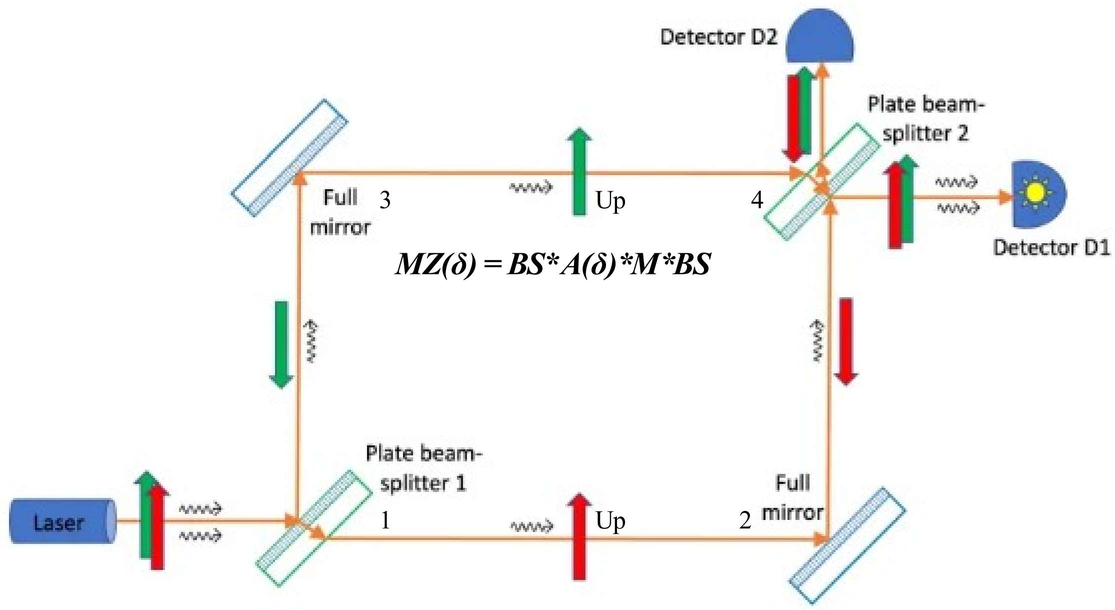
XVI. Quantitative Analysis of Phase Splitting on Mach-Zehnder Inferometer

Graphics: https://quantumphysics-consciousness.eu/index.php/en/the-mach-zehnder-interferometer-explained/

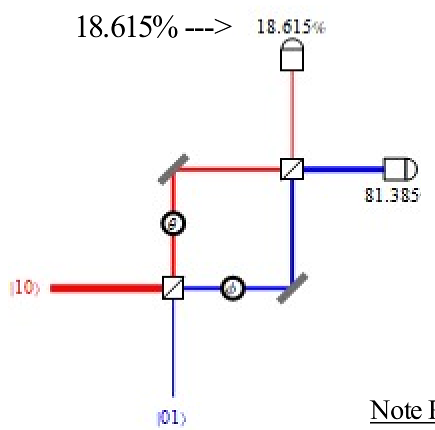
A wave can experience a phase shift (δ) upon full or partial reflection. This is a feature that is applied in the Mach-Zehnder interferometer, MZ, to induce phase differences in split light waves en thus invoke interference effects when they are combined again. Mach-Zehnder interferometer beam splitters (BS) are used to achieve several things:
*split a light beam in two equal and synchronous beams, a reflected beam and a strait-through passing beam,
*induce a phase (δ) shift in the reflected beam. NB: The strait-through passing beam does not experience phase shift.
*recombine the two light beams in order to let them interfere.

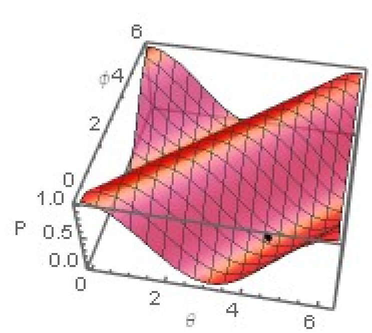


Now we follow the waves that should reach detector D2. The Up wave traveling along 1-2-4 receives a 180° phase shift at beam splitter (BS) 1. Another 180° phase shift (δ) at full mirror 2. Then finally zero phase shift by the reflection from glass by Mirror (M) to air at beam splitter 4 in the direction of D2. Total is thus 360°. The wave D traveling along 1-3-4 receives only one phase shift at mirror 3 of 180°. So the recombined two waves going from beam splitter 4 to detector D2 will interfere with phase difference 180°, which means fully opposite phases. Which means destructive interference. D2 receives no light.

Mathematica: 3D Solution of Beam Probability with Relative Phase Shifts θ and ϕ.

18.615% --->



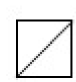


Note P, θ, ϕ Location of above black dot.

Probability of going into top detector: P_{top}

$$P_{top}(\theta,\phi) := \cos\left(\frac{\theta-\phi}{2}\right)^2$$

$$P_{top}(2.24938, 0) = 18.615\cdot\%$$

beam splitter		$\frac{\begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}}{\sqrt{2}}$
mirror		$\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$
phase shifter		$\begin{pmatrix} e^{i\theta} & 0 \\ 0 & e^{i\phi} \end{pmatrix}$