A5.2 The Mach-Zehnder interferometer.

The Mach-Zehnder interferometer is used in experiments on light because it is a convenient and sensitive way of detecting interference. It is also often used in thought experiments to illustrate various principles in quantum mechanics. The device, shown in Fig. A05.2-1, starts with a beam splitter (half-silvered mirror), BS(1), that divides the wave function into two equal parts. The part transmitted through BS(1) travels on a horizontal path, H, hits mirror M(2) and is reflected vertically to half-silvered mirror BS(2), while the part reflected on a vertical path, V, hits mirror M(3) and is reflected horizontally to BS(2).

Figure 1. The Mach-Zehnder interferometer. BS refers to a beam splitter and M to a mirror while the D denotes a detector. For equal paths, detection occurs only at A.

For the V beam, there is a 90^o phase shift at BS(1), M(1), and the part reflected vertically at BS(2), (assuming the silver is on the top surface) while for the H beam, there is a 90^o phase shift at M(2).

There is a detector at A and a detector at B. If the path lengths from the two paths are the same, the two parts of the wave function that go towards A are in phase and one gets constructive interference, while the two parts that go towards B are exactly out of phase and cancel. That is, for equal path lengths, detector B will never detect a photon while detector A will detect every photon. If either path is blocked, half the remaining photons will be detected at A and half at B (no matter which one is blocked).