Lecture 3: Stern-Gerlach Experiment

September 28, 2019 10:24 AM

QM I – Fall 2019
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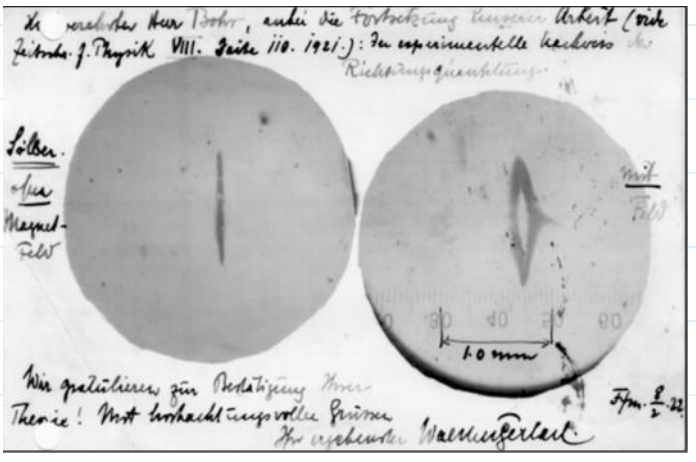
Stern-Gerlach experiment

(A6) Do the full analysis of the SG experiment.

Consider the experiment with niddles that are magnetized.

- How would the outcome look like?
- If there's a splitting in the distribution of the needles that reach the screan, what does that imply?
- Why is it contnous in the

In the actual experiment in , we saw the following pattern. What does this mean?



Postcard form Gerlach to Bohr
1922
experiment with Silver atoms
https://www.nature.com/articles/milespin02

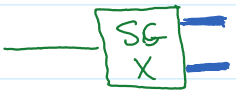
See https://seop.illc.uva.nl/entries/physics-experiment/app5.html

See also https://physicstoday.scitation.org/doi/full/10.1063/1.1650229 if you are interested in some history.

— Quantization → Do this yourselves and we talk about it later.

— Realism and Uncertainty → Commutive algebra

a)



The outcome could be random.

b)

The outcome is fully deterministic. (Always up)

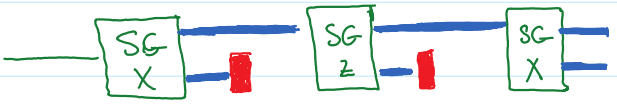
c)

The outcome is fully

c)

The outcome is fully random.

d)



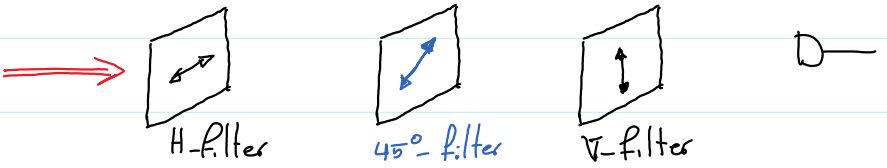
Now if we combine (b) & (c), what would we get?

In the experiment, we get 50/50 outcomes.

What does this result imply?

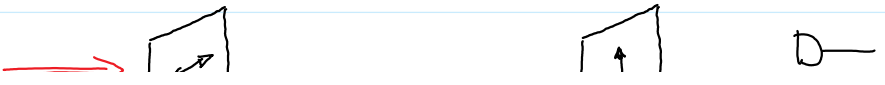
Shouldn't all the particles come out as $X+$?

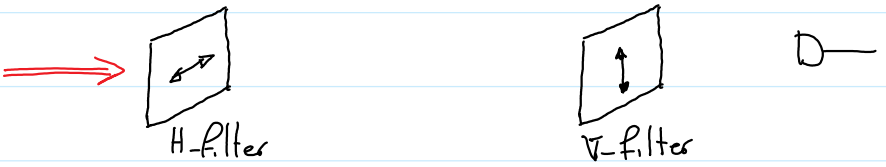
Classical Analogue: Polarization of light



Does the light reach the detector? Yes

What if we do this?





NO!

So we remove a filter & light stops going through.

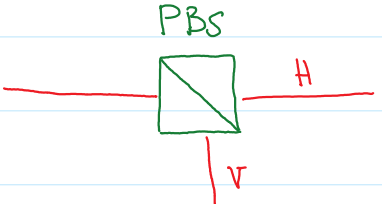
* Think about how this experiment is related to SGE.

(A7) What's the difference?

How can we resolve the difference?

What's the classical justification of the experiment above?

Do particles of light (photons) show the same kind of behavior?



Polarizing beam-splitter:
It lets through the Horizontally polarized photon/light and

It lets through the Horizontally polarized photon / light and reflects the vertically polarized photo- / light.

(A8) Design an experimental setup to test (a-d) above with this PBS. (Hint: Use a polarization rotator to change the measured polarization form $\{H \& V\}$ to $\{\pm 45\}$.

What are the implications of SG experiment?

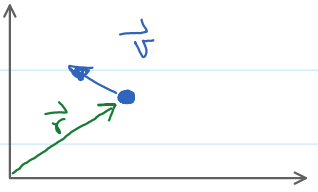
- Quantization of angular momentum
  or more precisely magnetic moment.

There are at least situations in which the magnetic moment has discritized values.

- No - Commutativity of measurements

Contextuality
↓
Uncertainity

Classically:



Example 1:

① What's the position? $\vec{r}$

② " " velocity? $\vec{v}$

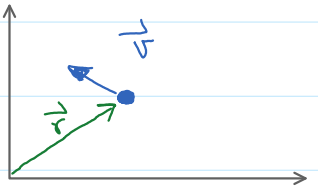
③ " " position? $\vec{r}$

The answer does not change.

$\{\vec{r}, \vec{v}\}$ are properties of (state) of the ball and not affected by the measurement

Example 2: Angular momentum

$$\vec{L} = \vec{r} \times \vec{p} = (L_x, L_y, L_z)$$



① What's L_x of a single particle? ℓ_x ℓ_x

② " L_y " that " ? ℓ_y ℓ_y

③ " L_x " " " ? ℓ_x $\ell'_x \neq \ell_x$

↑ Classically

↑ Suggested by SGE

Is it well-defined to talk about these properties of the system?

Can we assume that they pre-exist before the measurement?