Stern Gerlach Experiment

how spins behave in magnetic fields

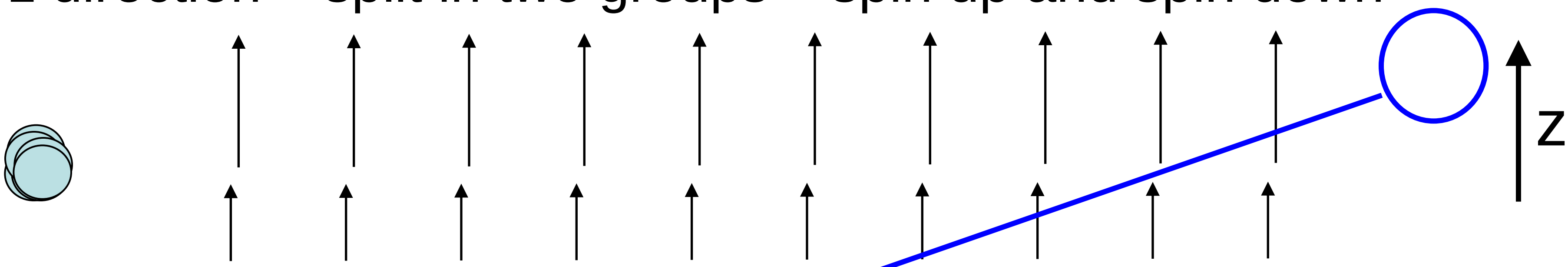
Spin is quantized

- For electrons (& other fermions), spin can only take on two values: up ↑ or down ↓.
- What's so special about the z-axis?
  - Answer: nothing.
- Can measure spin along any axis, will always find spin either aligned or anti-aligned with the axis you measure along.
- Just like position and momentum, spin along orthogonal axes obeys Heisenberg uncertainty principle: $s_x s_z \geq \hbar/2$; $s_y s_z \geq \hbar/2$; $s_x s_y \geq \hbar/2$
- State of definite spin in x-direction -->

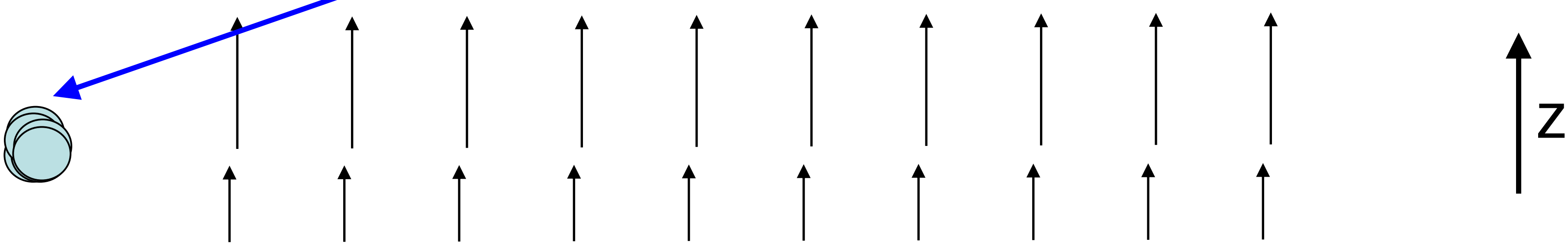
  50/50 superposition of up and down in z-direction.

<u>How do we know? Stern-Gerlach Experiment</u>

Put atoms in inhomogeneous magnetic field pointing in z direction – split in two groups – spin up and spin down

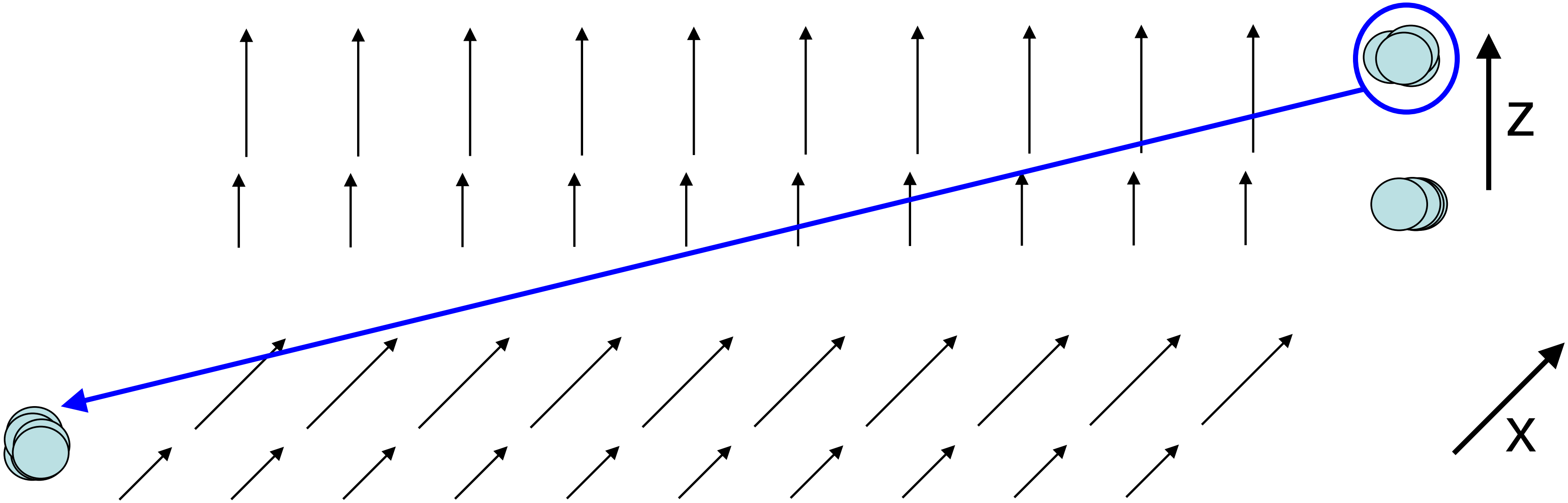


What if I take just atoms that went up, and send them through another, identical magnetic field – What happens?



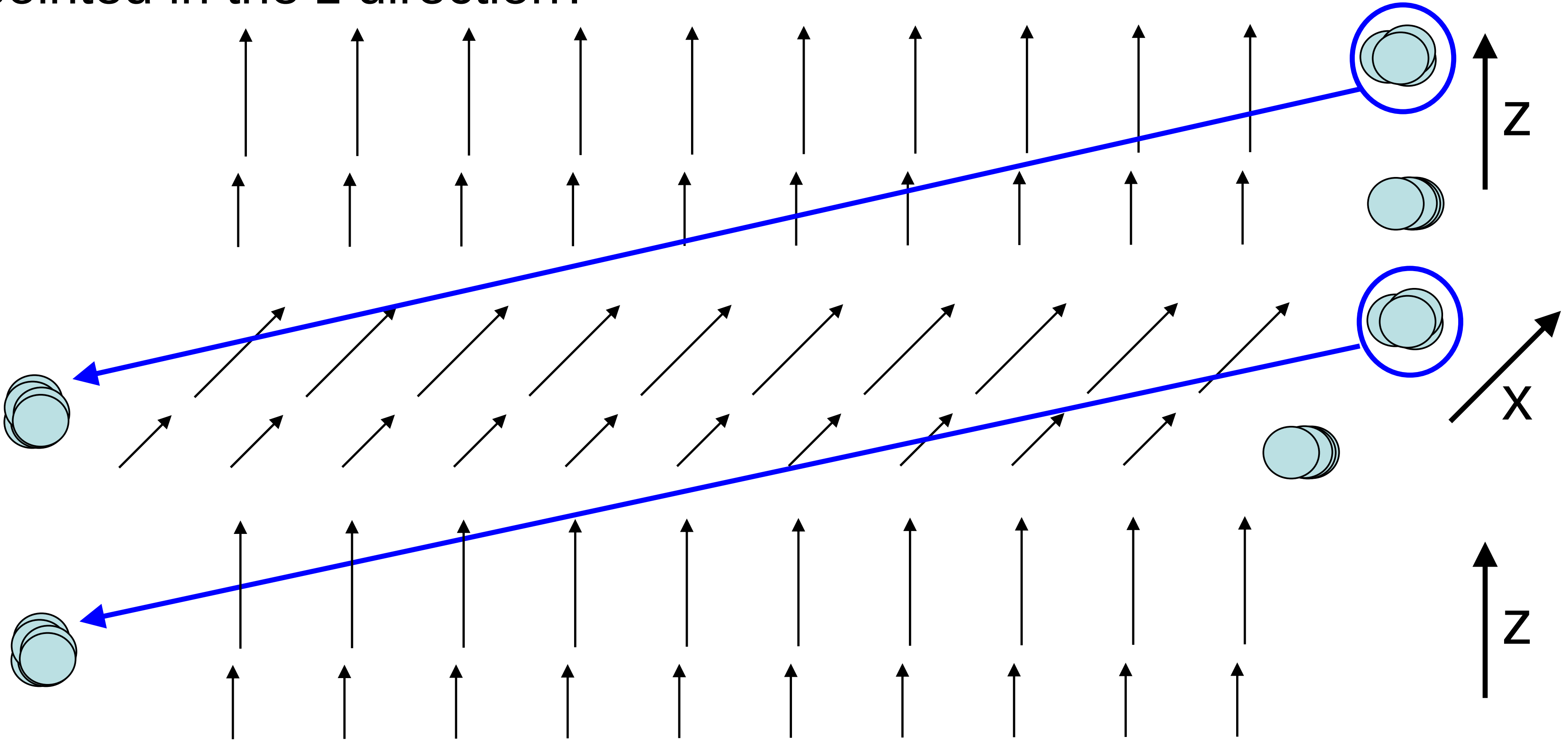
a. Half go up (+z), half go down (–z)
b. All go up (+z)
c. All go down (–z)
d. Range of paths all smeared out

Second Experiment: What if I take just atoms that went up, and send them through a magnetic field pointed in the x direction – <u>perpendicular</u> to first field (pointing into the screen)?



a. Half go into the screen (+x), half go out of the screen (–x)
b. All go into the screen (+x)
c. All go straight (no deflection)
d. Range of paths all smeared out
e. All go up (+z)

Third Experiment: Take just the atoms that went in +x direction in second experiment, and send them through a third magnetic field, pointed in the z direction?



a. Half go up (+z), half go down (–z).
b. All go up (+z)
c. All go down (–z)
d. Range of paths all smeared out.