Waves as a useful tool

If light is really made up of particles, and we can calculate the probability that the particle will do something, why do we ever need to talk about waves?

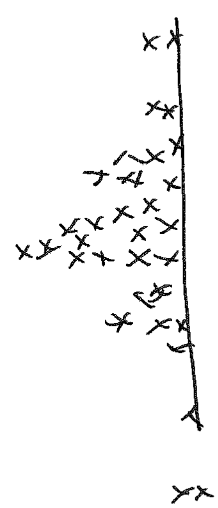
As we saw, in order to calculate something as simple as the probability that a photon will pass through a slit to a detector, we have to consider the different ways in which it could happen (as we will see, ~~we~~ to calculate <u>anything</u>, we will have to account for <u>all</u> the different ways ~~w~~ it could happen, no matter how ridiculous) If we want to calculate something as detailed as a diffraction pattern, we would have to account for all the ways a photon ~~would~~ could hit each individual point on the screen. This could take forever!

Describing light as a wave allows us to use our intuition for ~~wave-like~~ behavior like interference diffraction, reflection, etc. to better understand the <u>probabilistic</u> behavior of photons. In short, the wave description is a useful tool for understanding and calculating the <u>expected</u> behavior of photons. It reduces a seemingly endless task to one in which we need only understand the interaction of waves.

We have to keep in mind, though, exactly what this description is telling us. When we see a diffraction pattern, we are seeing the accumulation of thousands (maybe millions?) of different events. We see all of these thousands of photons hit the screen at the same time. The bright areas have the most photons because that is where ~~they~~ photons have the <u>greatest chance</u> of landing. However, if we send only one photon at a time at the screen, we see (or the photon sees)

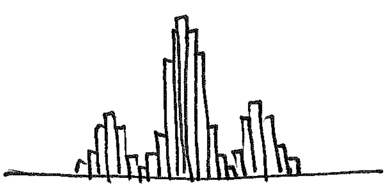
As we continue to send photons, we begin to "build up" the interference pattern, one photon at a time:

(of course, if we are sending photons in slowly, they don't stay on the screen)



The "wave" that we see is the accumulation of many many individual particles. More importantly, the "wave" gives us the <u>probability distribution</u> (as a function of position on the screen) for a <u>single photon</u>.

think of this as a histogram



even though there are <u>no photons</u> on the screen, this wave (the same wave we saw filled with photons on the screen in our diffraction experiment) tells us where the next photon is <u>likely to go</u>.

The only reason that we see this "probability wave" in the diffraction experiment is because we are sending photons in so quickly that we can see them realize all probable destinations all at the same time.

If we send photons in slowly, we have to wait a really long time to ~~build up the probabi~~ "fill in" the probability wave

But now you begin to see where we're headed. If the best we can do in physics is to calculate probabilities, and the distribution of these probabilities somehow looks like a wave, and we understand the behavior of waves... we can use our understanding of waves to help us understand, describe, and quantify the probabilistic behavior of photons.