PC3130

Quantum Mechanics II

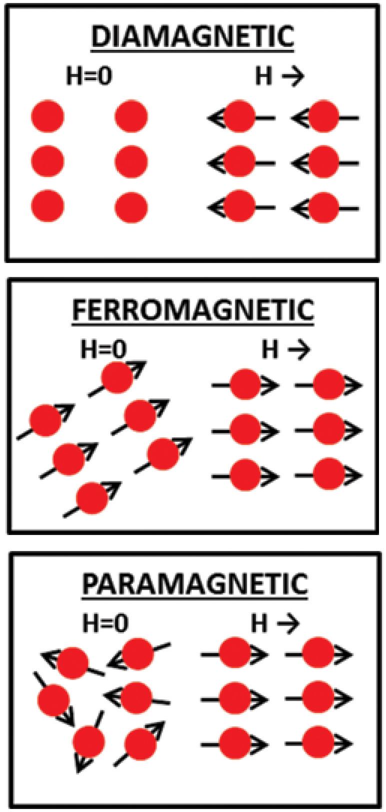
Spin: a form of angular momentum

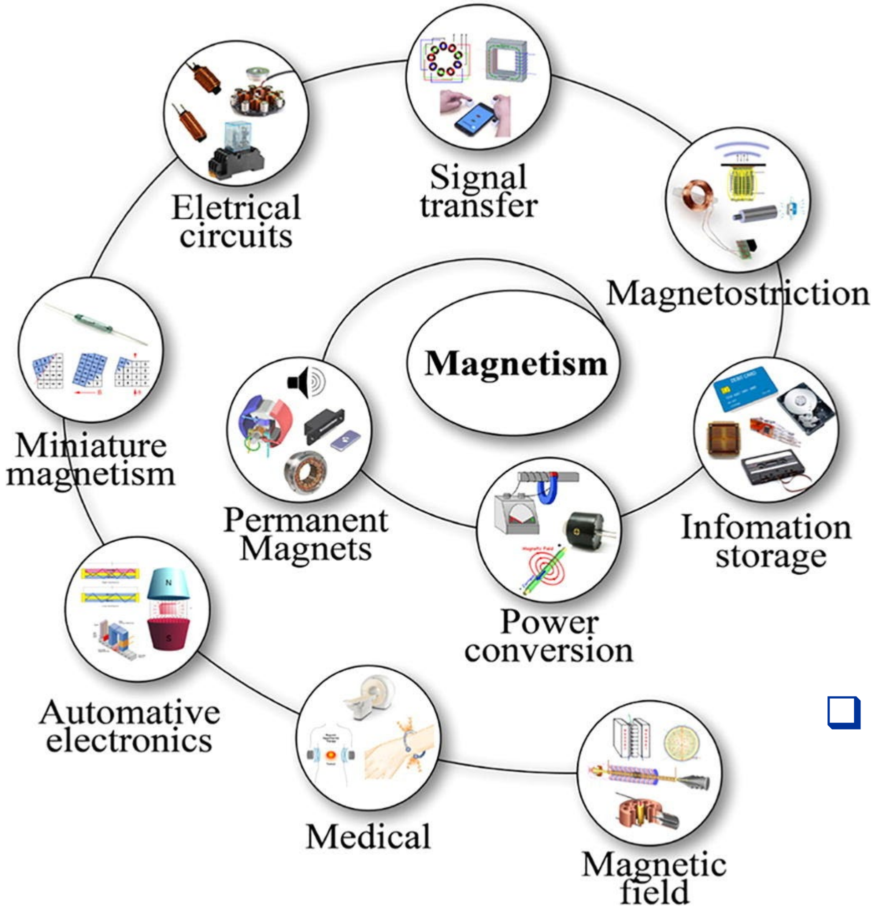
Spin: a QM quantity

- Why did scientists conclude that there is such a thing as spin?
- Why did scientists think that spin is a form of angular momentum?
- How did scientists deduce/agree upon the form of the Pauli spin matrices?

Spin in Nature

Spin and Magnetism in Modern Technology

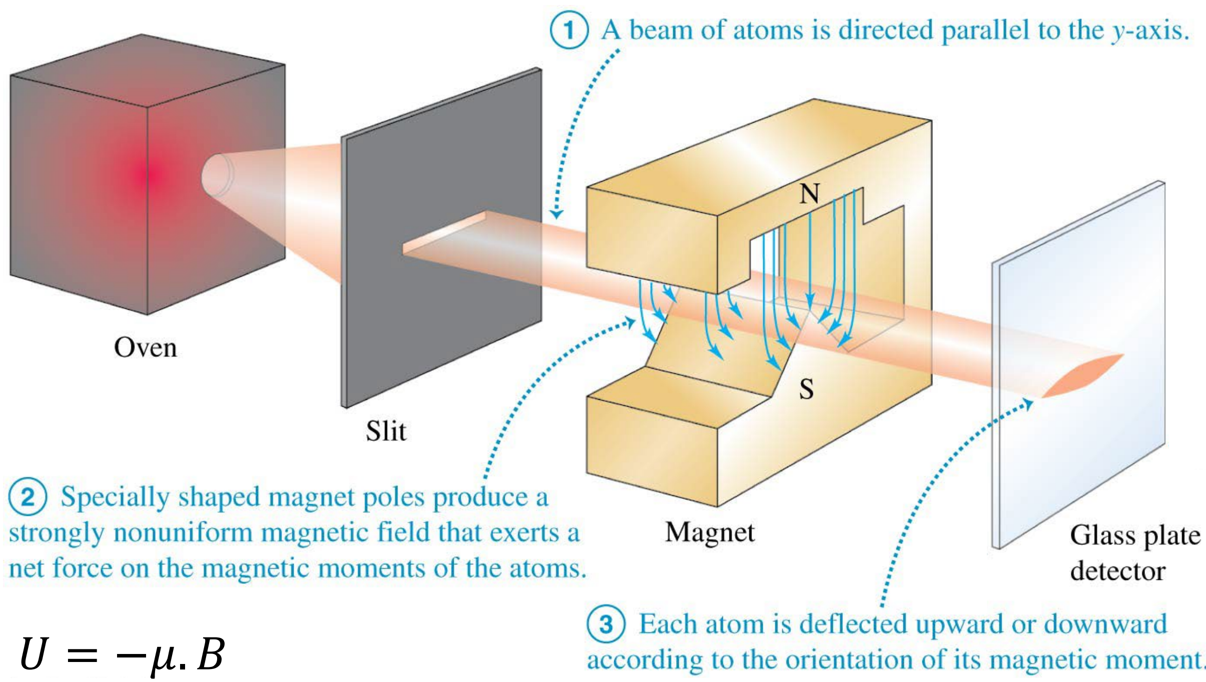




- Computers and telephones
- Health and medicine
- In the home (refrigerator, children's toys …)

Figures taken from Iacovacci, V., et al., *Magnetic Field-Based Technologies for Lab-on-a-Chip Applications*, in *Lab-on-a-Chip Fabrication and Application*. 2016 (left), InTech and Sethulakshmi, N., et al., *Magnetism in two-dimensional materials beyond graphene.* Materials Today, 2019 (right).

Stern-Gerlach experiment



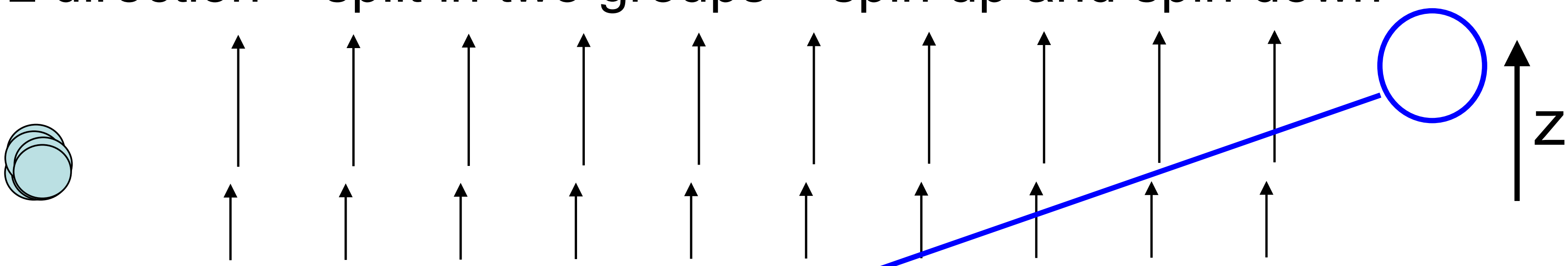
$\downarrow z$

$$U = -\mu . B$$

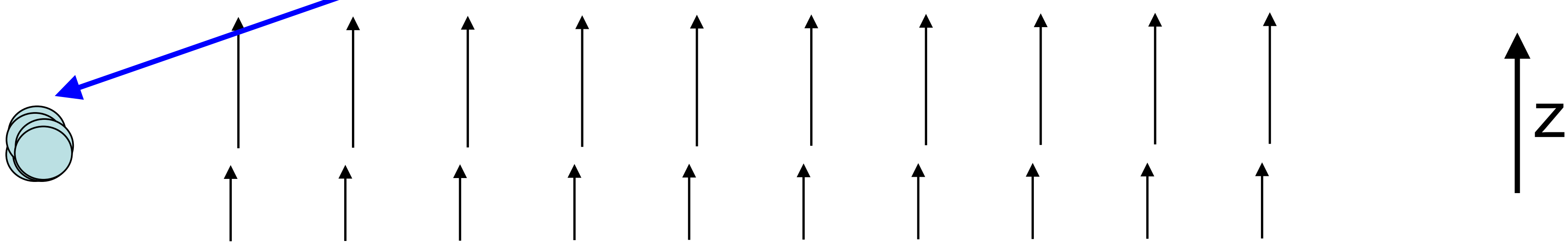
$$F = \nabla(\mu . B) \approx \mu_z \frac{dB}{dz}\hat{z}$$

Stern-Gerlach Experiment

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

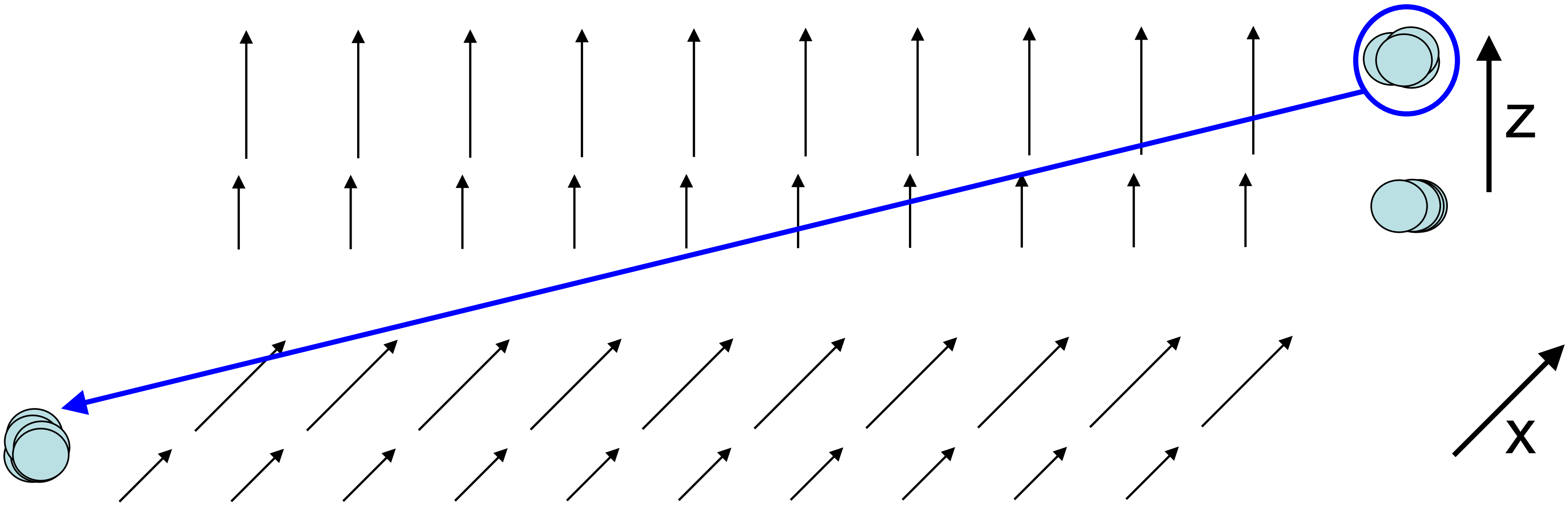


What if I take just atoms that went up, and send them through another, identical magnetic field – What happens?



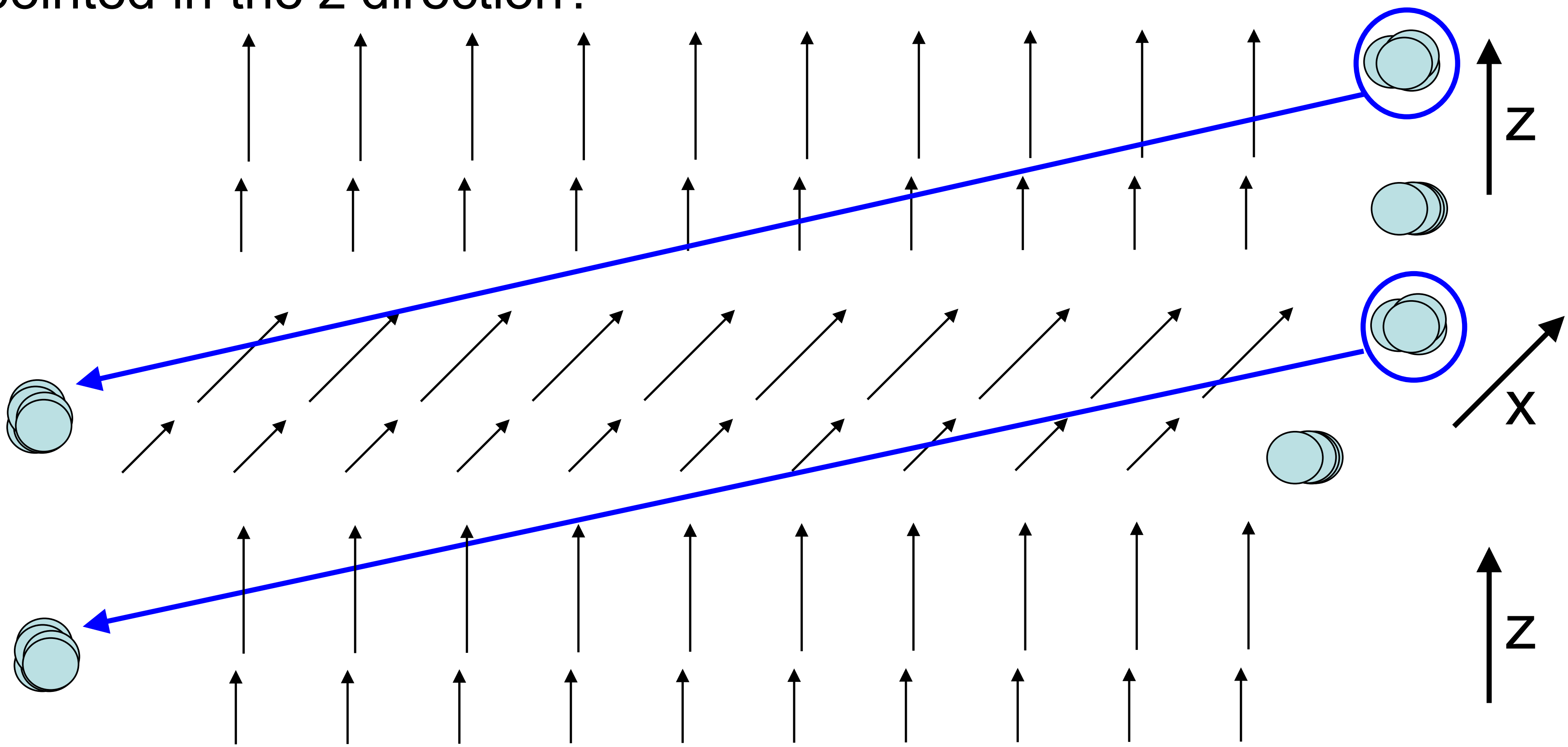
a. Half go up (+z), half go down (–z)
b. All go up (+z)
c. All go down (–z)
d. Range of paths all smeared out

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



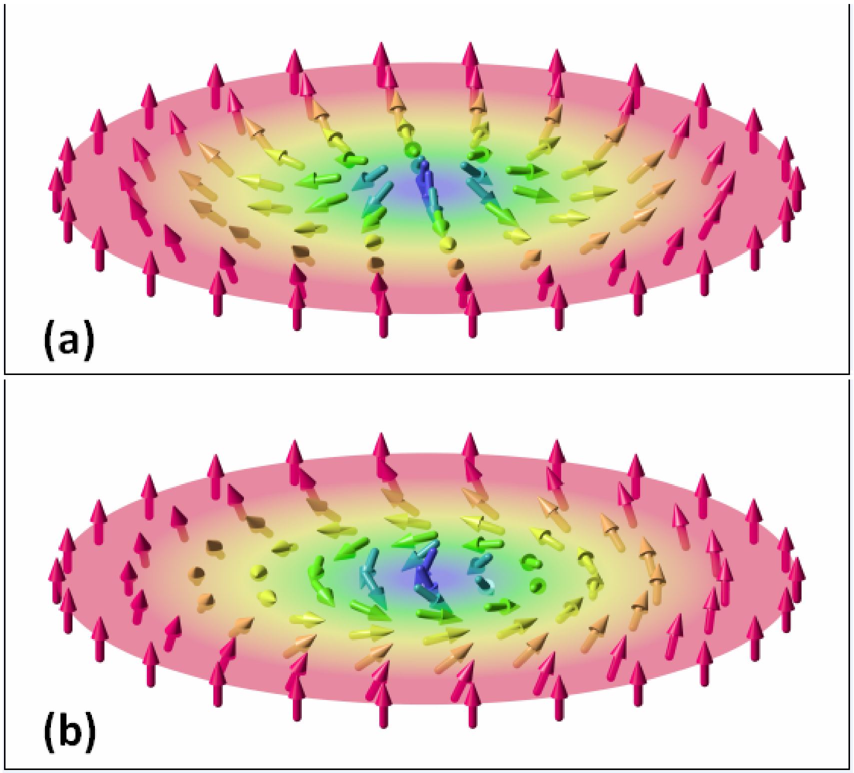
a. Half go into the screen (+x), half go out of the screen (–x)
b. All go into the screen (+x)
c. All go straight (no deflection)
d. Range of paths all smeared out
e. All go up (+z)

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

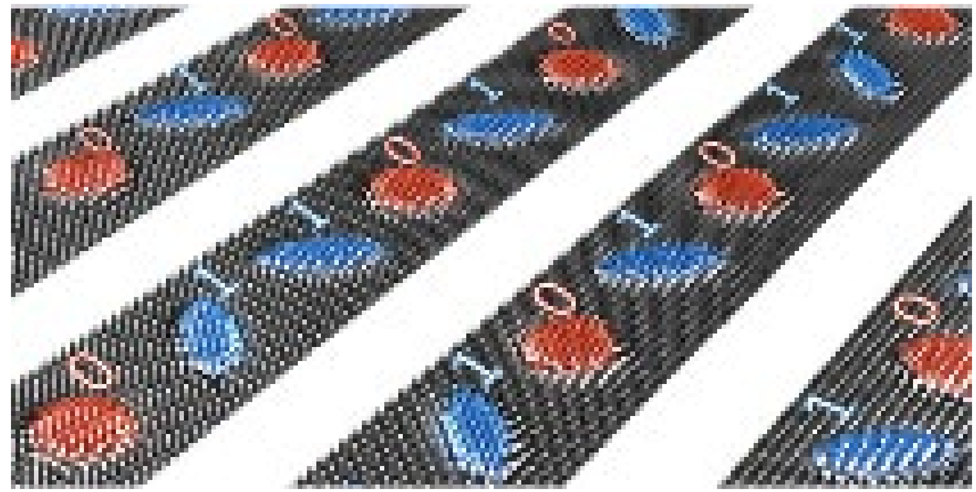


a. Half go up (+z), half go down (–z).
b. All go up (+z)
c. All go down (–z)
d. Range of paths all smeared out.

Skyrmions



Two different types of skyrmions



The "handedness"/chirality of the arrows can be used to define "0" or "1". Skyrmions can be controlled with spin currents and are of interest in new types of memory storage schemes.

Spin-orbit coupling couples the spin and lattice degrees of freedom. Here, a complex dependence of spin on position is seen.