Hyperfine spectroscopy of antihydrogen

Alberto Jesus Uribe Jimenez
auribeji@cern.ch

Department of Physics and Astronomy
University of Calgary
ALPHA Collaboration

Early Career Conference in Trapped Ions (ECCTI) 2024

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**Characterization of the
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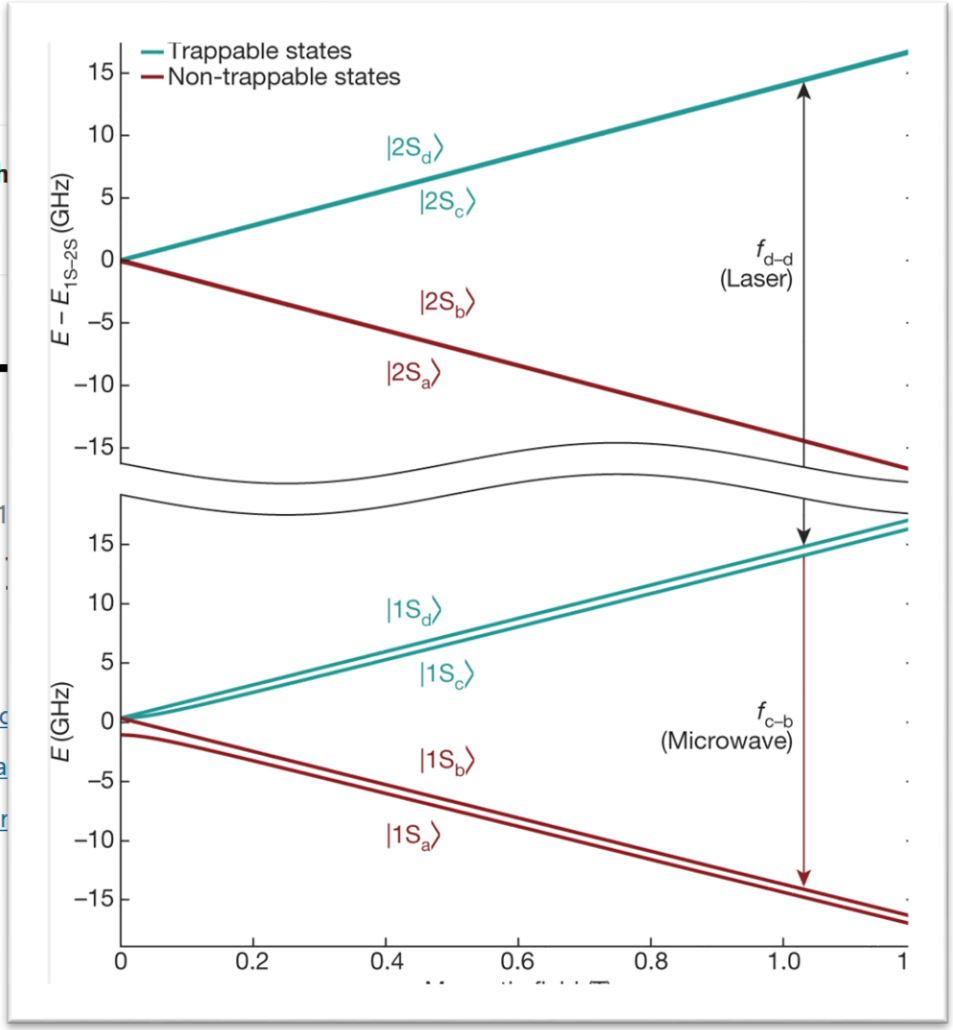

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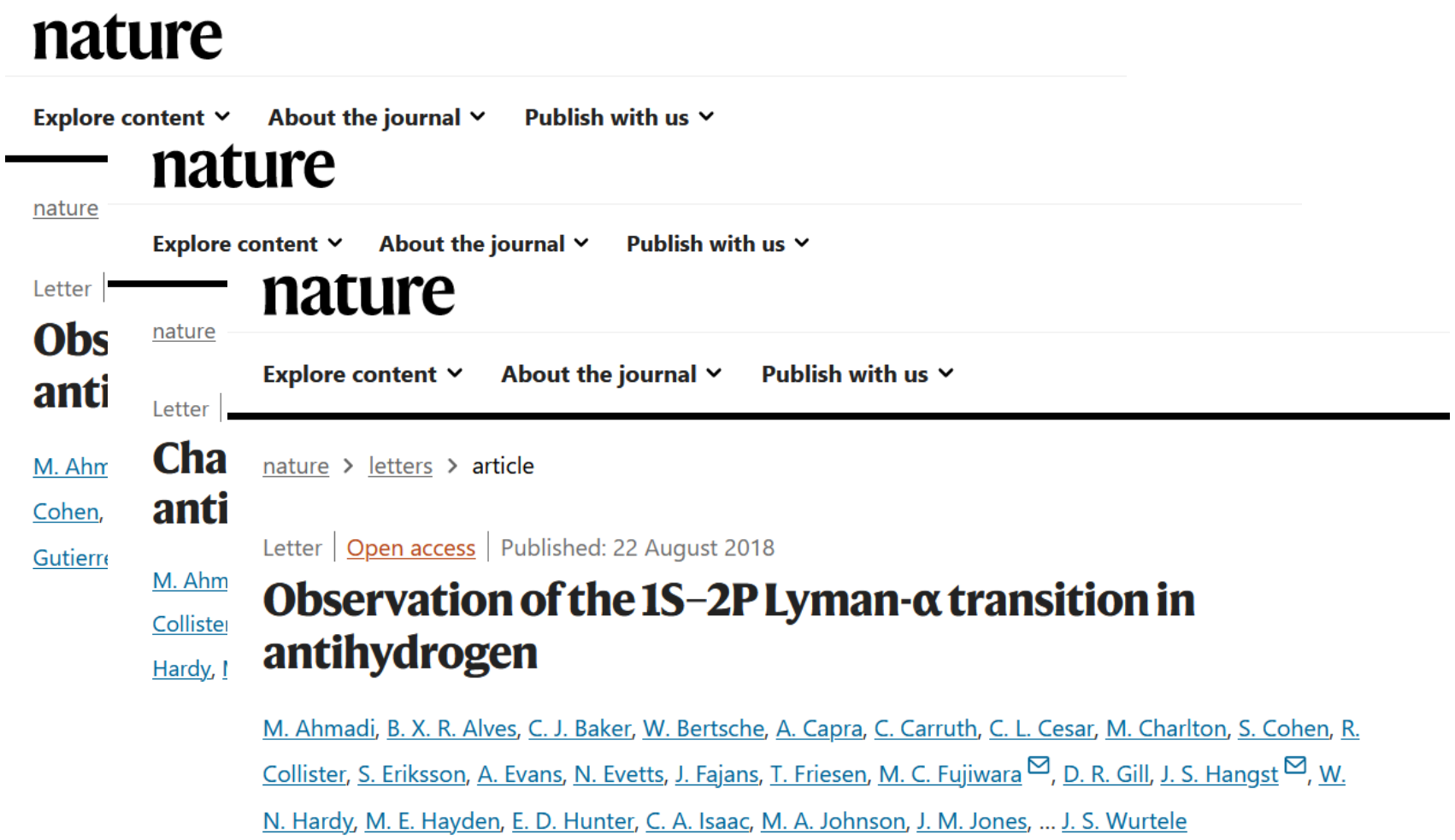

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R.
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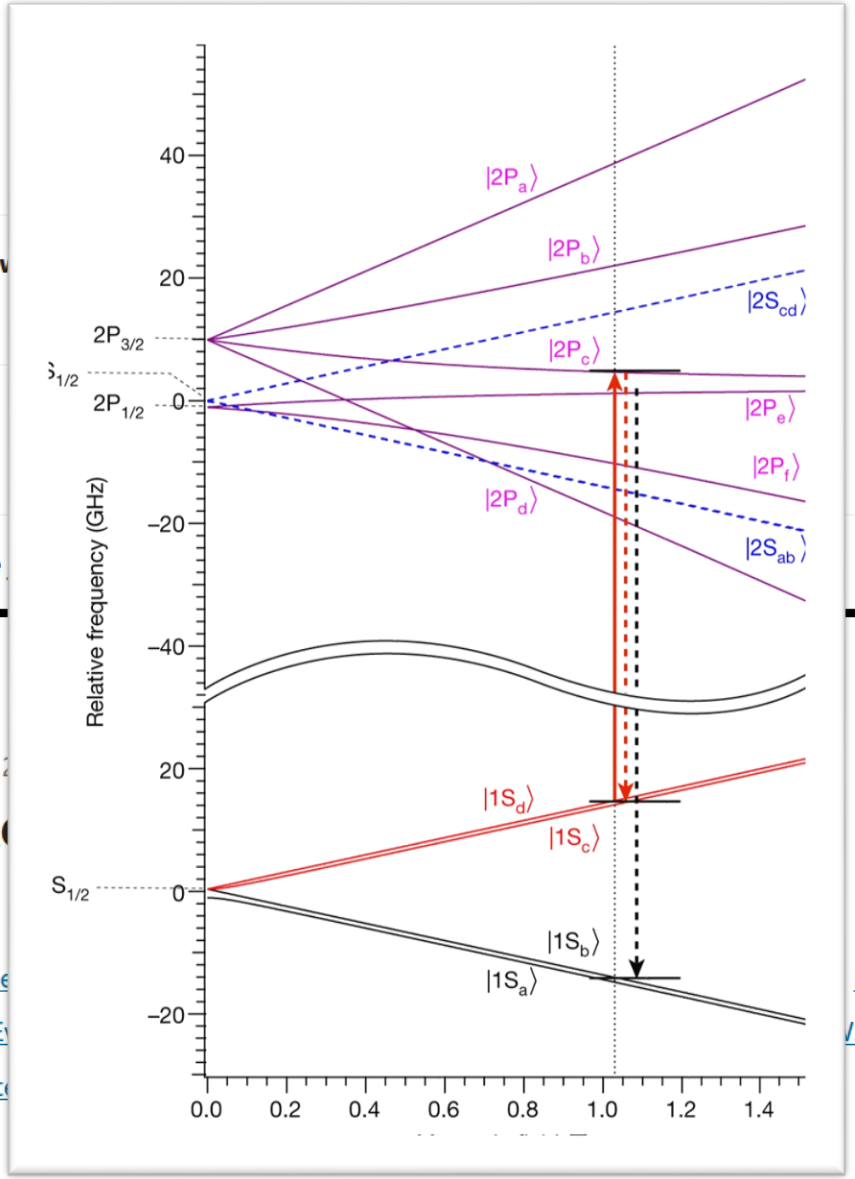

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Collister
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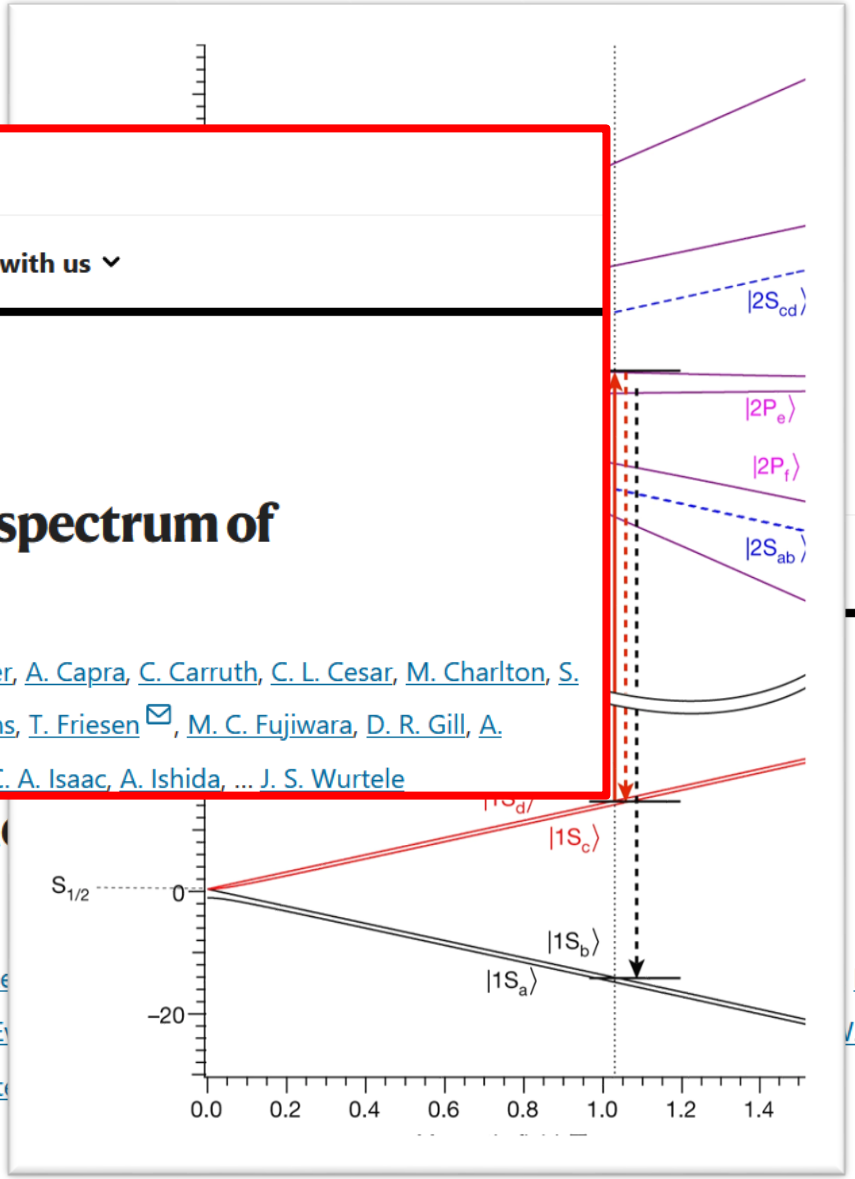
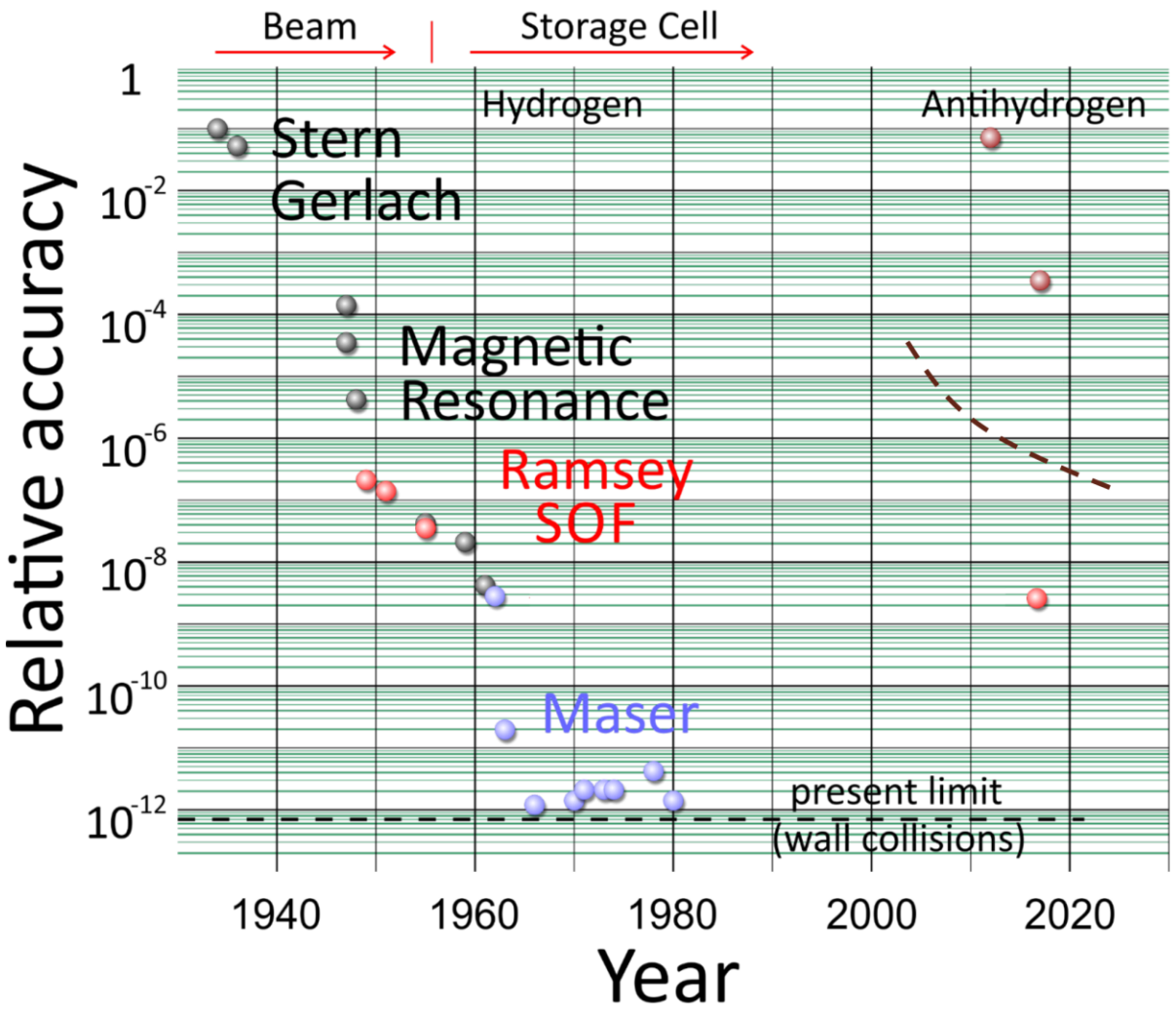


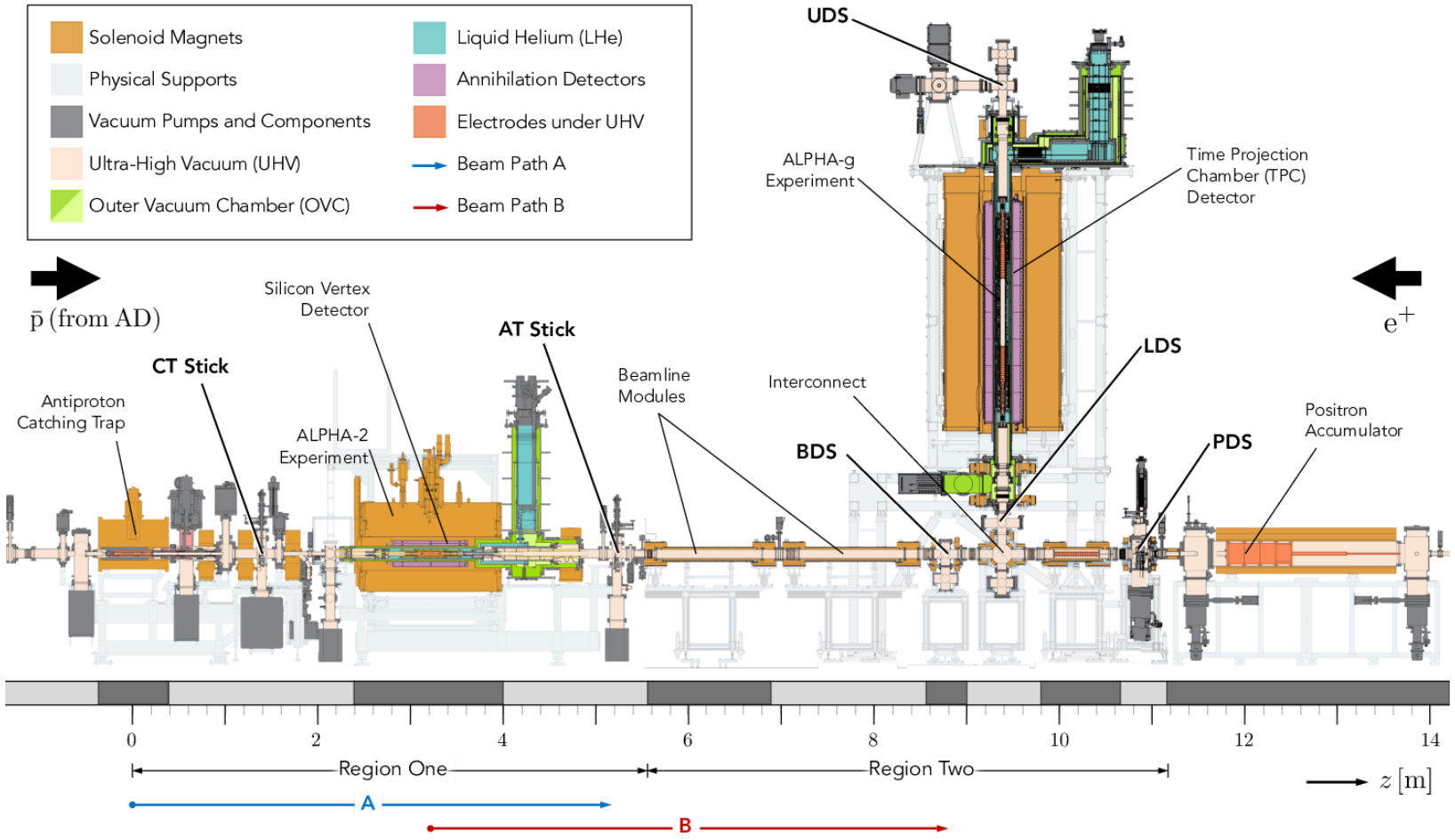
Status of hyperfine spectroscopy



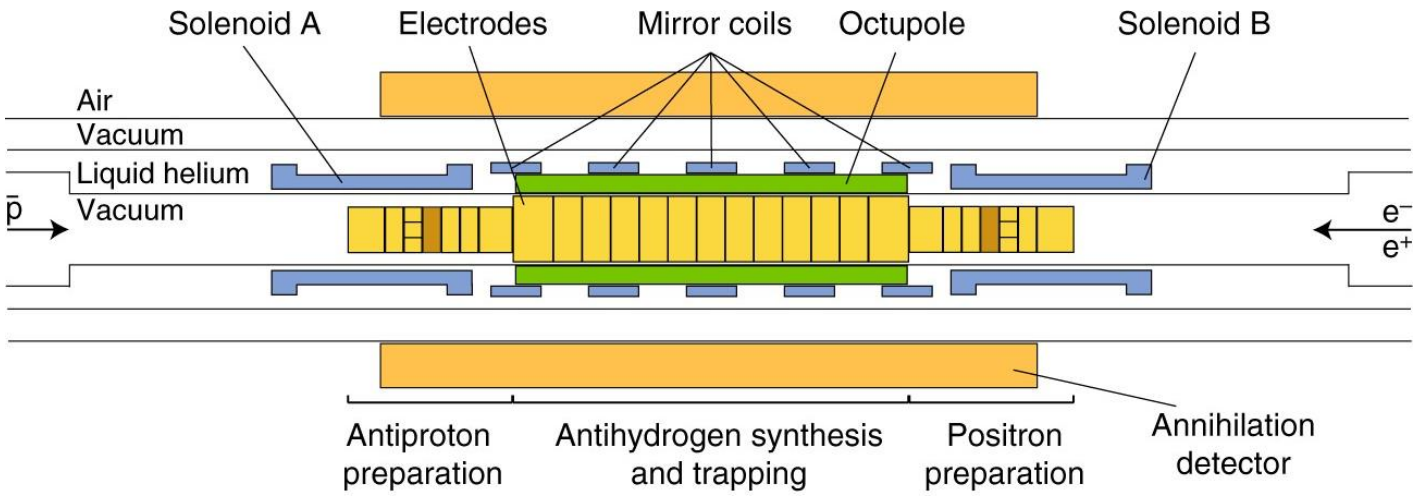
Nature **483**, 439 (2012)

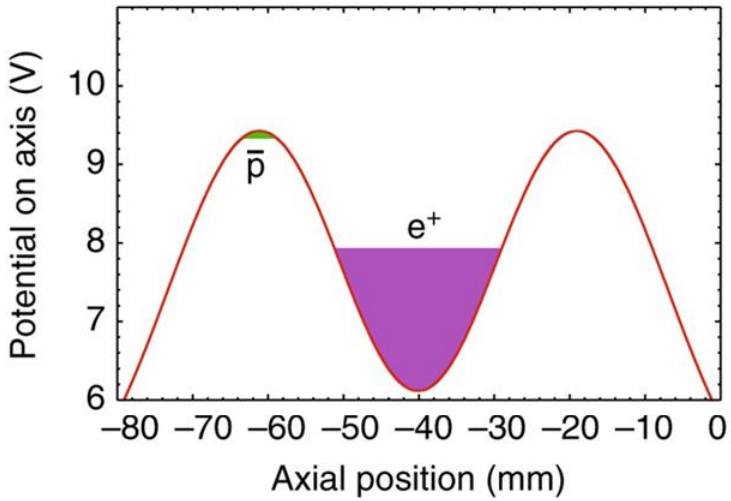
Nature **548**, 66 (2017)

Alpha-2 Penning trap



Antihydrogen in Alpha-2 Penning trap





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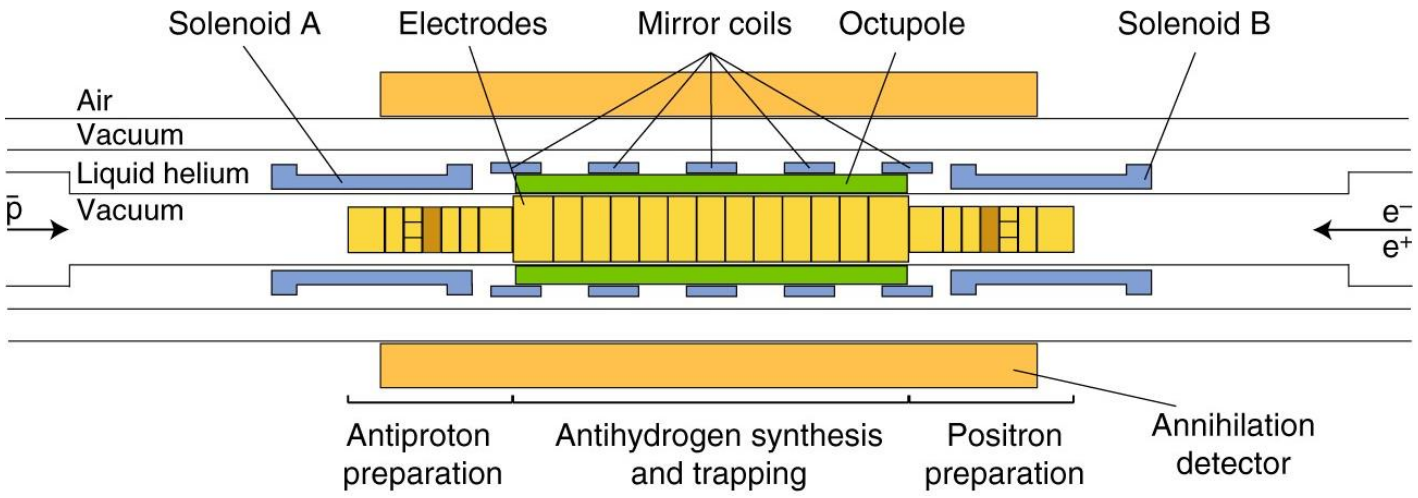

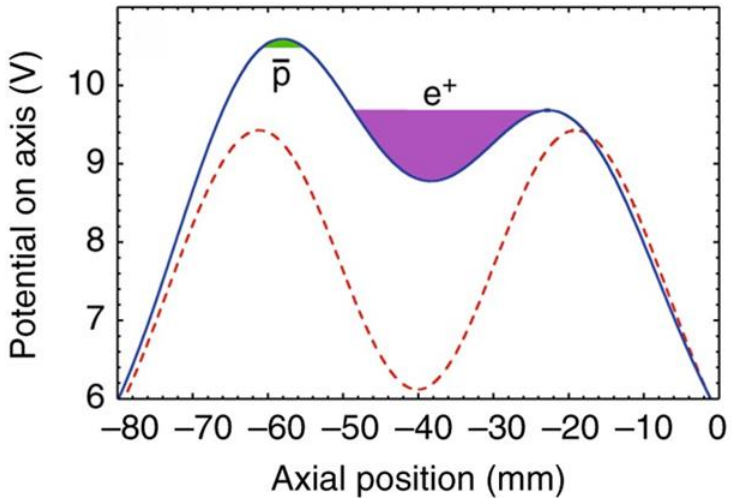

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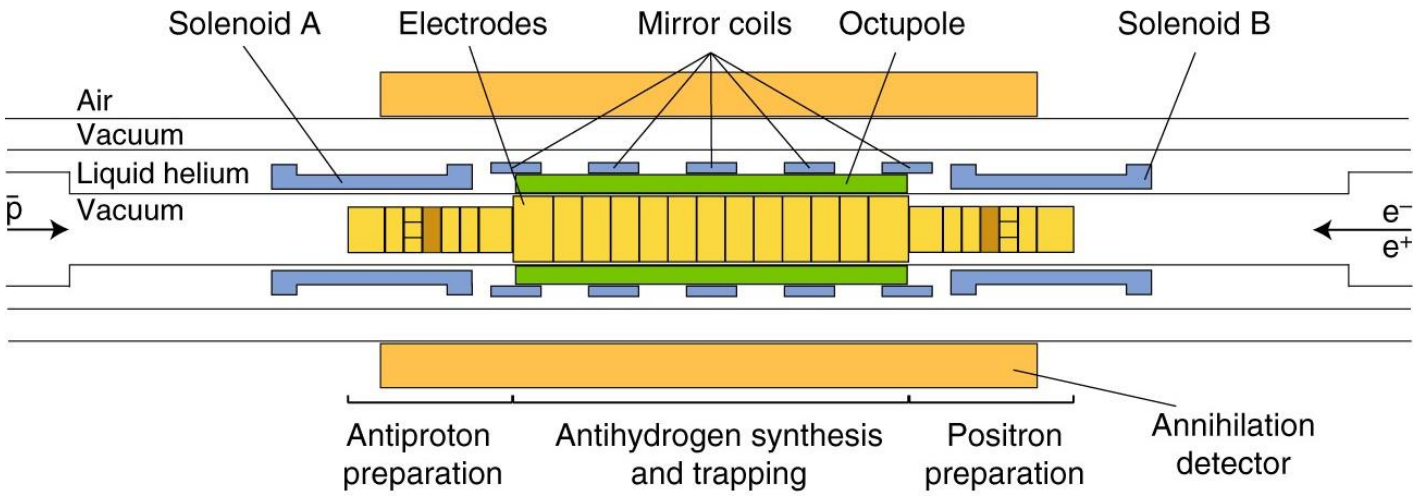

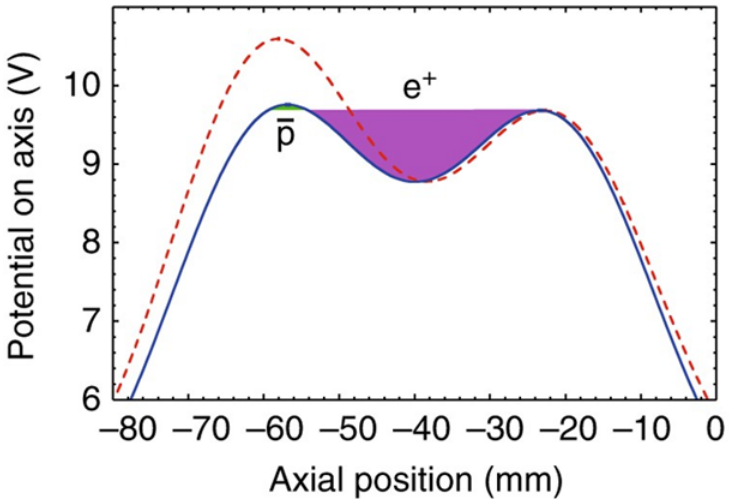

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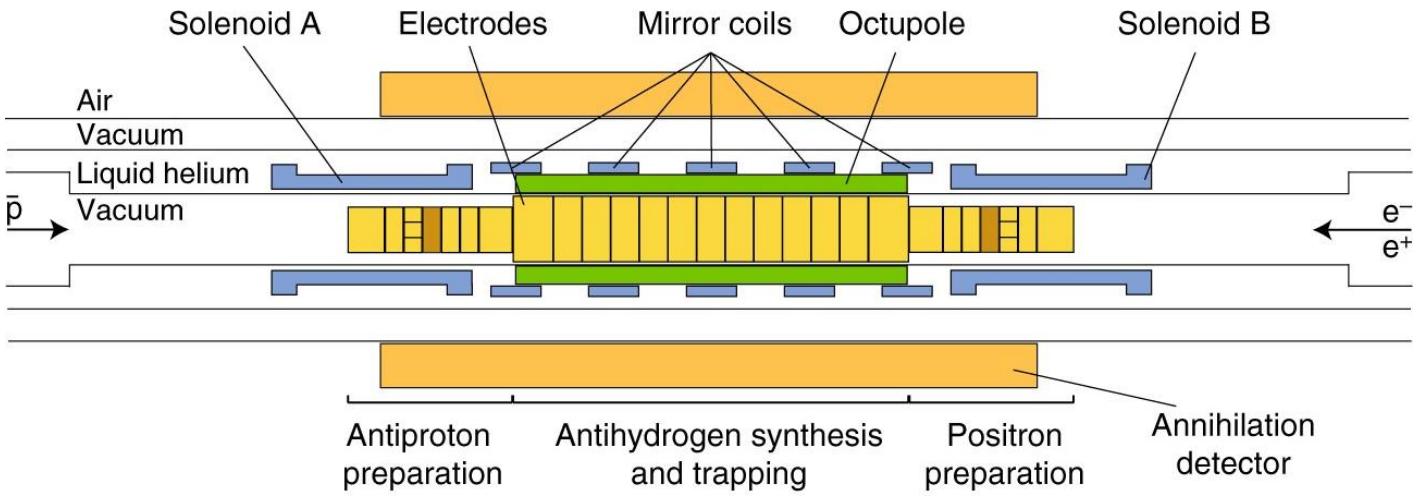
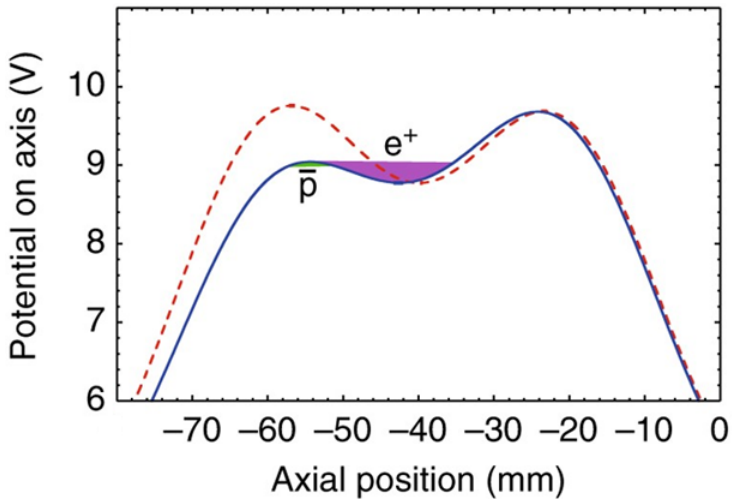
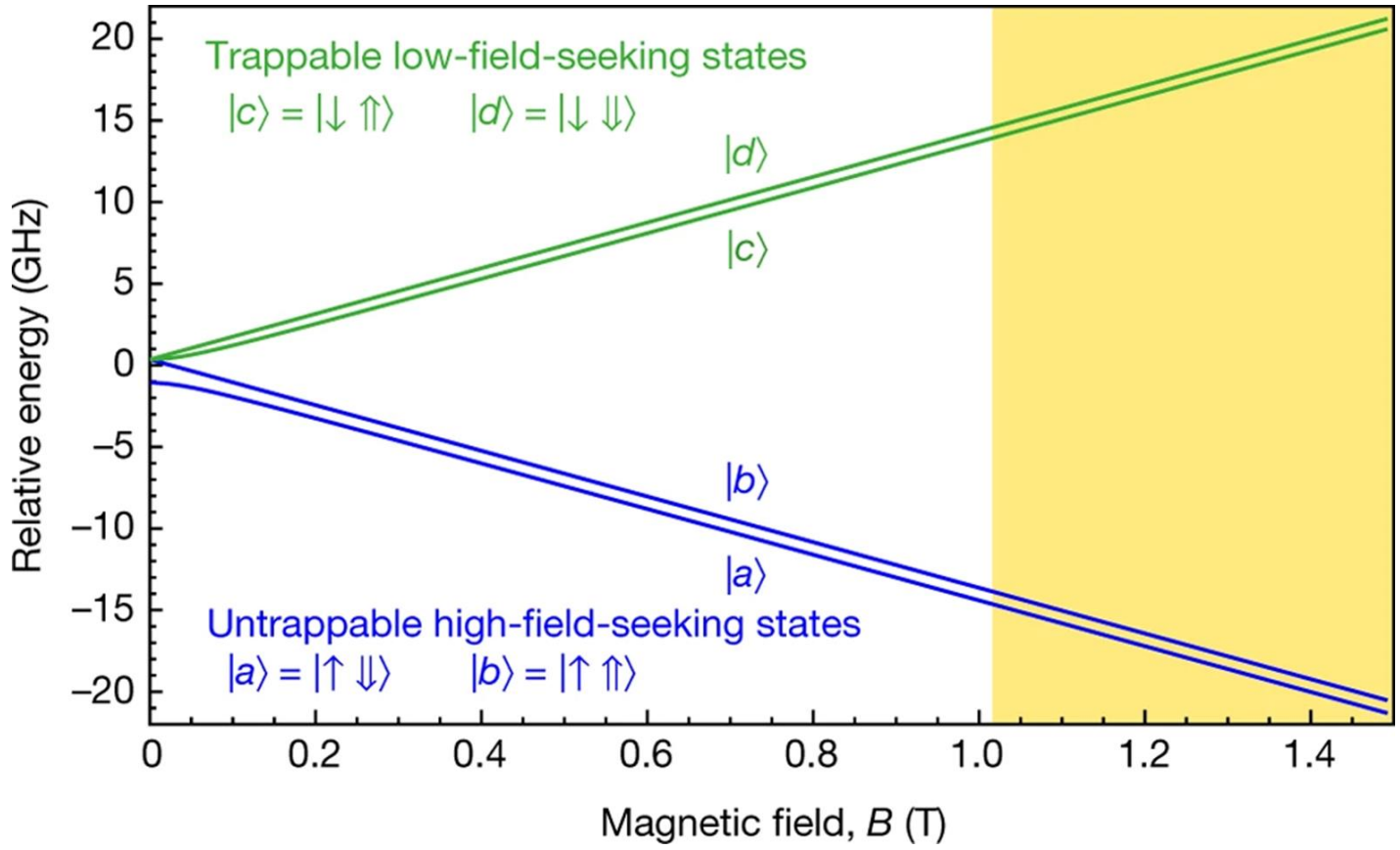


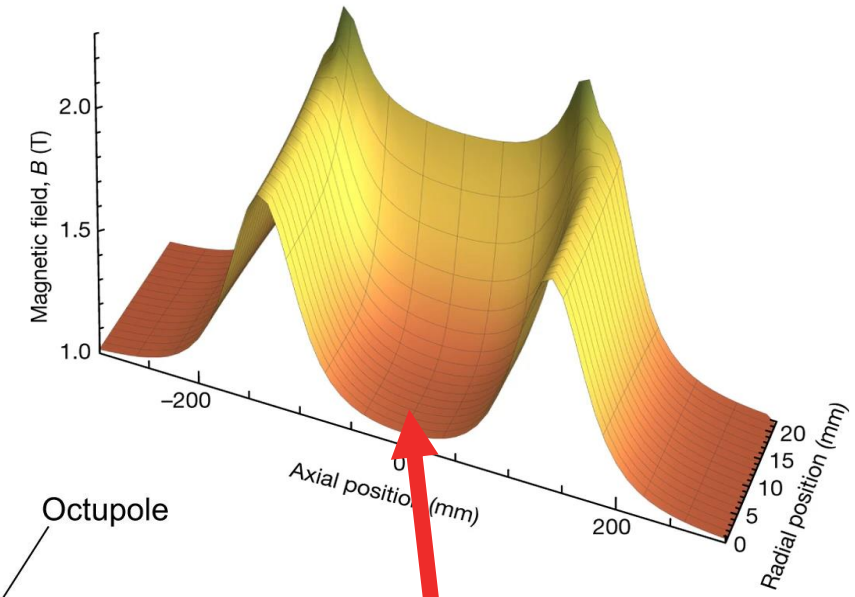


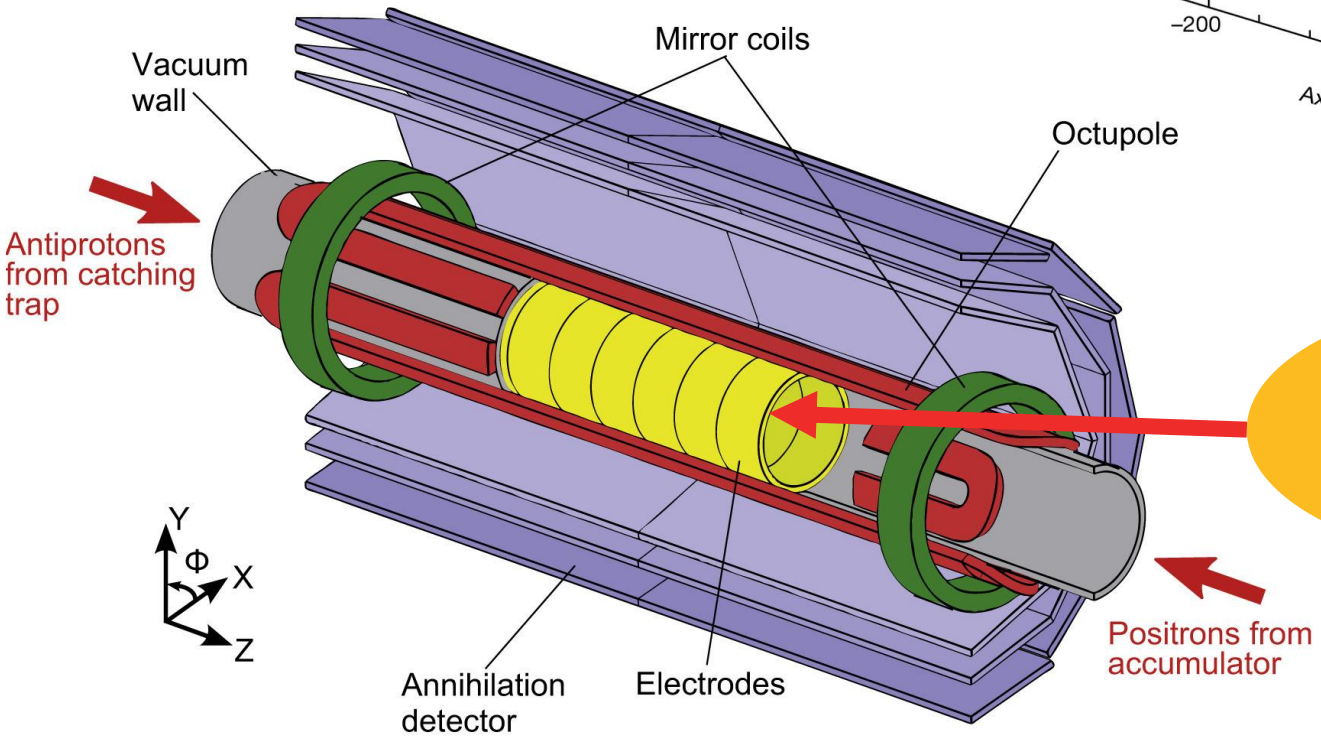
Magnetic field in Alpha-2 Penning trap



Magnetic trap for neutral antihydrogen

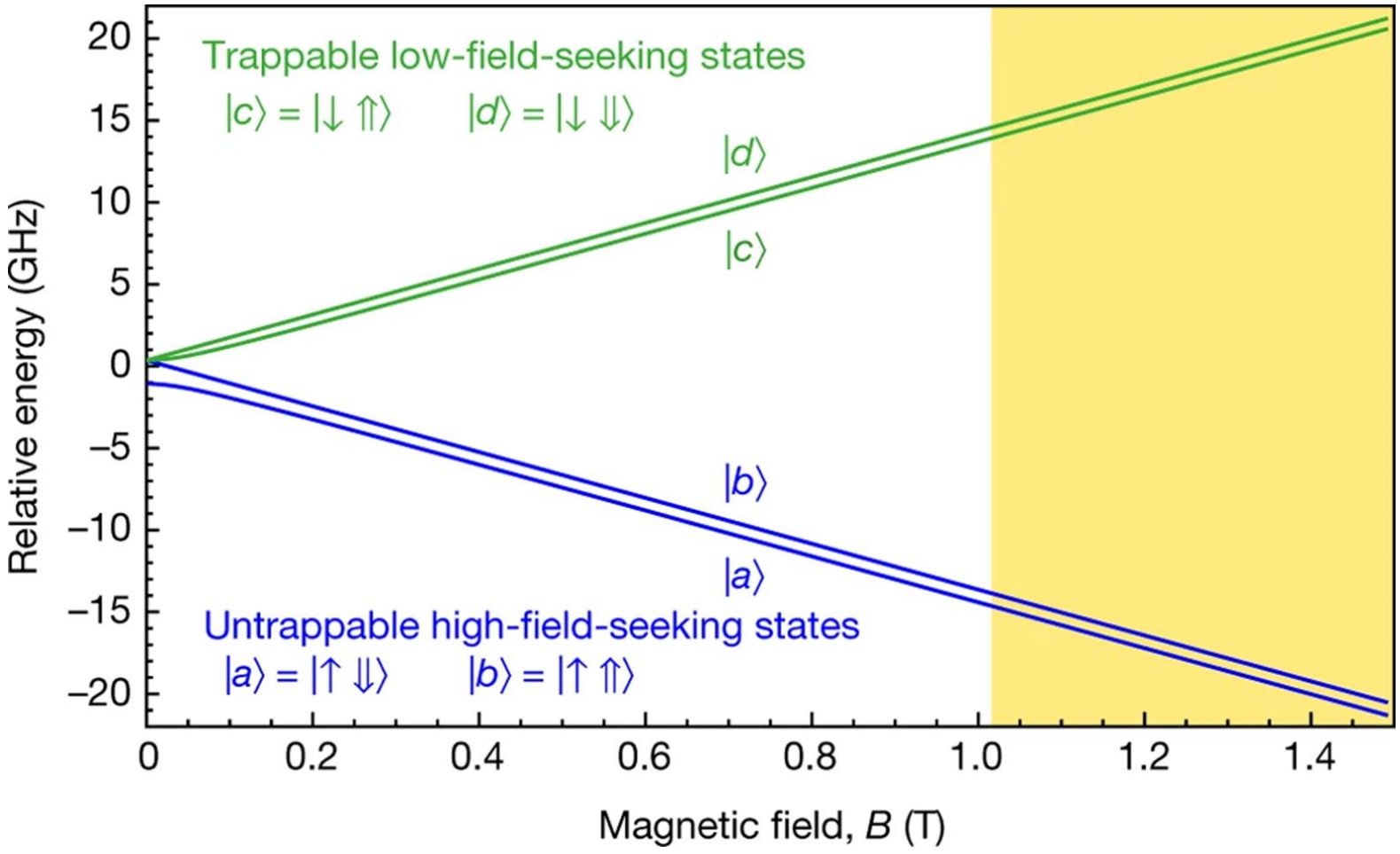
Atoms in high-field-seeking states scape and annihilate with the walls of the trap



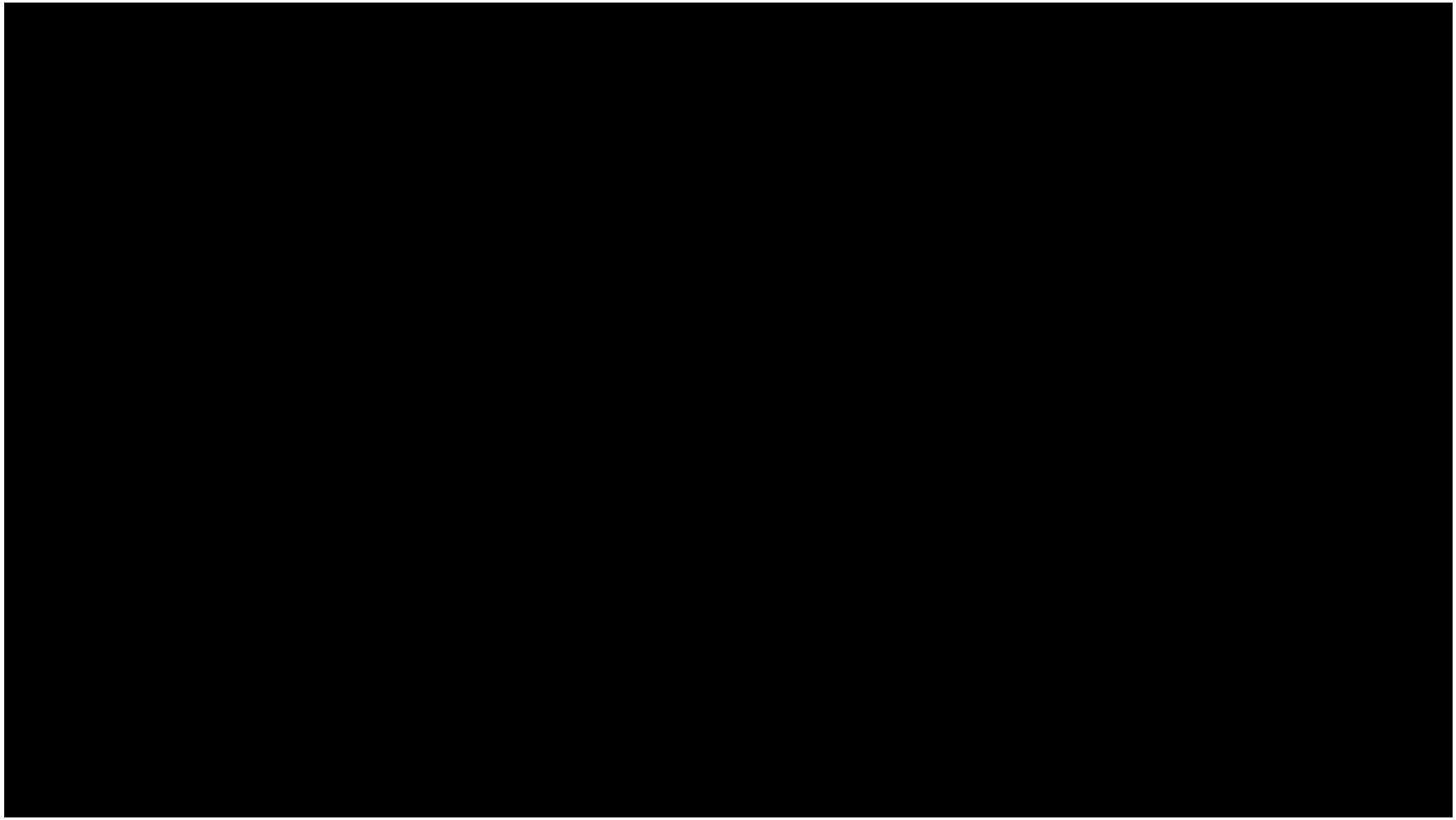


Atoms in low-field-seeking states remain trapped

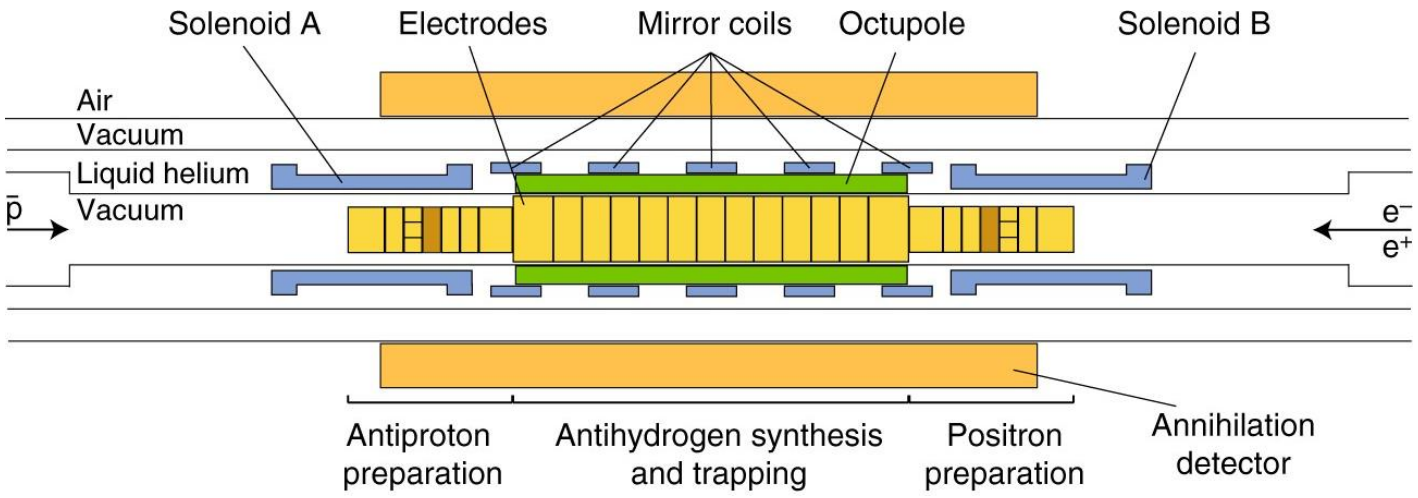
Positron Spin Resonance (PSR)

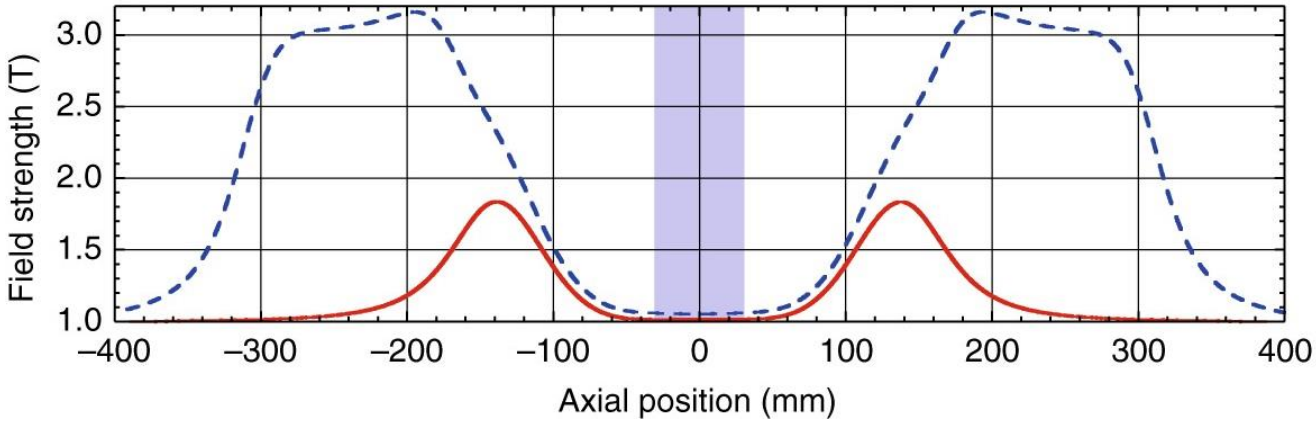


Positron spin resonance (PSR)

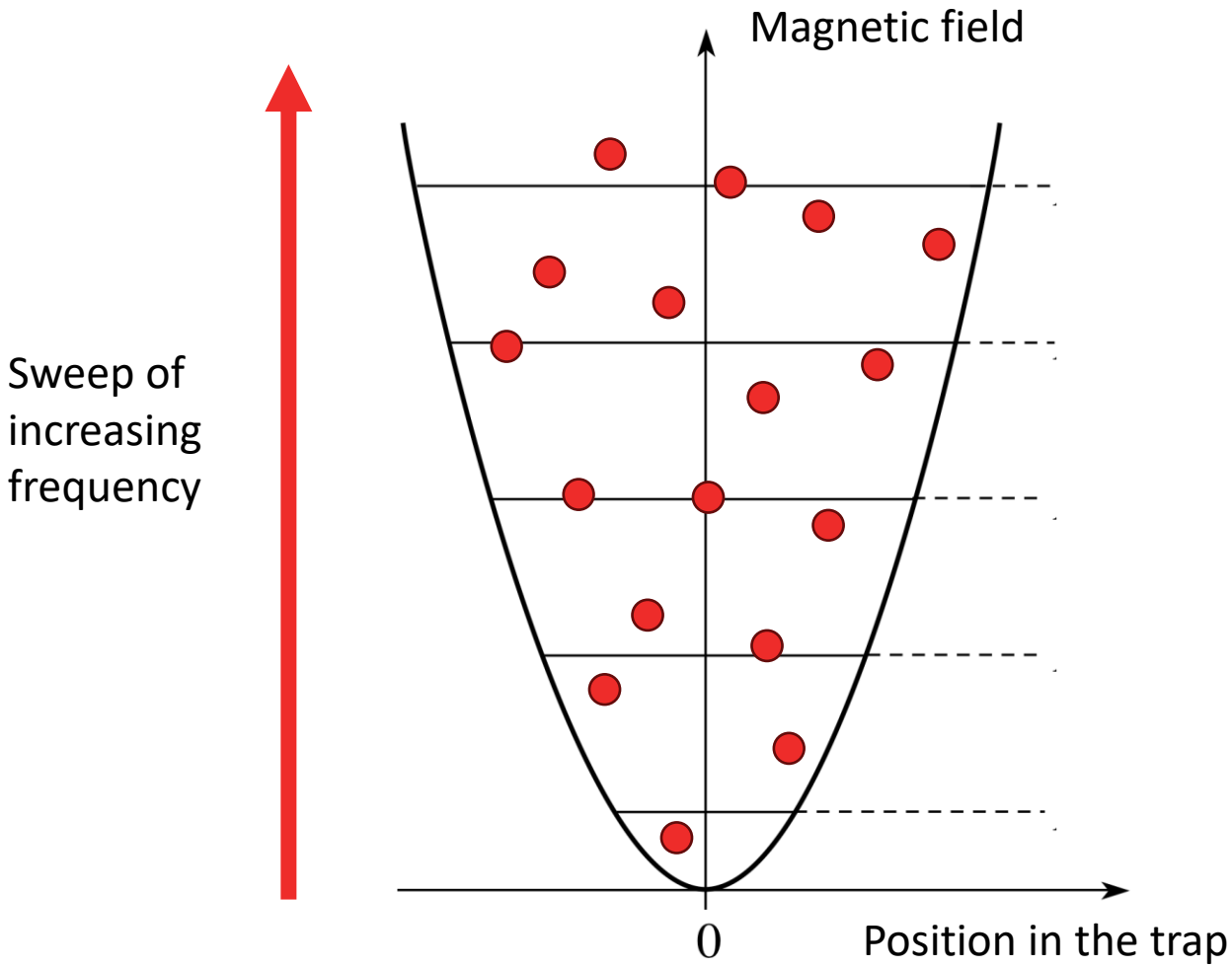


Flat magnetic field





Microwave sweep



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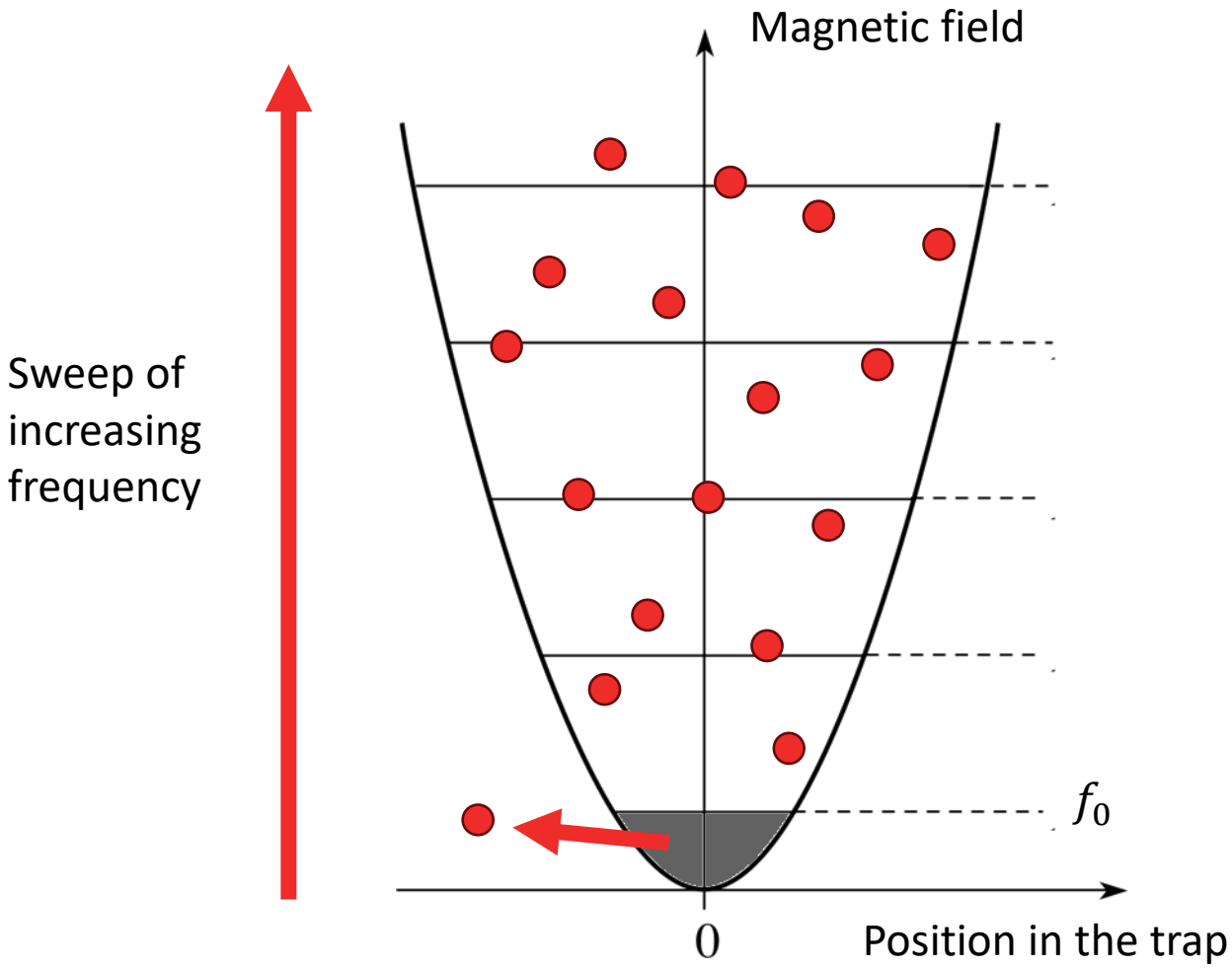

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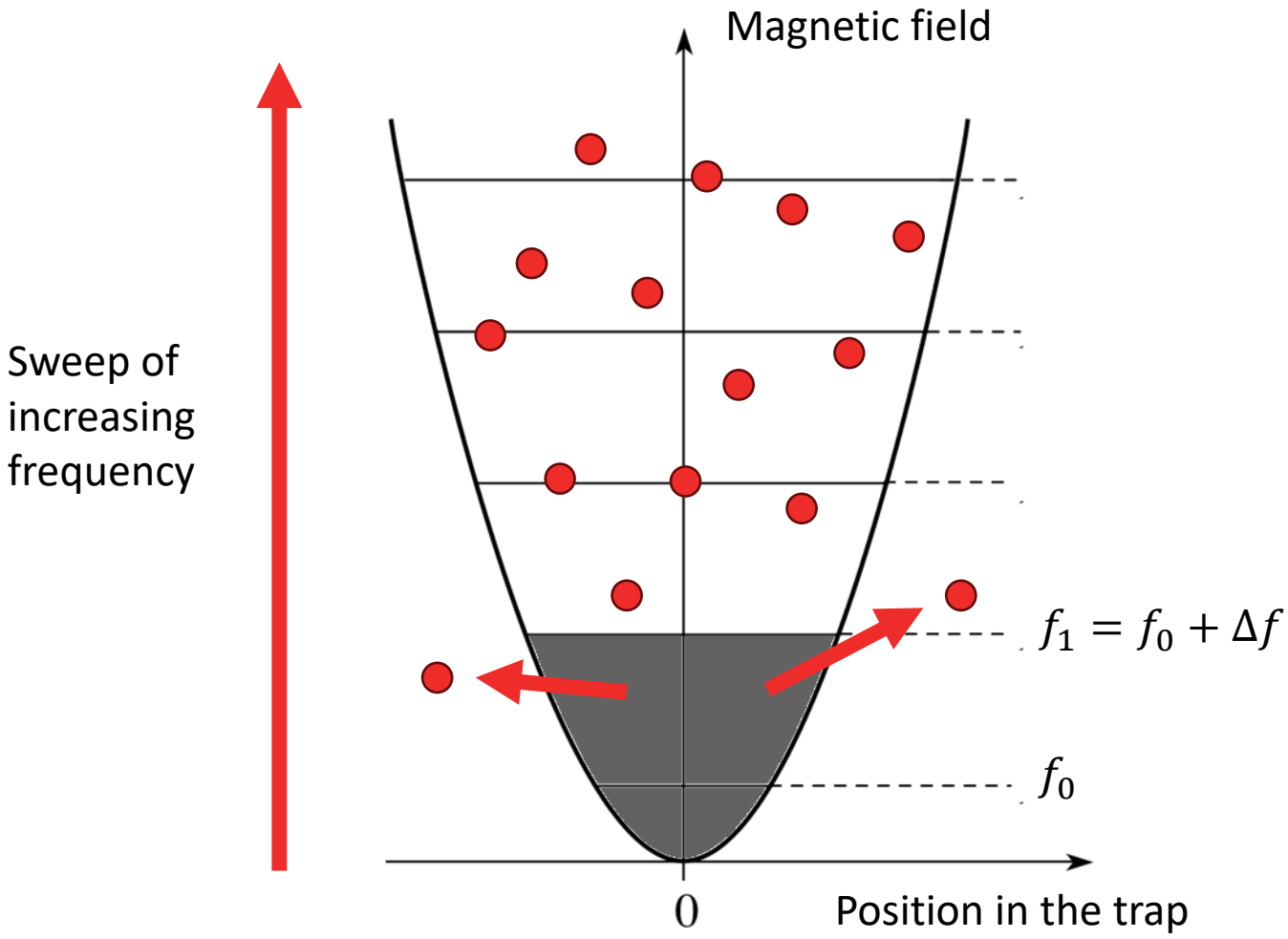

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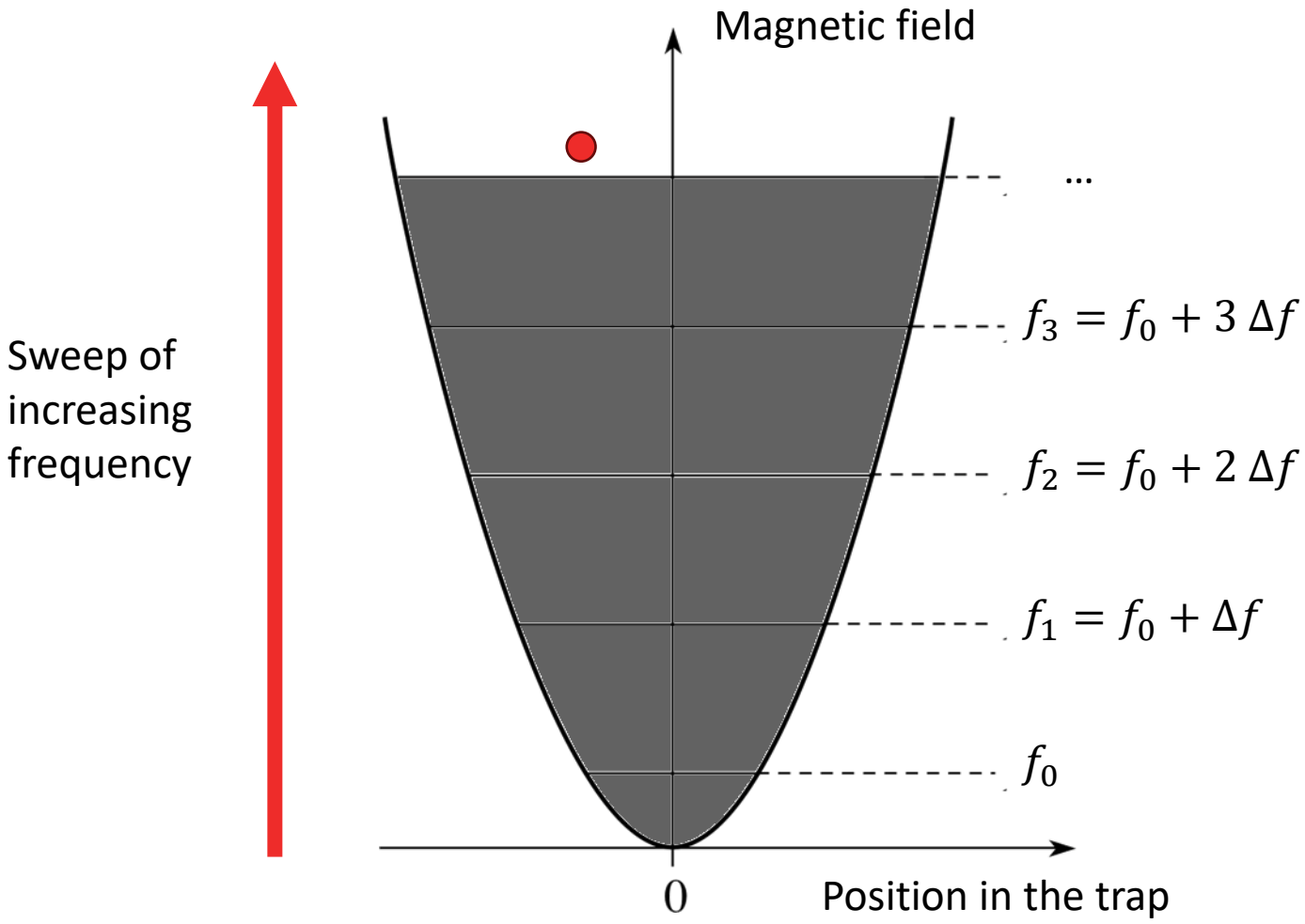
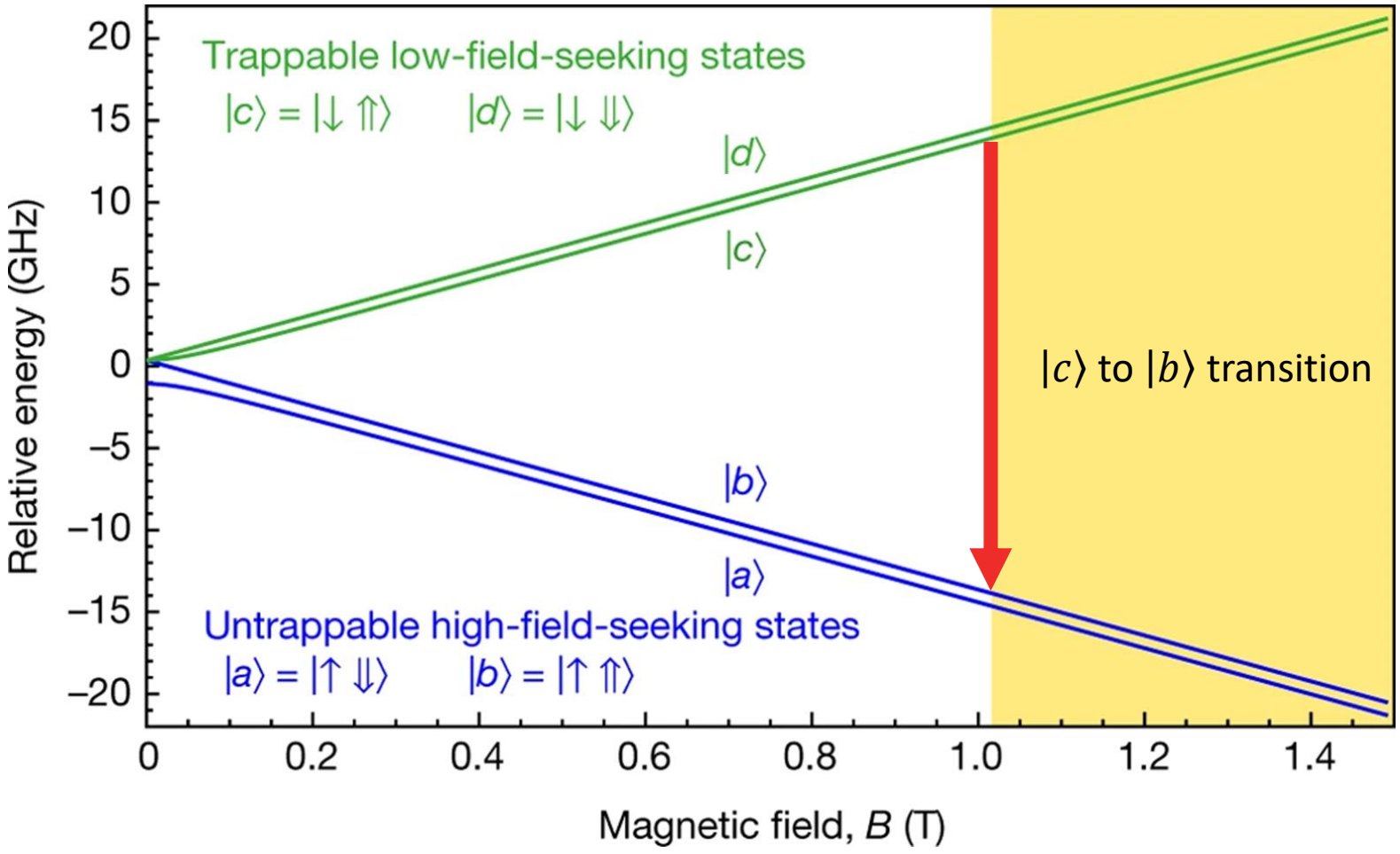


Positron Spin Resonance (PSR)



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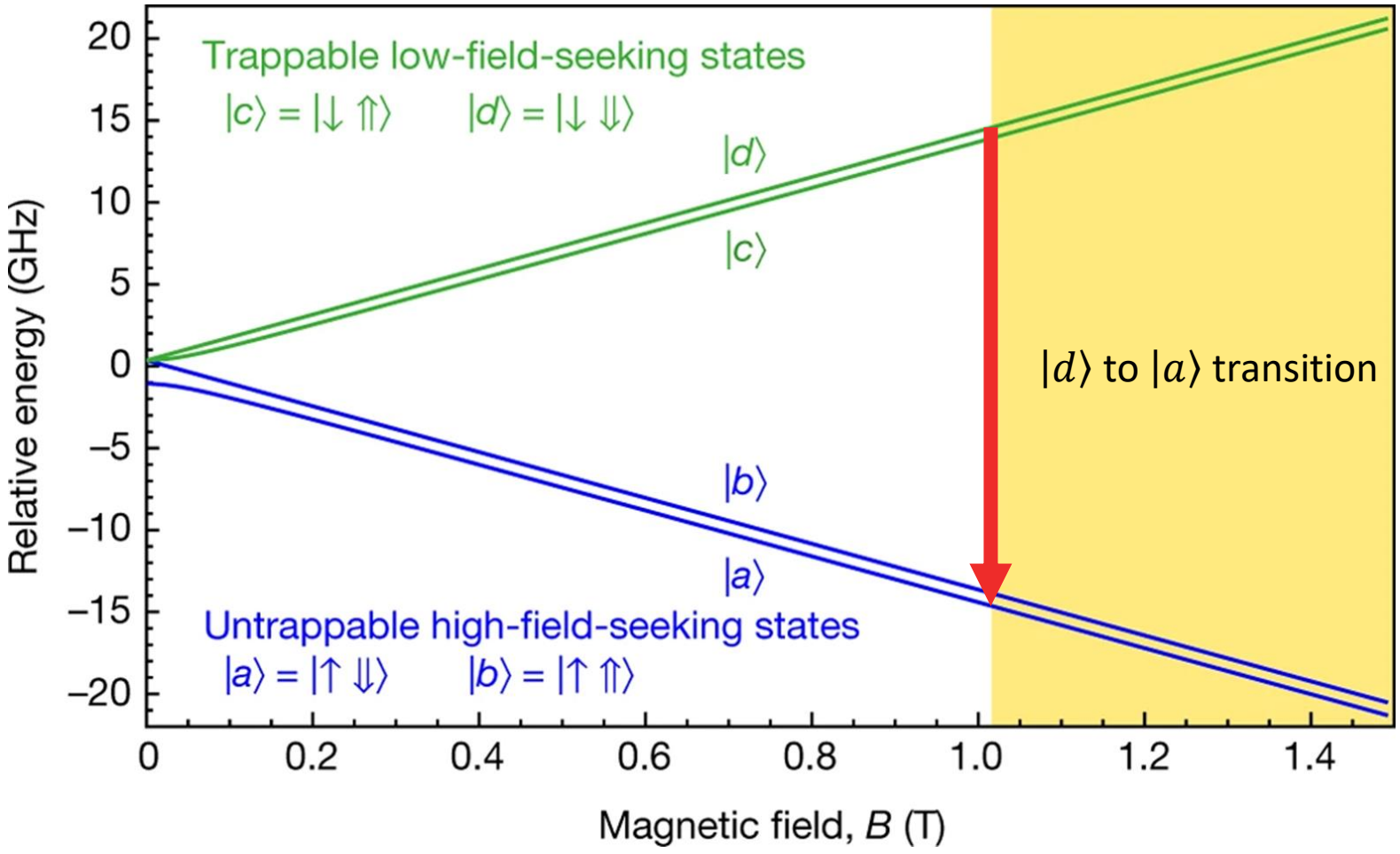
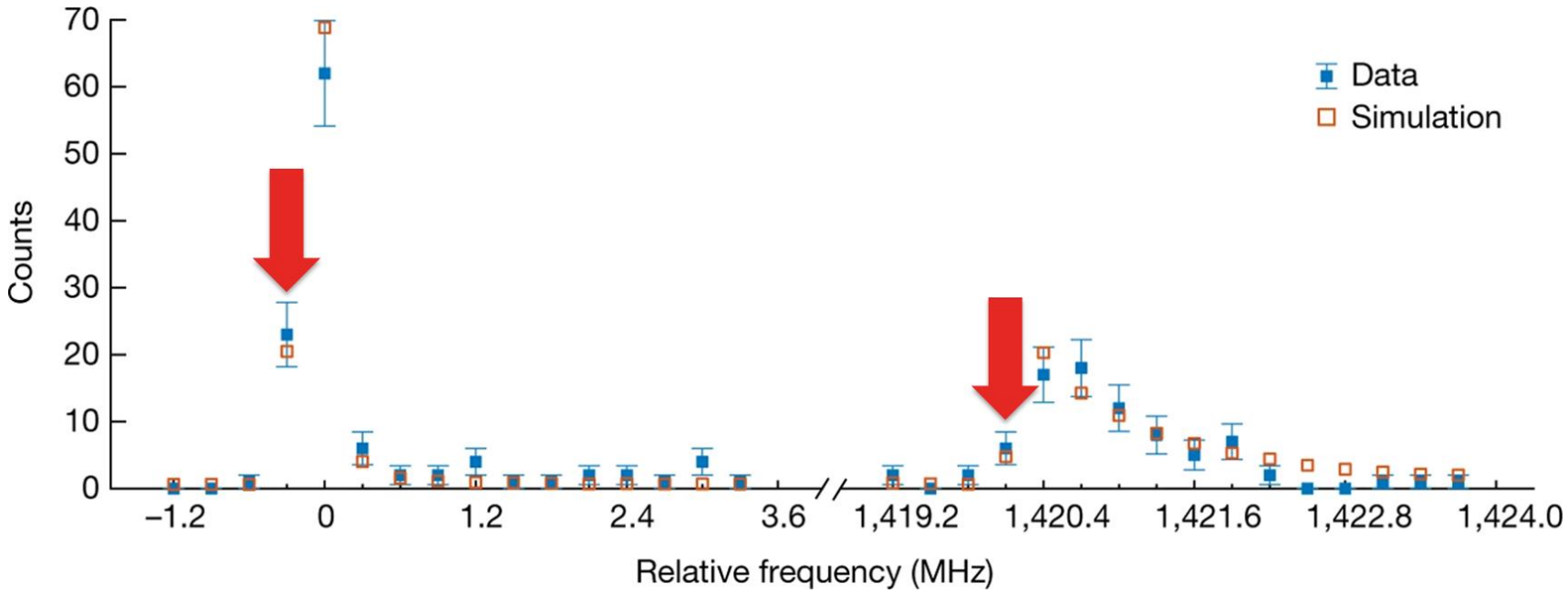
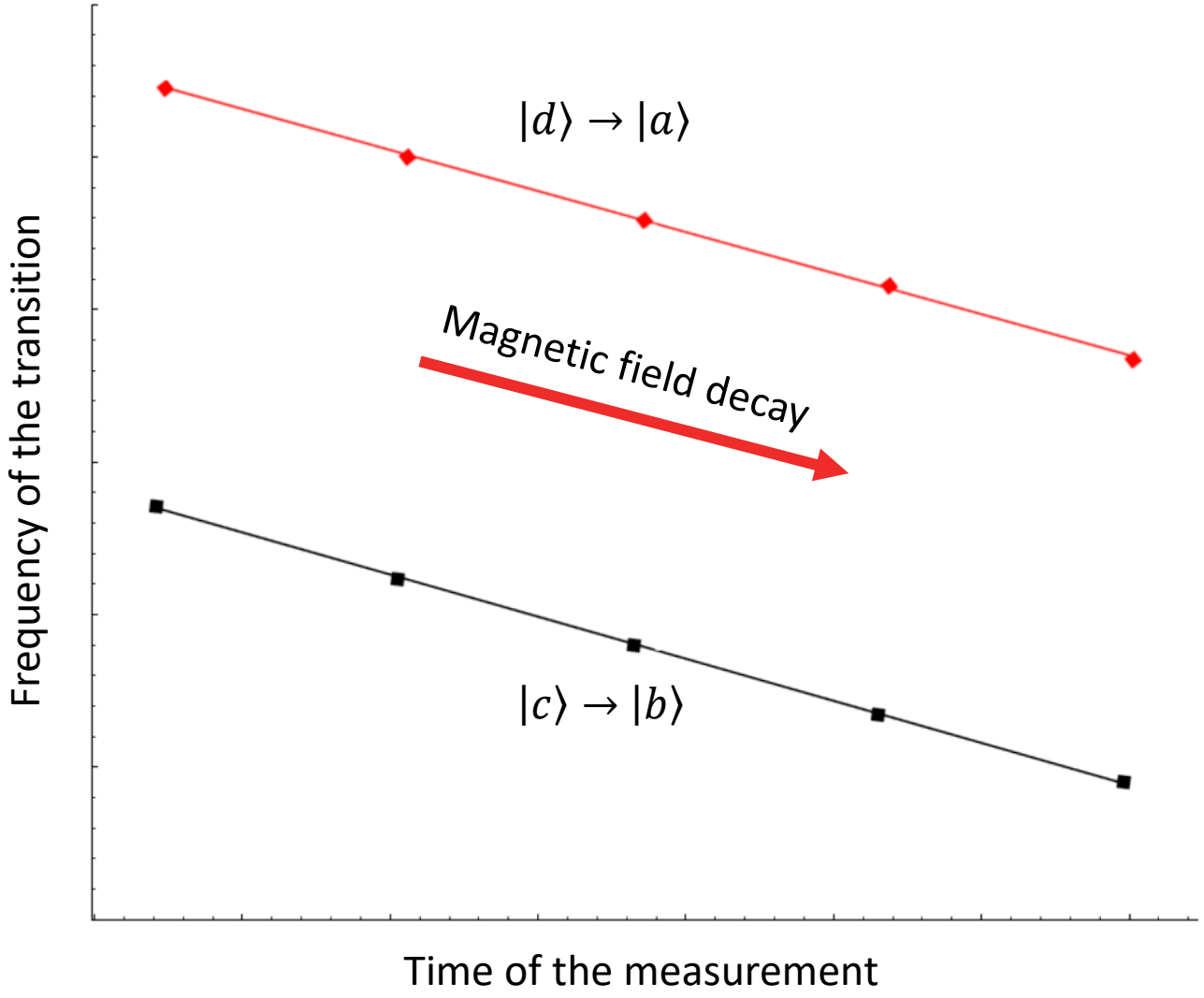


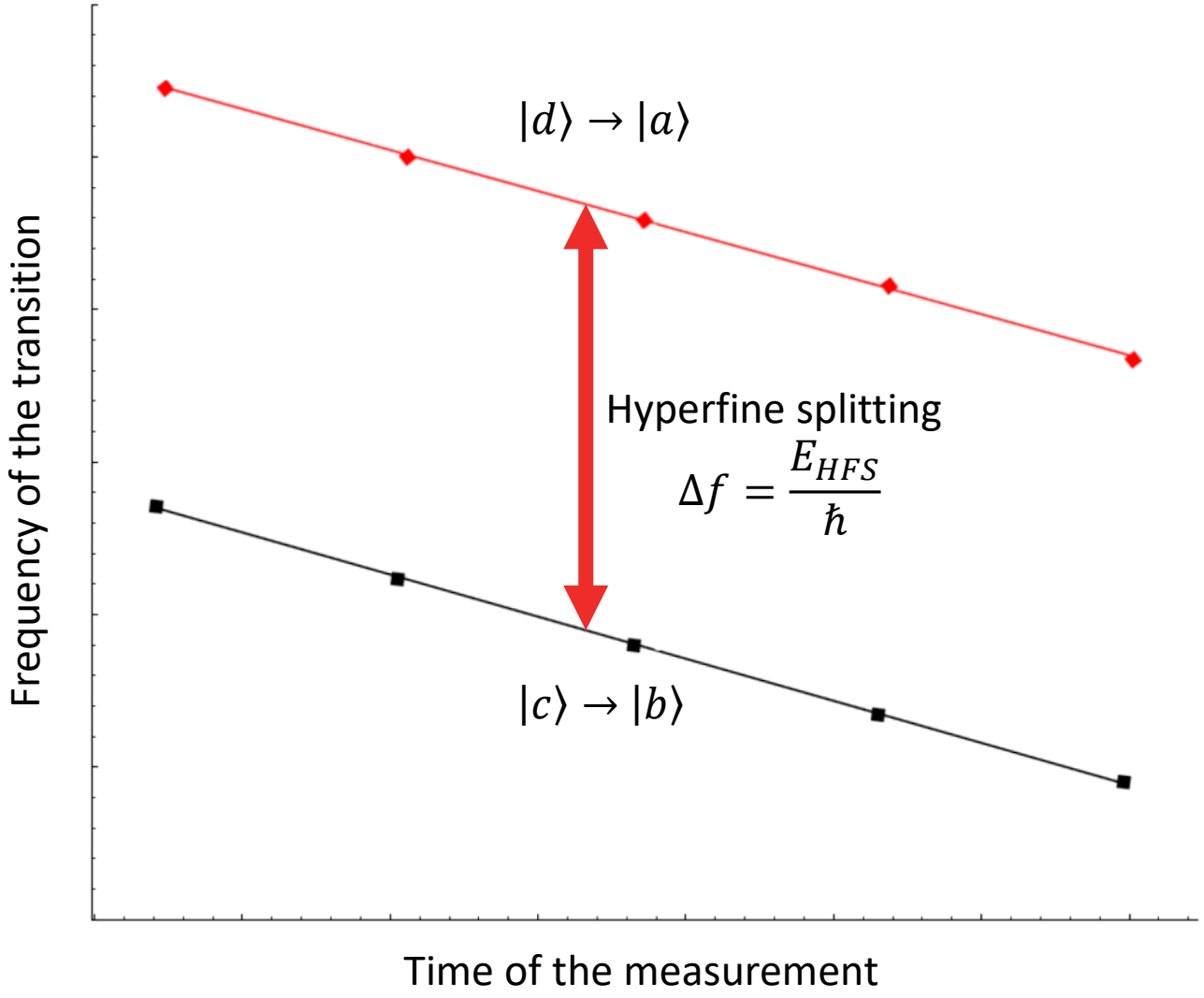
Onset finding



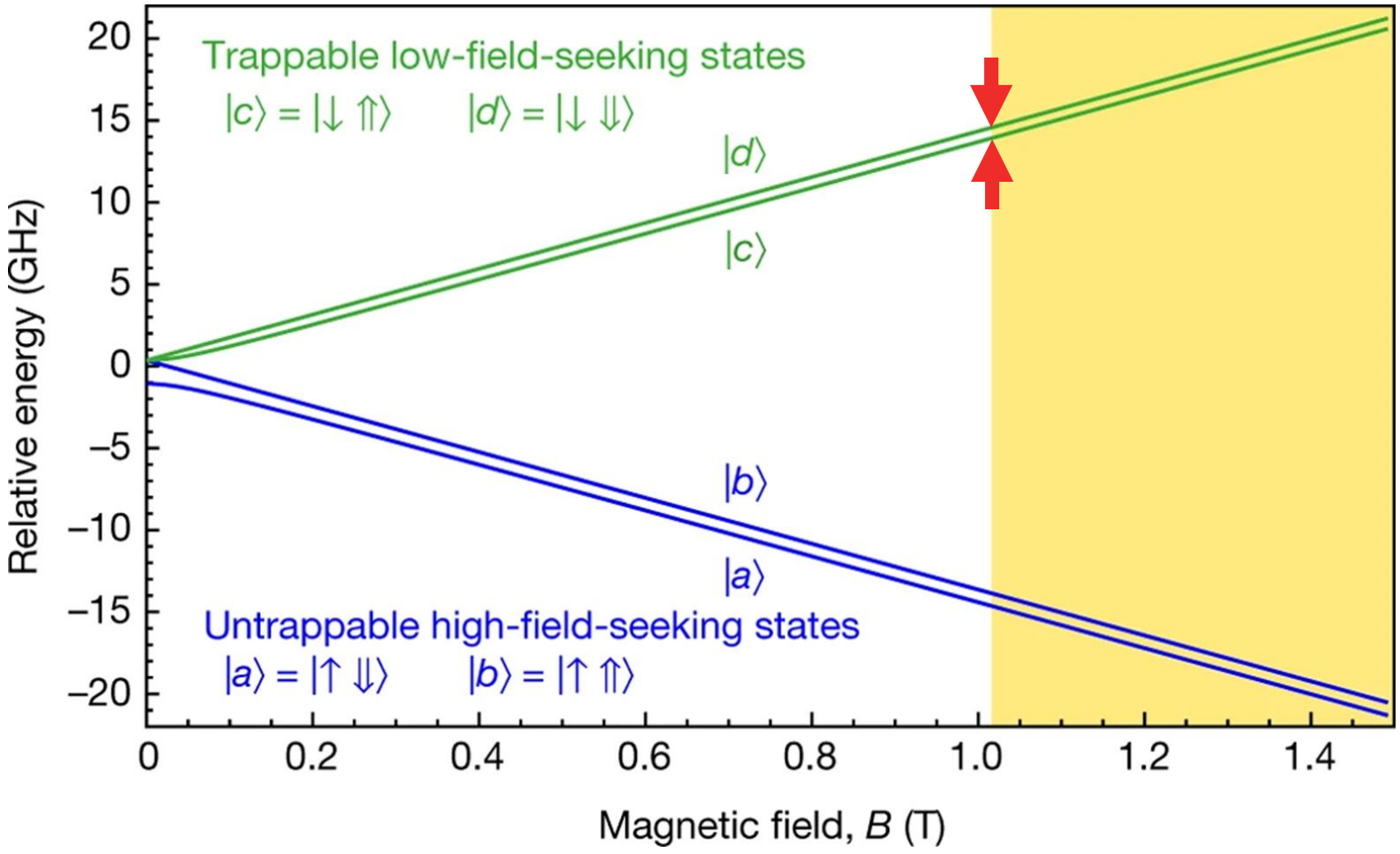
Hyperfine splitting



Hyperfine splitting



Nuclear Magnetic Resonance (NMR)

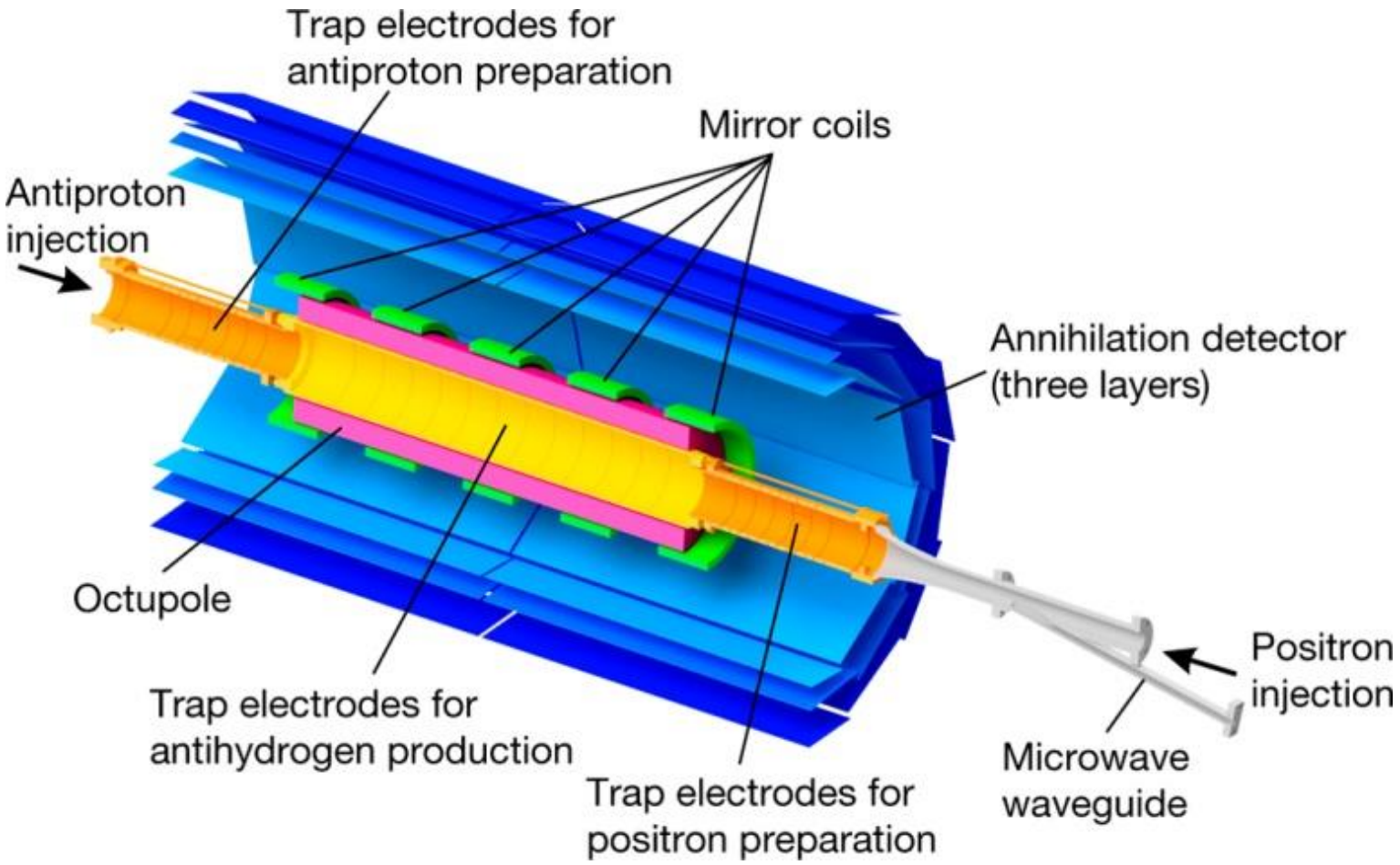


Nuclear Magnetic Resonance (NMR)

$$f_{cd} = \frac{a}{h}\left(1/2 - \frac{-\sqrt{\gamma_{\bar{p}}/\gamma_{e^+}}}{1+\gamma_{\bar{p}}/\gamma_{e^+}}\right) \approx \boxed{655MHz}$$

- a/h = Hyperfine splitting
- $\gamma_{\bar{p}}$ = antiproton gyromagnetic ratio
- γ_{e^+} = positron gyromagnetic ratio

Microwave injection



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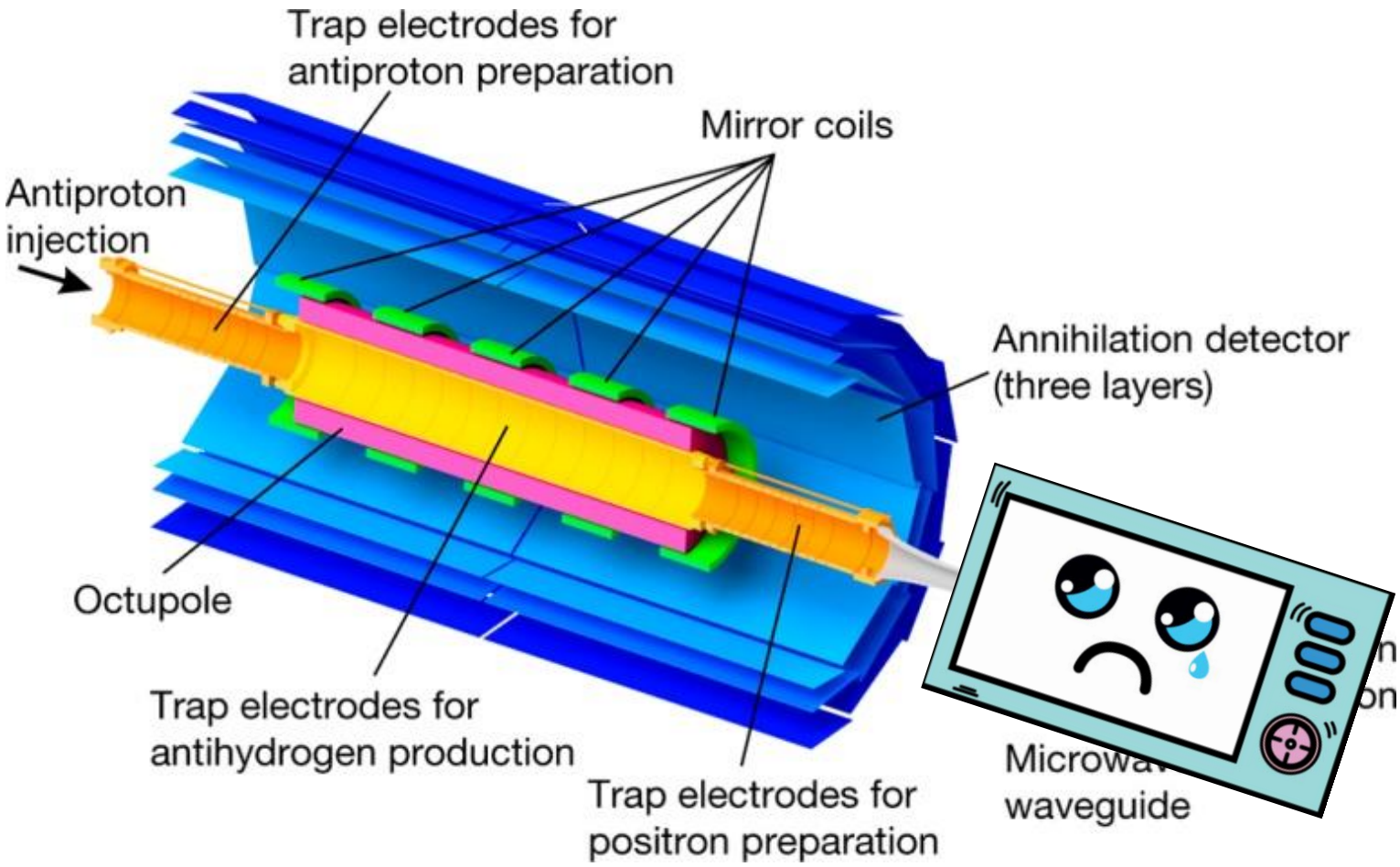
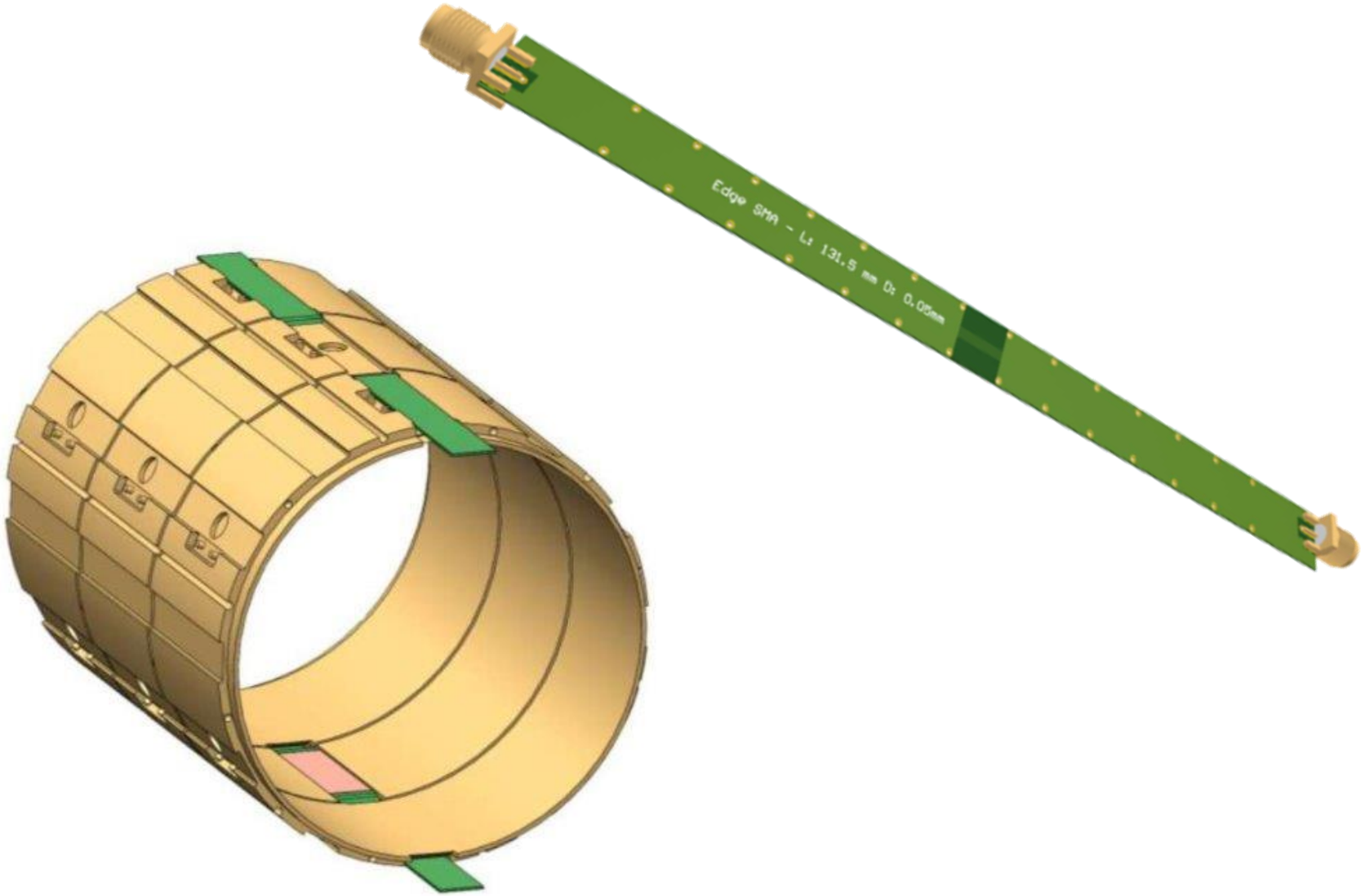
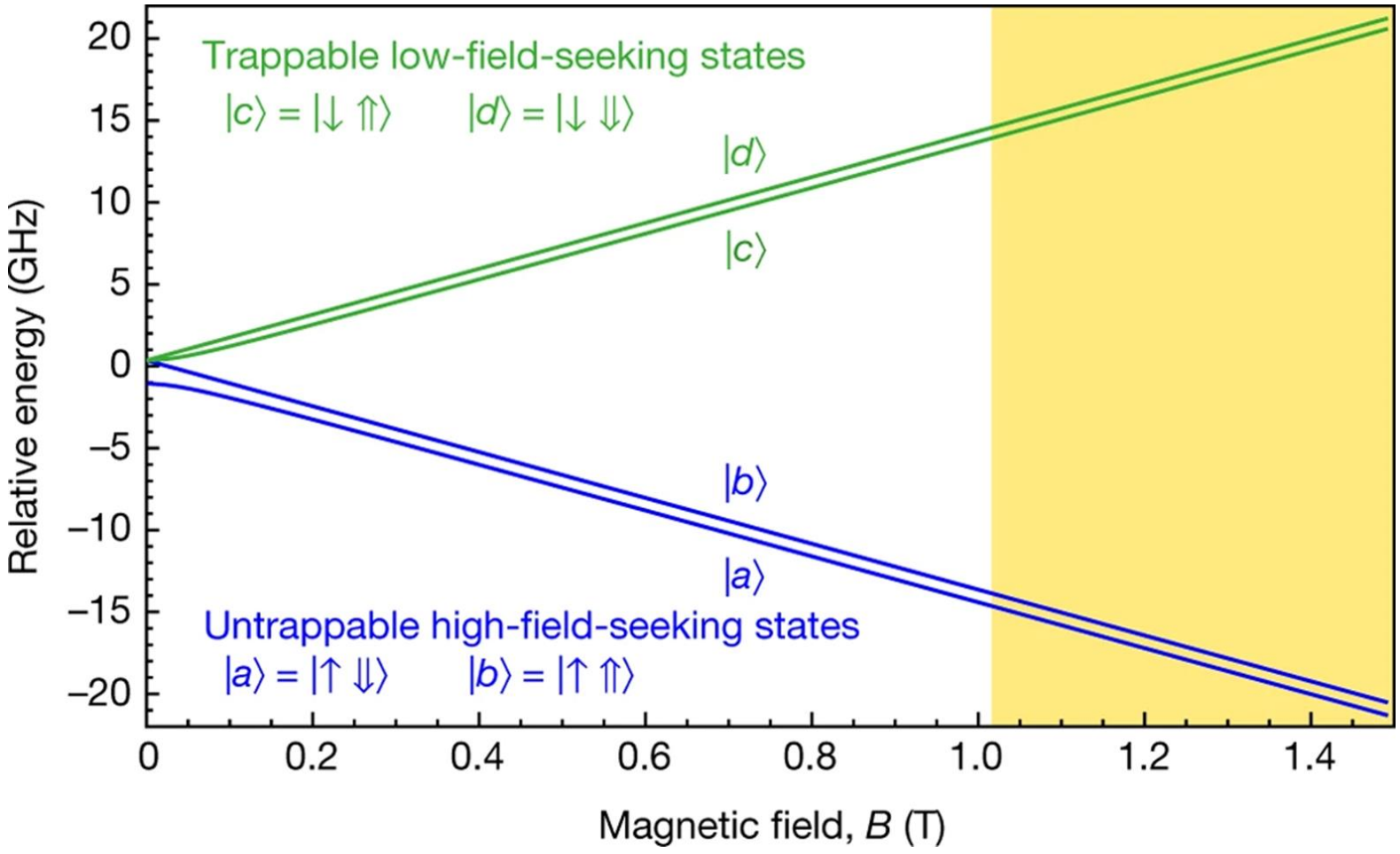


NMR electrode



NMR transition measurement



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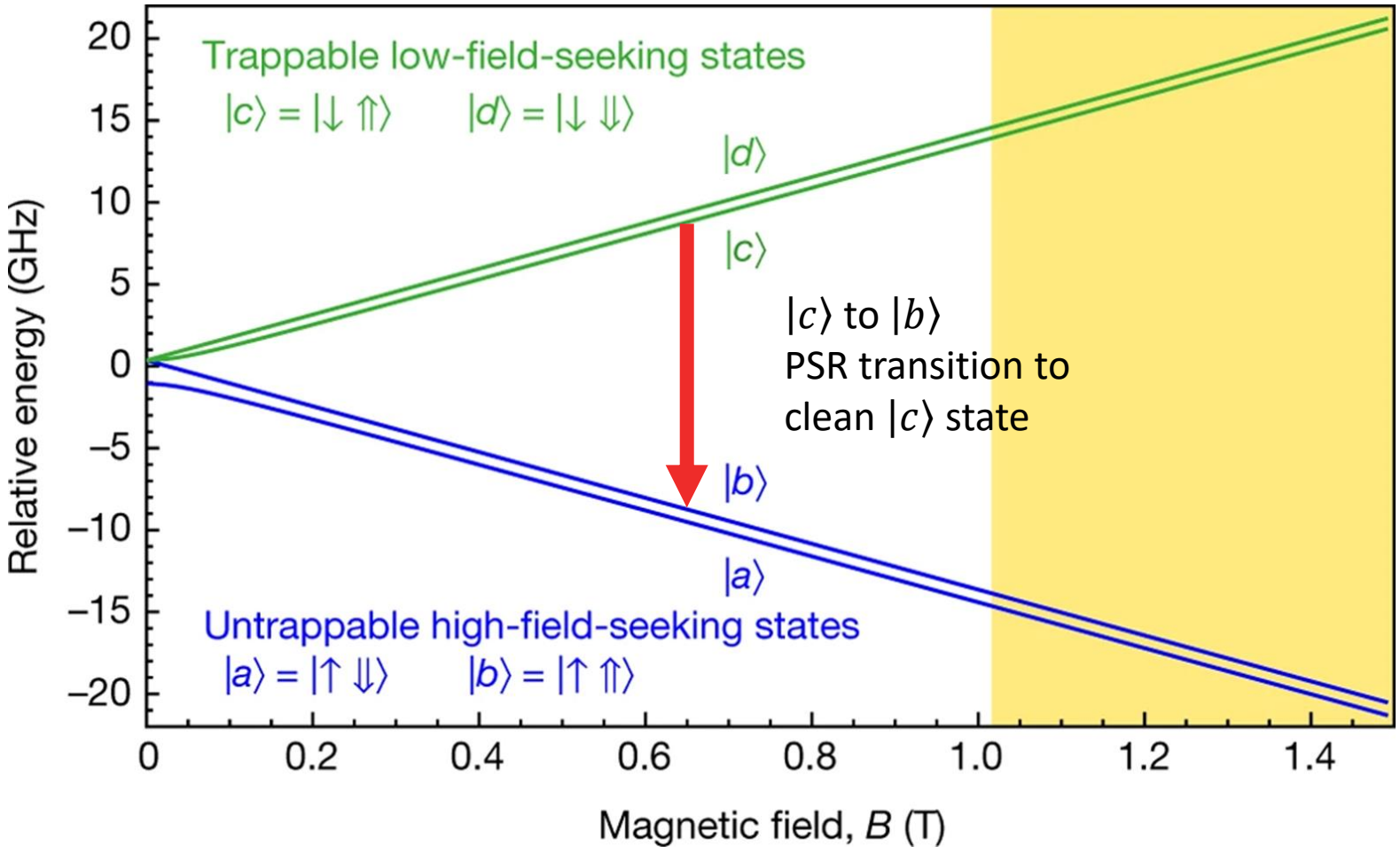

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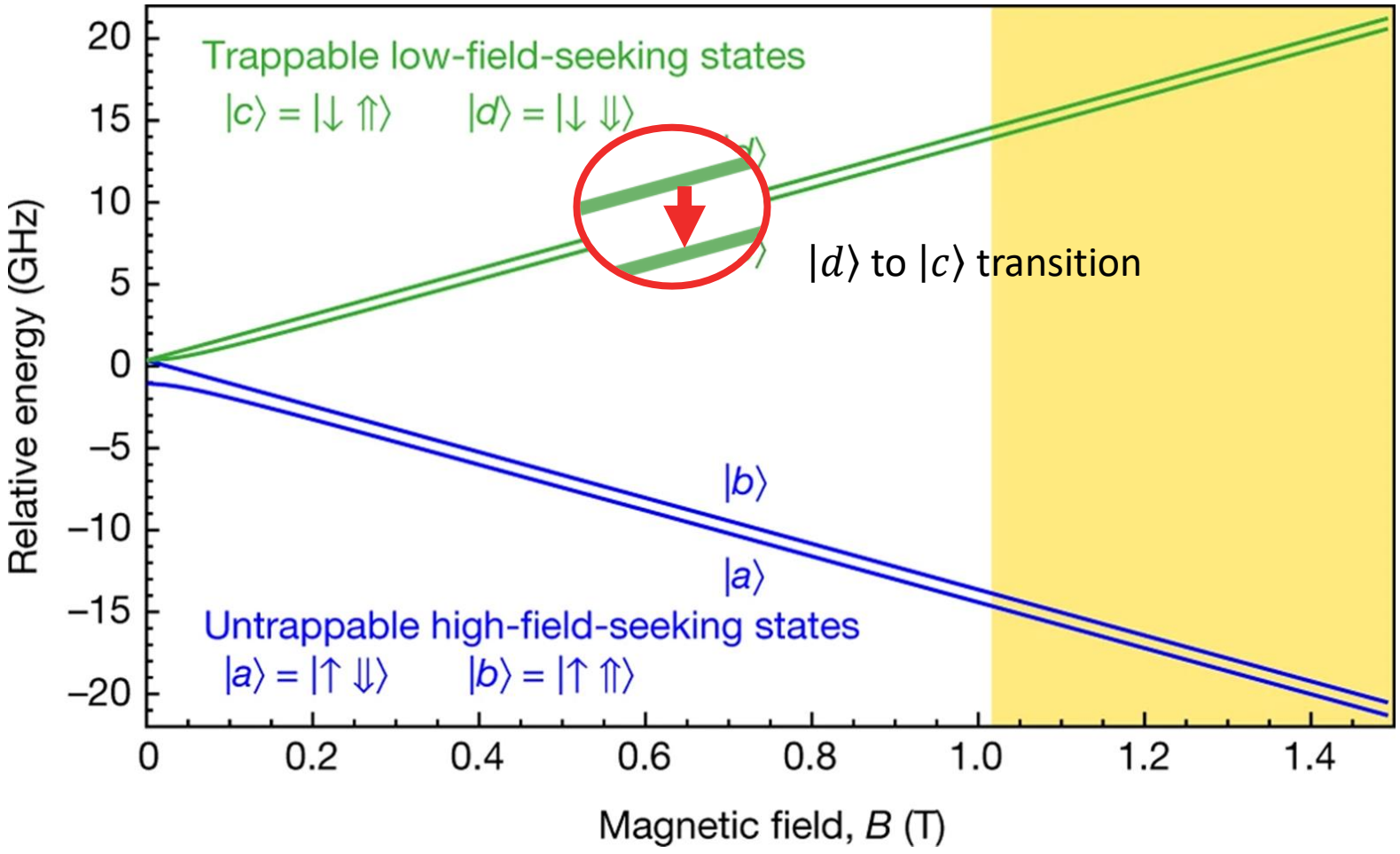

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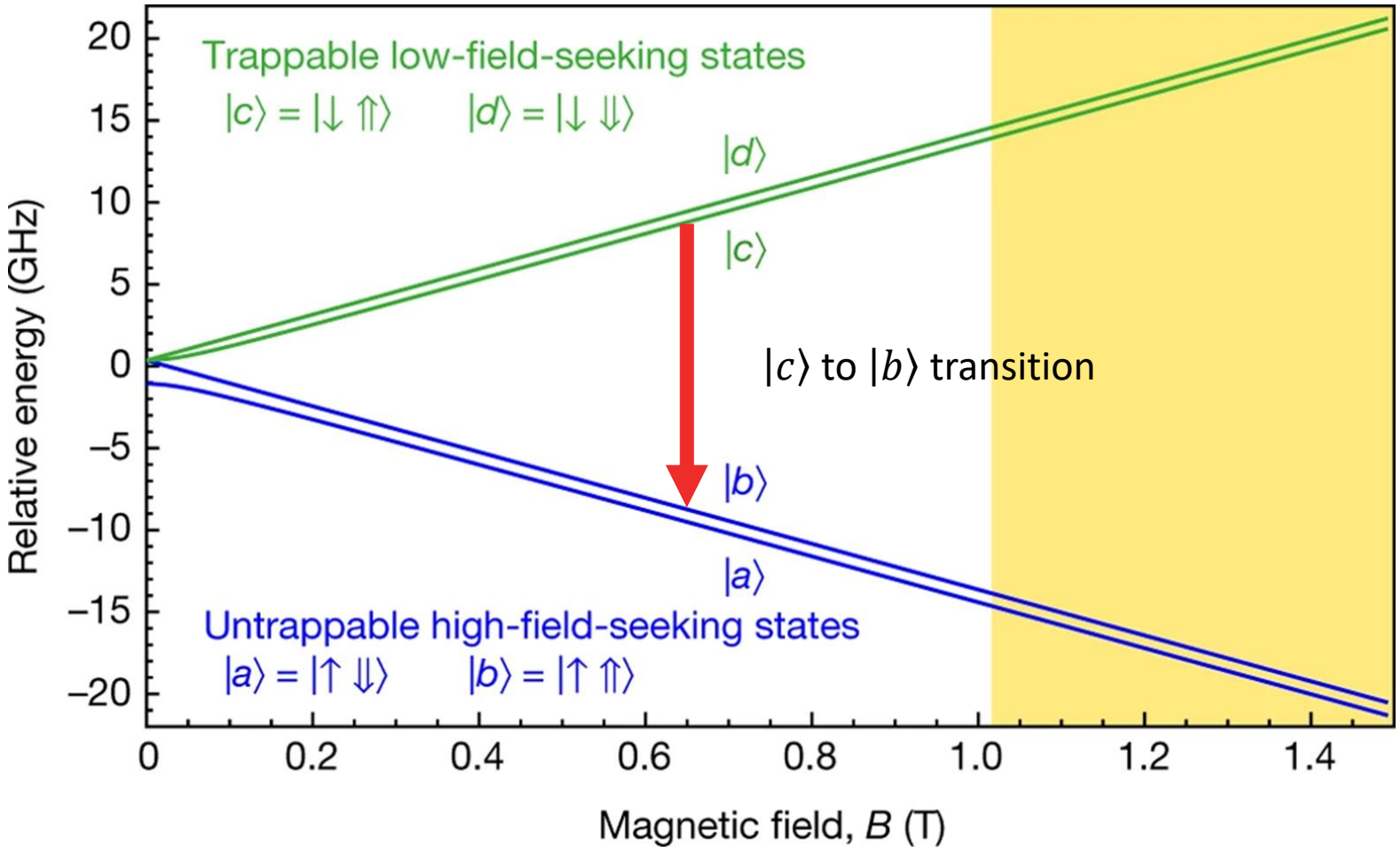


Thank you!

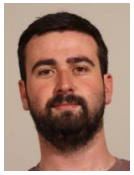

Prof. Timothy Friesen


Prof. Michael Hayden

PI


Alberto Uribe

Postdoc


Adam Powell


Pouya Heidari

PhD


Abbygale Swadling


Jay Suh

Graduated student