
- Camera and beamer to show the demonstration to a large audience.

Safety:
- The loop is fixed to the wave driver. When the loop is agitated heavily it is possible that it loosens itself. Then a free end sweeps around dangerously. So fix the loop tightly.

TUDelft

Delft University of Technology

deBroglie applied to Bohr

Presentation: The wire loop is fitted to the mechanical wave driver shaft. The wave driver is connected to the signal generator. The image of wire loop and display of the frequency of the driving generator is projected (see Diagram).
Start at low frequency (around 5Hz) and low amplitude, making the loop starting to vibrate. Increase the frequency to see various modes of standing waves in the circular loop. (At higher frequencies the amplitude of the signal generator has to increase to obtain visible amplitude in the oscillating wire loop.) We observe:
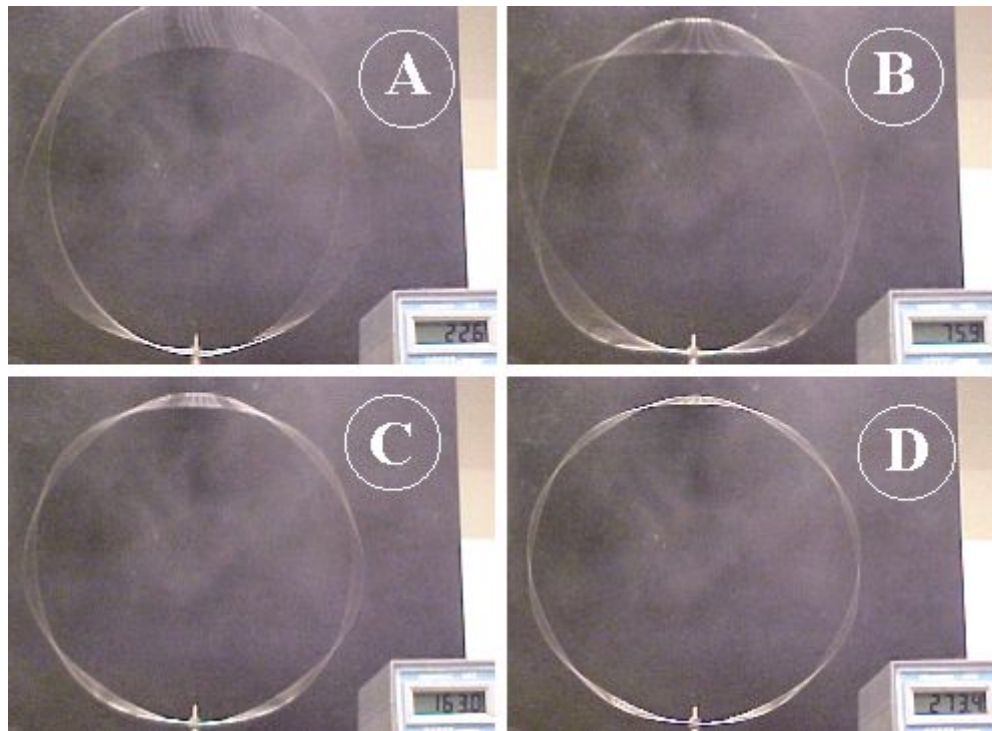

Figure1

- 2 nodes and anti-nodes at 14 Hz;
- 3 nodes and anti-nodes at 23 Hz (very large amplitude) (see Figure1A);
- 4 nodes and anti-nodes at 30 Hz;
- 5 nodes and anti-nodes at 76 Hz (see Figure1B);
- 7 nodes and anti-nodes at 163 Hz (see Figure1C);
- 9 nodes and anti-nodes at 273 Hz (see Figure1D);
-11 nodes and anti-nodes at 398 Hz (this last one is not so good visible to a larger audience due to its low amplitude).

Explanation: According to Bohr electrons move in circles.
DeBroglie argued that the "electron wave" was a circular standing wave that closes in itself (in order to obtain constructive interference). So, for persisting

waves: $2\pi r_n = n\lambda$, n =1, 2, 3,...,. This is what we observe in our demonstration.

DeBroglie: $\lambda = h/mv$ and we get: $mvr_n = nh/2\pi$. In this way the *ad hoc* quantized

orbits of Bohr are derived form deBroglie. This "shown" wave-particle duality is at the root of atomic structure.
(In discussing the analogy it should be remembered that the "electron wave" is not in reality a standing wave along a line, but it extends through all space.)

deBroglie applied to Bohr

Remarks:
- For the lower frequencies, 14 -, 23 - and 30 Hz, the successive patterns (2, 3 and 4 half wavelengths) are "logic" when we suppose that $1/2\lambda$ is obtained at around 6 -, 7 Hz. For higher number of nodes/anti-nodes this logic order is apparently a different one.

Sources:
- [Giancoli, D.G., Physics for scientists and engineers with modern physics](), pag. 971-972
- [Mansfield, M and O'Sullivan, C., Understanding physics](), pag. 573-574
- [Meiners,H., Physics demonstration experiments, part 2](), pag. 1185-1188

TUDelft

Delft University of Technology