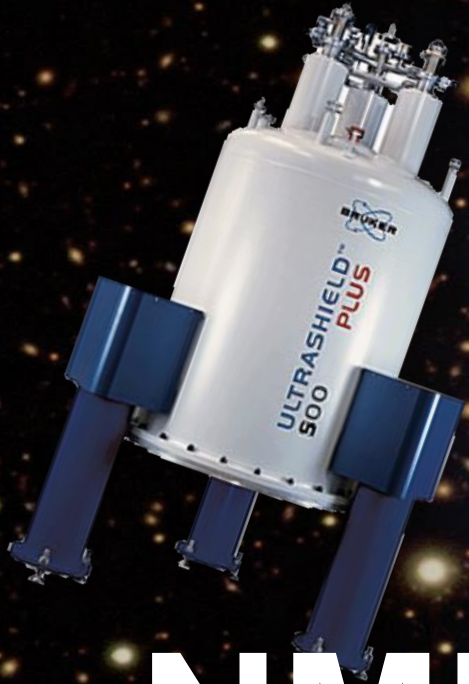


Status of the Cosmic Axion Spin Precession Experiment (CASPEr)



NMR Meets Dark Matter

Marina Gil Sendra,
for the CASPEr collaboration



Axion – spin couplings

CASPEr – Wind:

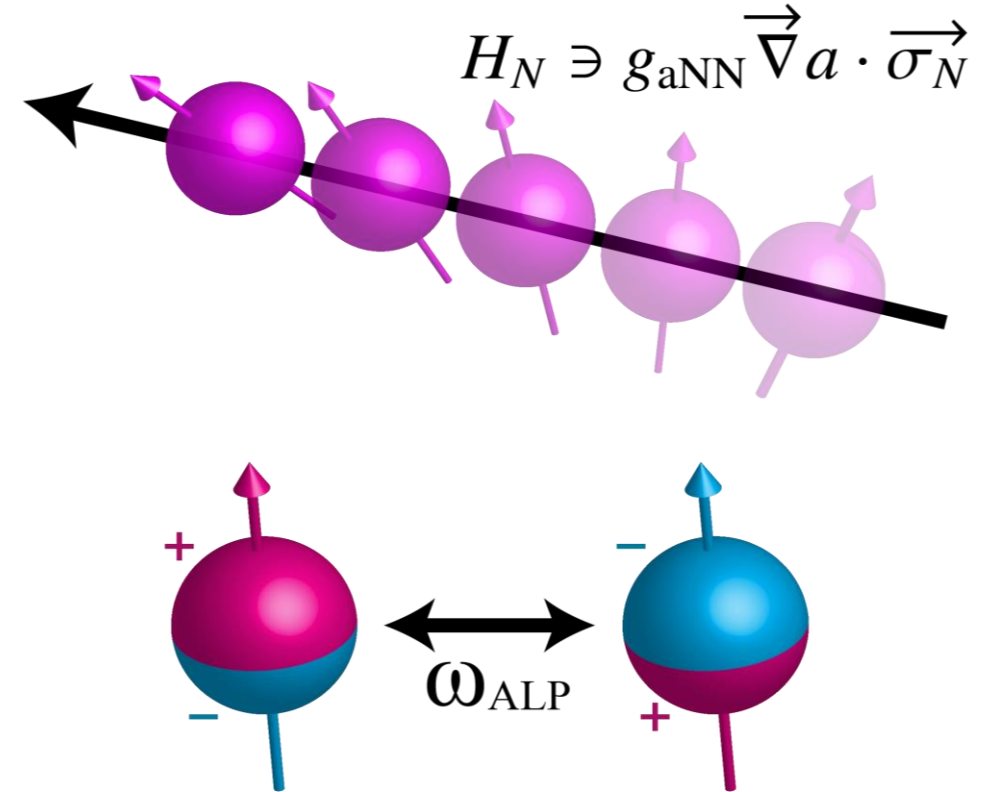
- ALP-nuclear spin couplings
- same as magnetic field coupling to spins
- induces precession

$$\mathbf{B}_{ALP} \approx g_{aNN} \sqrt{2\rho_{DM}} \cos(m_a t) \mathbf{v}_{ALP}$$

CASPEr - Electric:

- ALP induce oscillating nuclear electric dipole moment

$$\mathbf{d}(t) \cdot \mathbf{E} \leftrightarrow \boldsymbol{\mu} \cdot \mathbf{B}(t)$$



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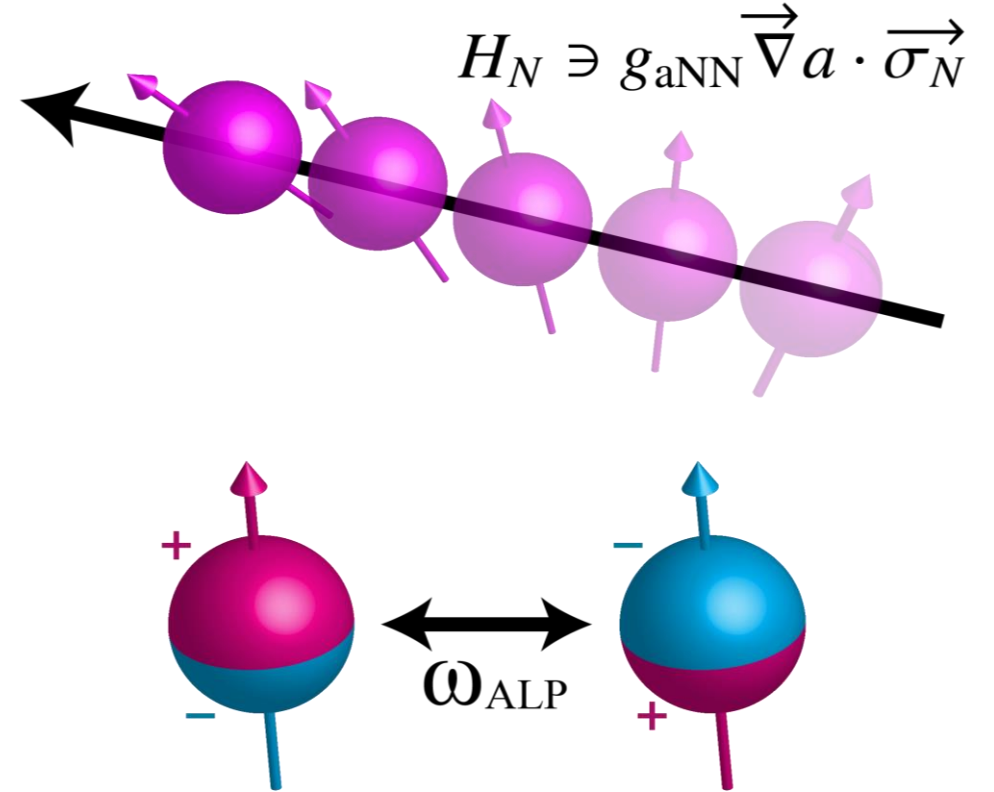
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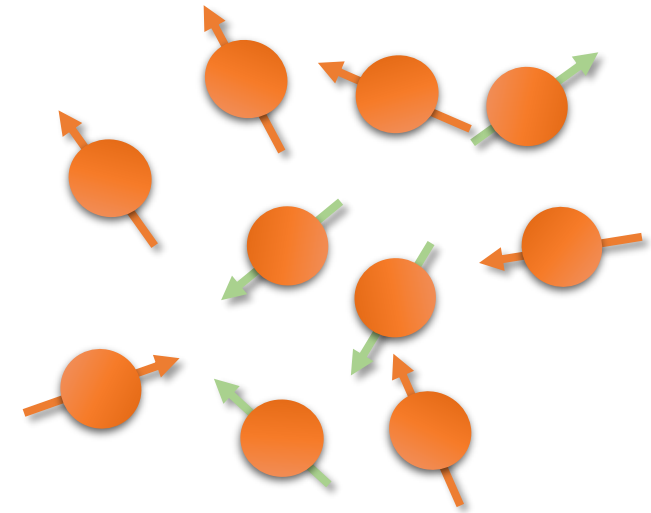


CASPEr looks for any kind of “wavy” dark matter that couples to nuclear spins

Nuclear Magnetic Resonance

1. Nuclei with $\mathbf{I} \neq \mathbf{0}$
2. In a magnetic field \rightarrow Spins precess
3. General magnetization \vec{M} (**polarization**)
4. Apply \vec{B}_1 **oscillating transverse** field
5. When $\omega_1 = \omega_L \rightarrow$ spins are tilted
6. We get **transverse magnetization**

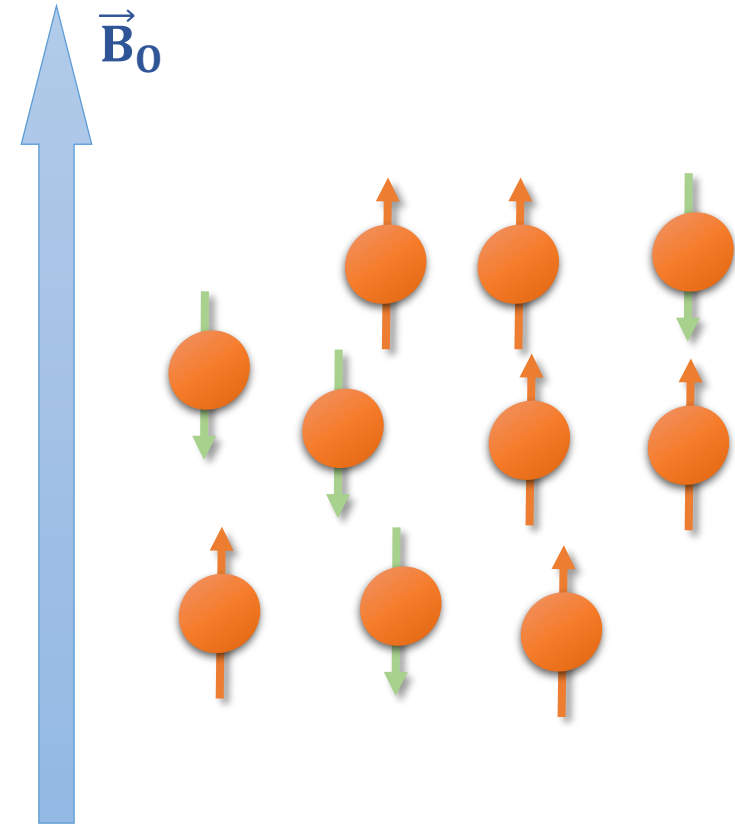
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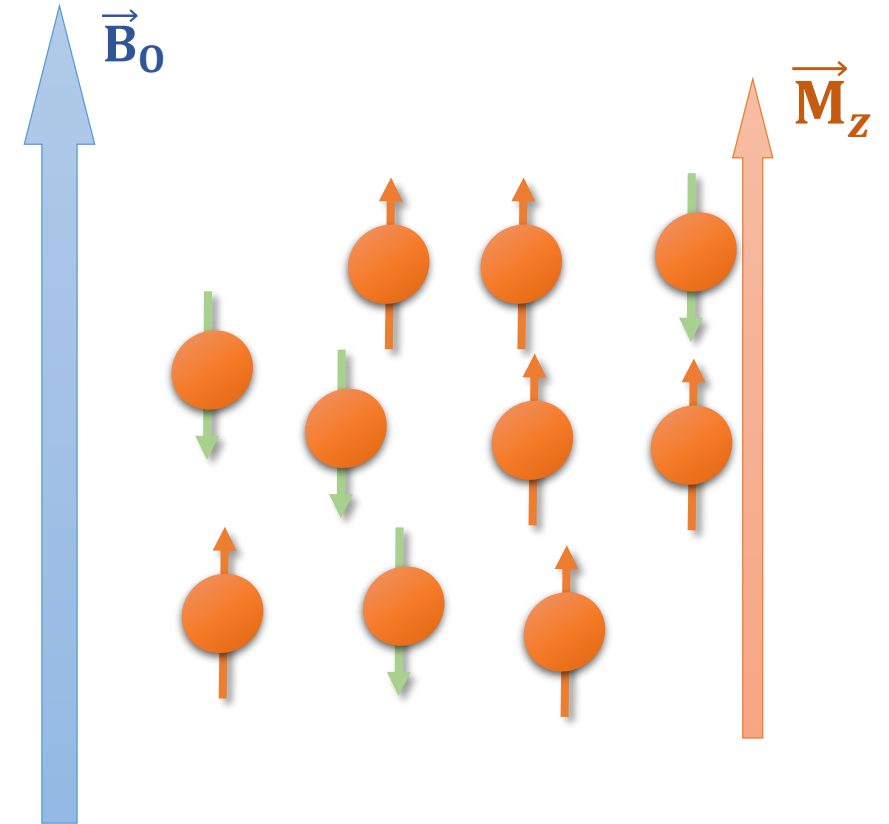
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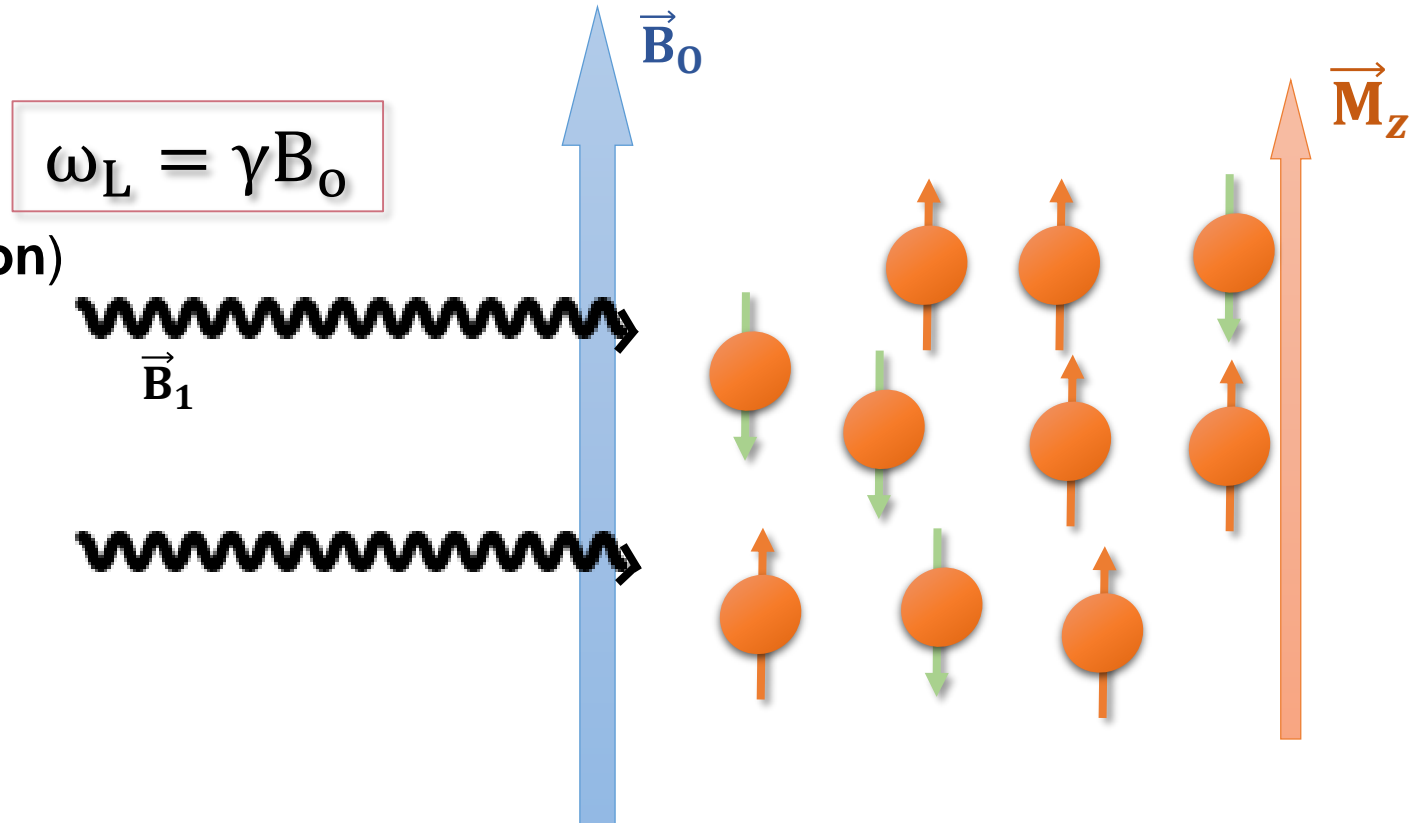
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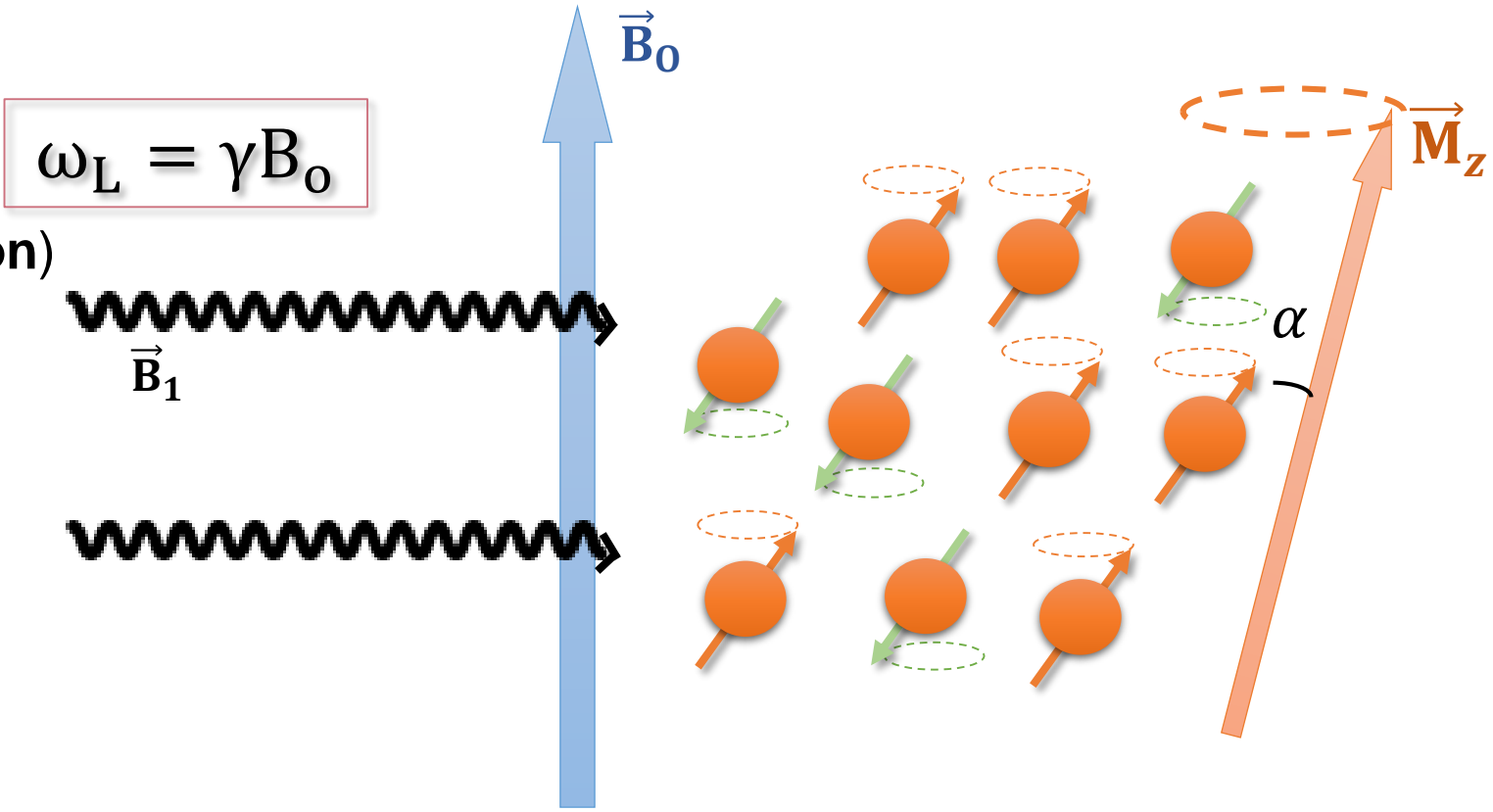
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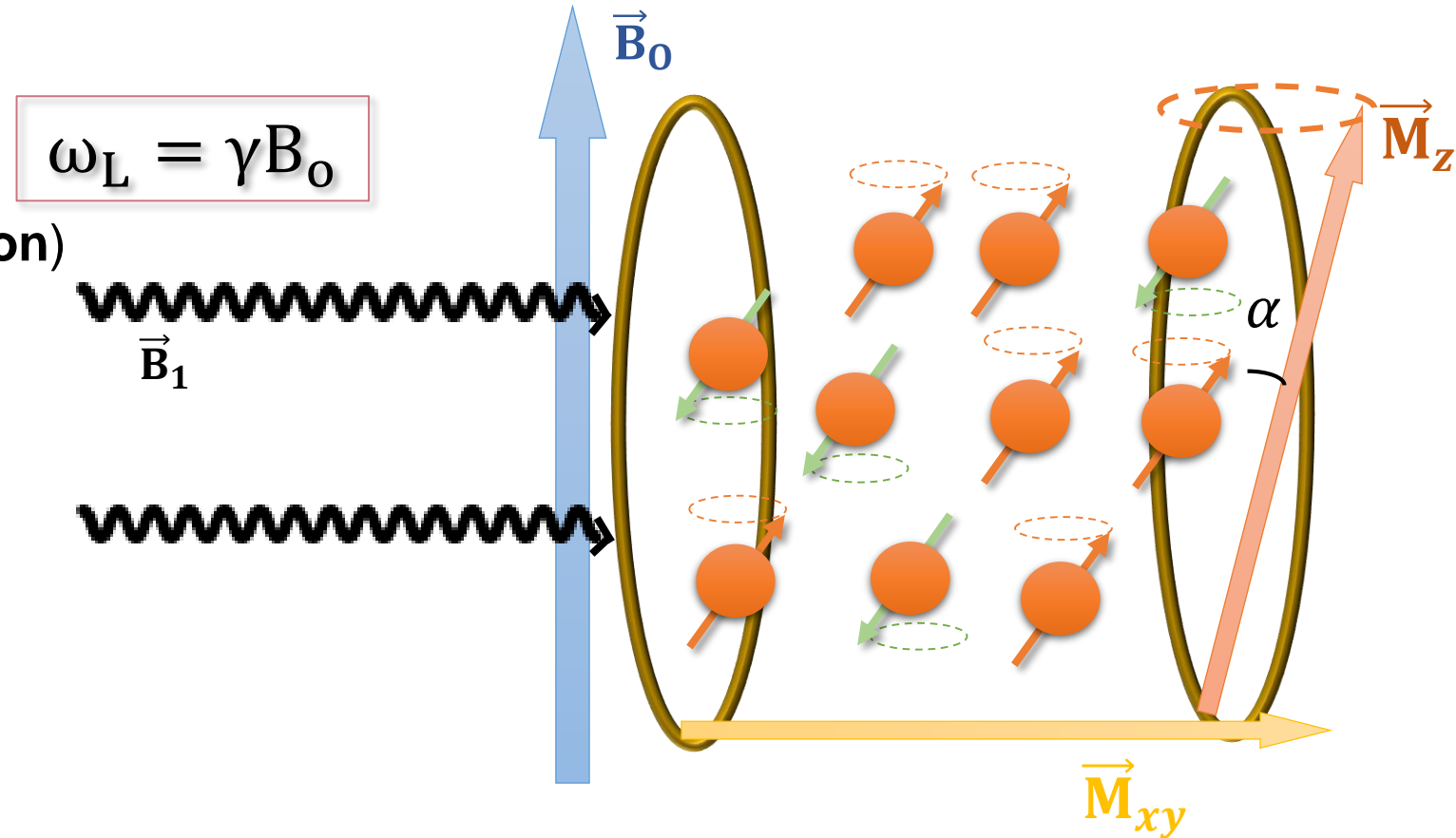
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Nuclear Magnetic Resonance

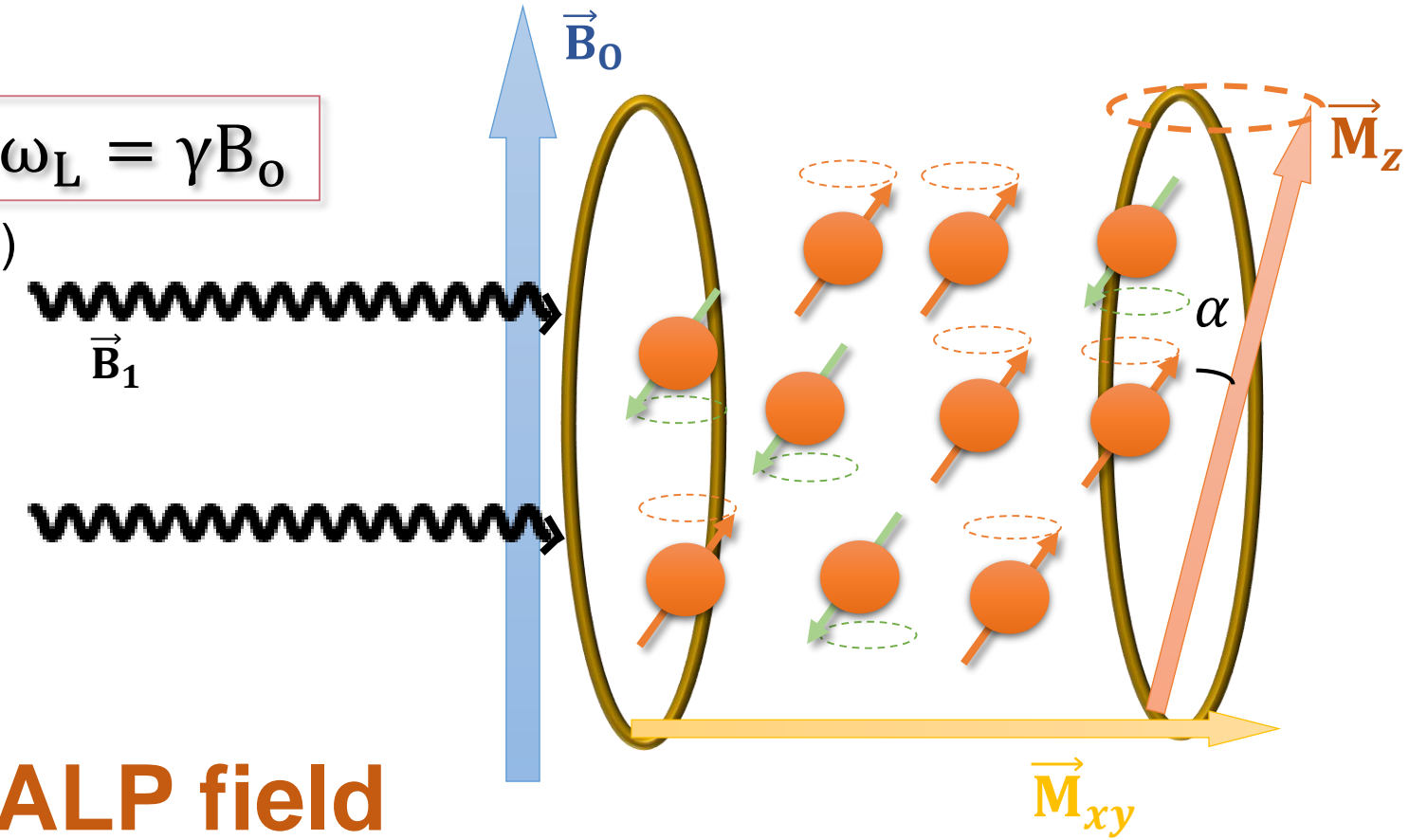
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Nuclear Magnetic Resonance

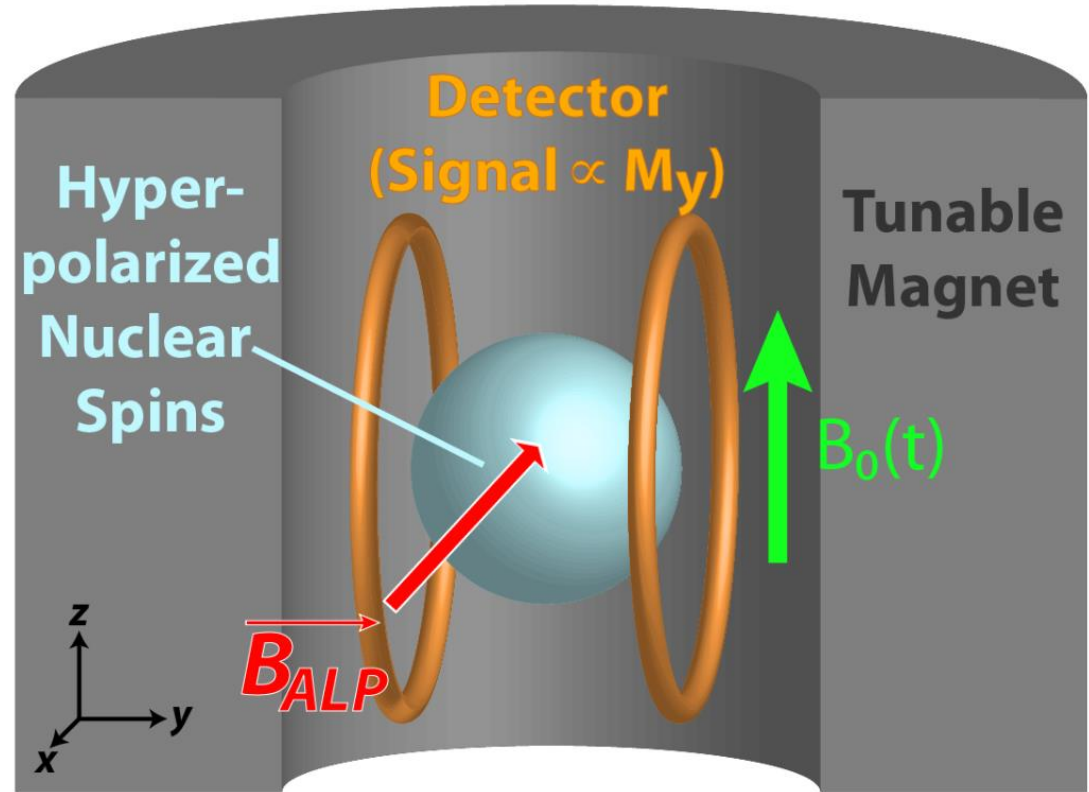
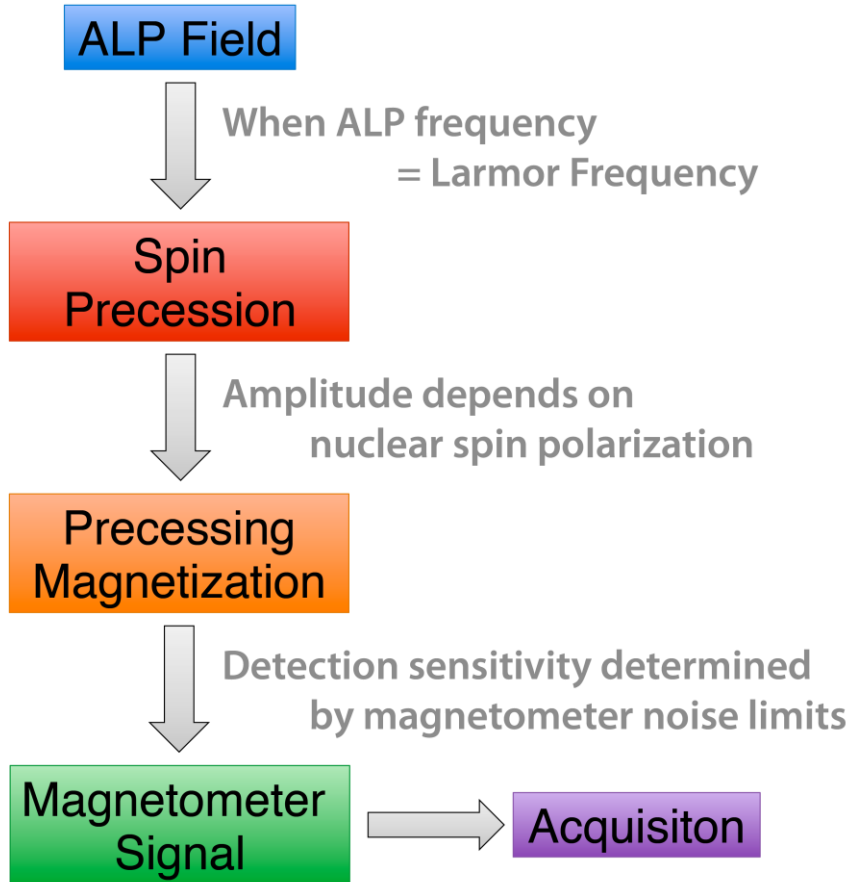
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$$\omega_L = \gamma B_0$$



CASPEr $\rightarrow B_1$ is the ALP field

CASPEr detection scheme



1. CASPEr ZULF $\rightarrow B_0 \leq 10^{-4}$ T
2. CASPEr -Wind Low Field $\rightarrow 10^{-4}$ T $\leq B_0 \leq 10^{-1}$ T
3. CASPEr -Wind High Field $\rightarrow 0.1$ T $\leq B_0 \leq 14$ T

CASPEr - Wind

$$M(t) \approx np\mu \left(g_{\text{aNN}} \sqrt{2\rho_{\text{DM}}\nu} \right) \frac{\sin [(2\mu B_0 - m_a) t]}{2\mu B_0 - m_a} \sin (2\mu B_0 t)$$

Signal is **REALLY** small!

We need to maximize:

- Number density (n)
- Polarization (p)
- Nuclear magnetic moment (μ)
- Sensitivity

CASPEr - Wind

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Hyperpolarized liquid ^{129}Xe

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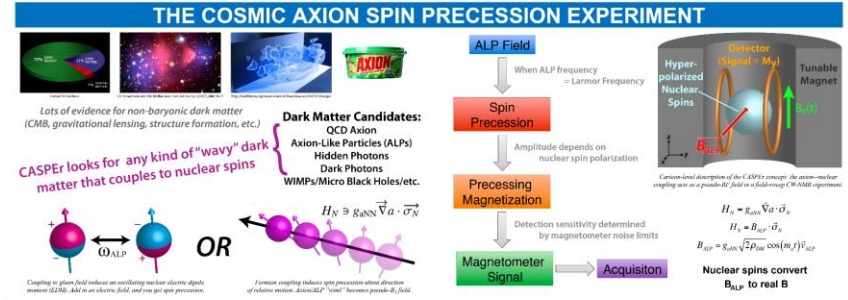
- Sensitivity

Cryogenic probe, SQUIDs, etc

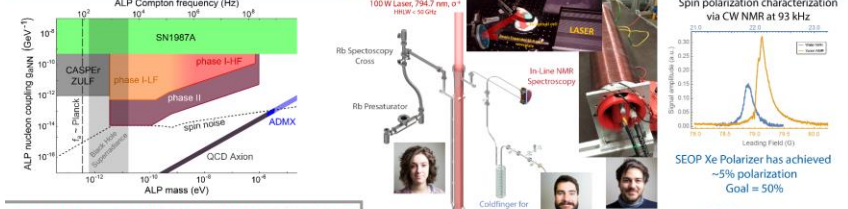


HIM MAM Status of the Cosmic Axion Spin Precession Experiment (CASPER)

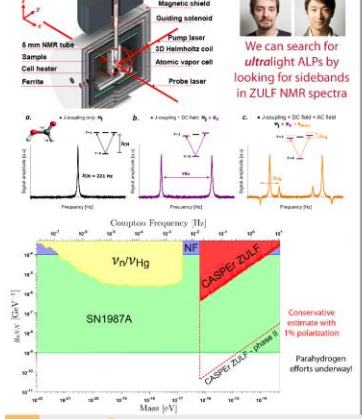
Marina Gil Sendra, for the CASPER Collaboration



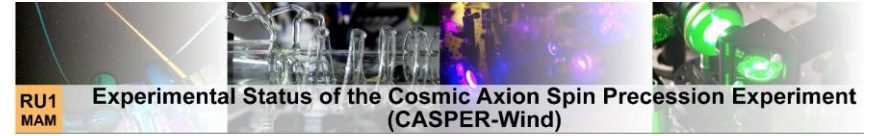
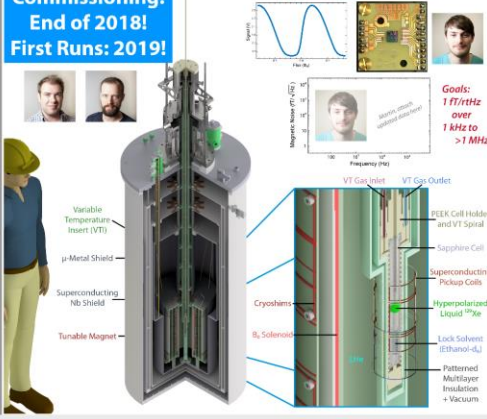
CASPER STATUS



Zero- to Ultralow-Field NMR → CASPER-ZULF



Commissioning: End of 2018! First Runs: 2019!

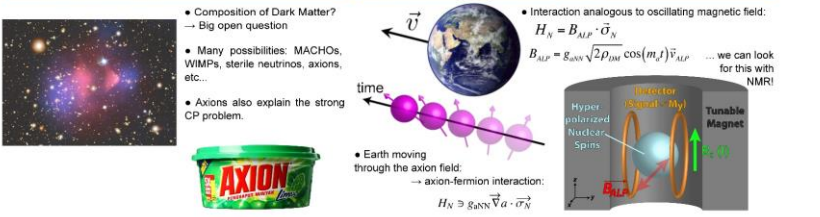


RU1 MAM Experimental Status of the Cosmic Axion Spin Precession Experiment (CASPER-Wind)

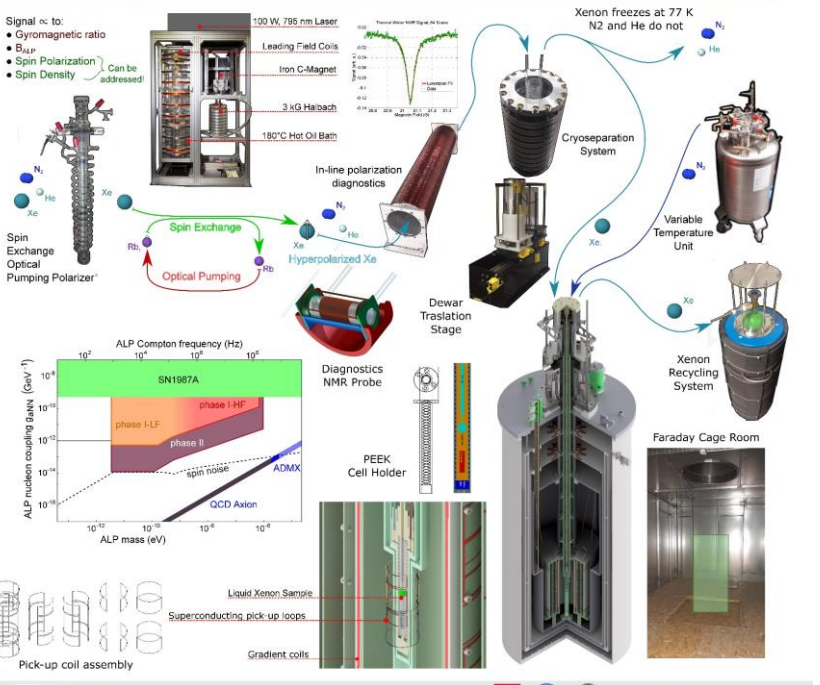
N. L. Figueroa^{1,2}, J. W., Blanchard^{1,2}, G. Centers^{1,2}, M. Engler^{1,2}, A. Garçon^{1,2}, M. G. Sendra^{1,2}, A. Wickenbrock^{1,2}, T. Wu^{1,2} & D. Budker^{1,2,3} for the CASPER Collaboration

1: Johannes Gutenberg Universität Mainz, Staudinger Weg 7, 55128 Mainz 2: Helmholtz Institut Mainz, 55099 Mainz 3: Department of Physics, University of California, Berkeley, USA

What is dark matter made of? The axion wind coupling



CASPER Experiments in Mainz: CASPER-Wind



THANKS!