How to Reconstruct the Axion Velocity from CASPEr

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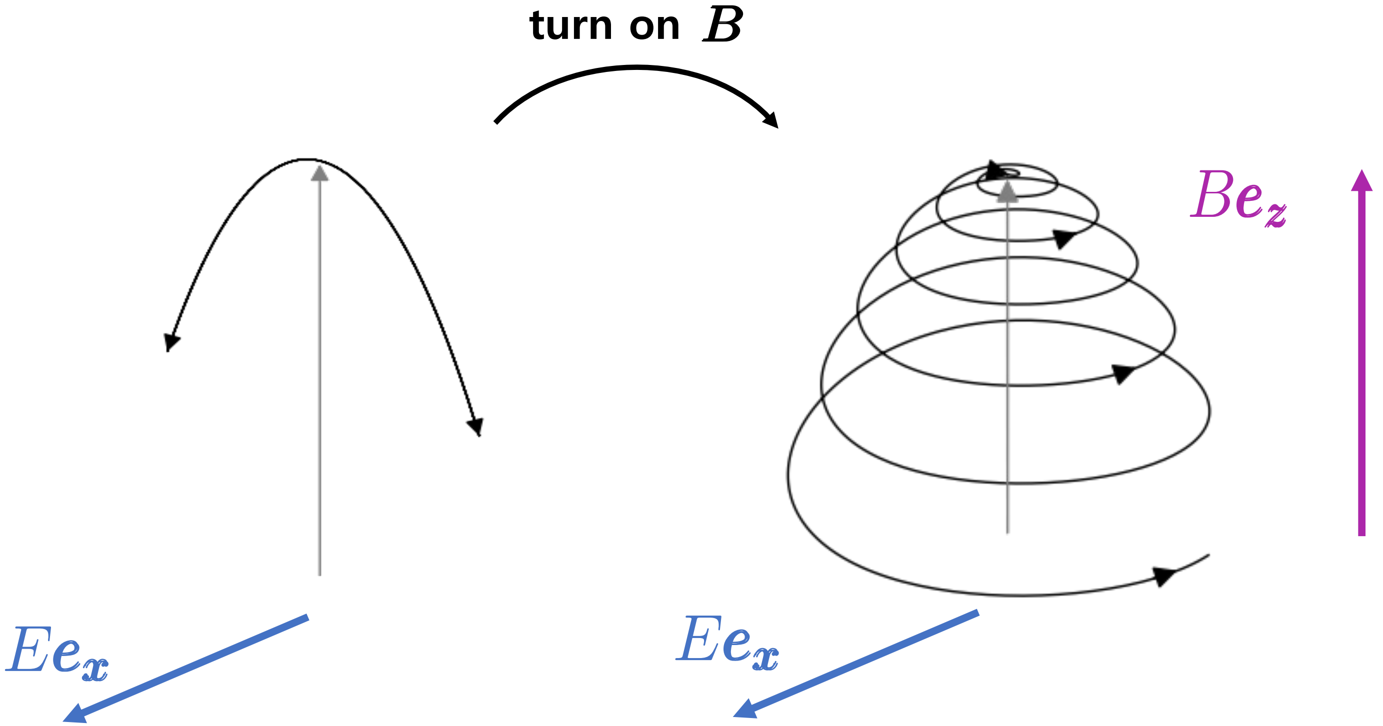
Investigating the Axion-EDM coupling using NMR

$$H_{\text{int}} \sim g_d a(t) \cdot d_n$$

Resonantly enhance axion

$$a(t) \sim \cos(m_a t)$$



Oscillation frequency of axion m_a

Coupling frequency ω_c

Hierarchy of scales $\frac{\omega_c}{m_a} \ll 1$

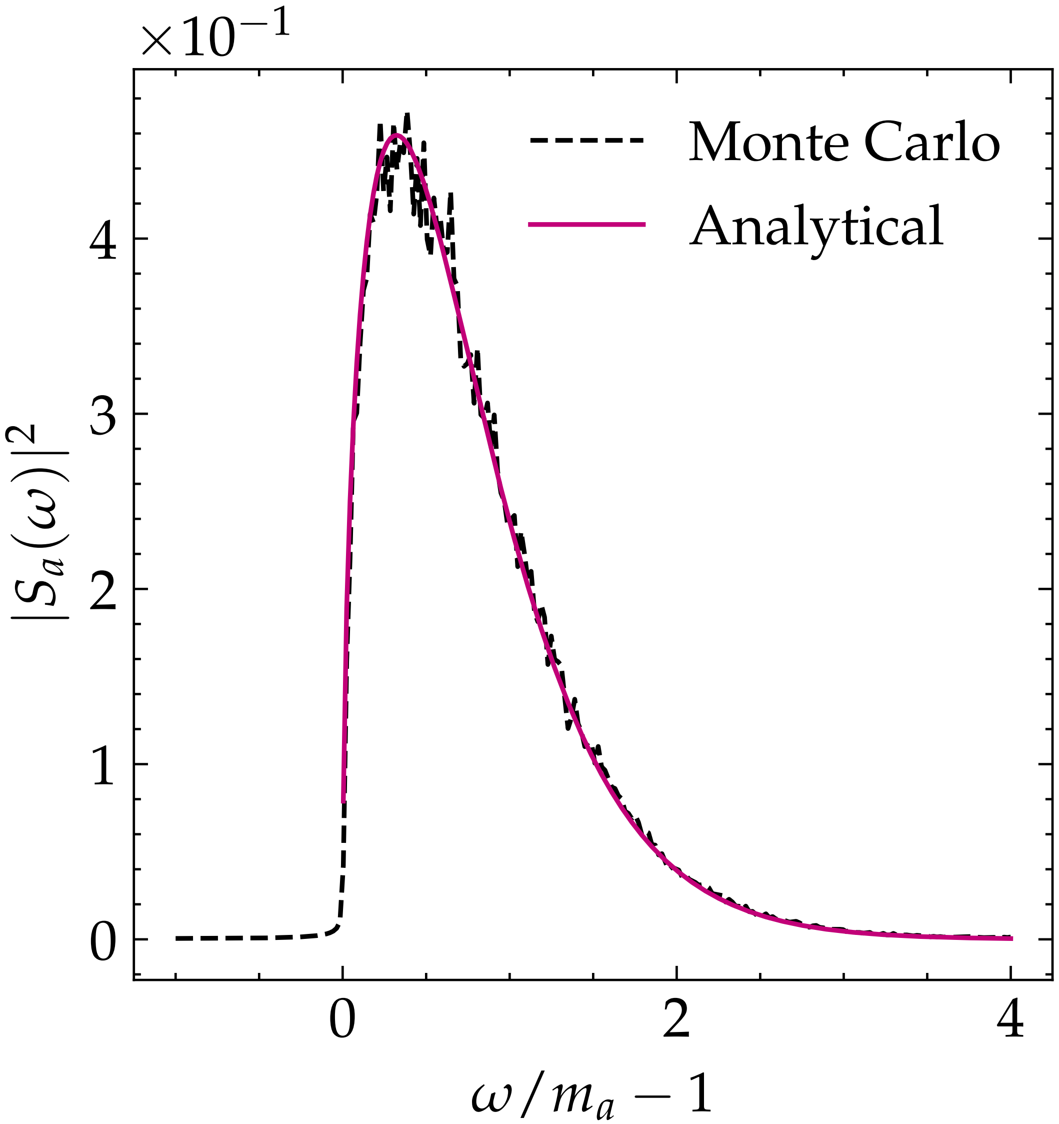
Larmor frequency $\omega_L \sim B$

But what about velocities?

$$m_a \longrightarrow m_a(1 + v^2/2)$$

Broadening of the Axion PSD

$$a(t) \sim \sum_i a_i(t, v_i)$$



Velocities distributed via SHM

$$f(\boldsymbol{v}) \sim e^{-\alpha \boldsymbol{v}^2}$$

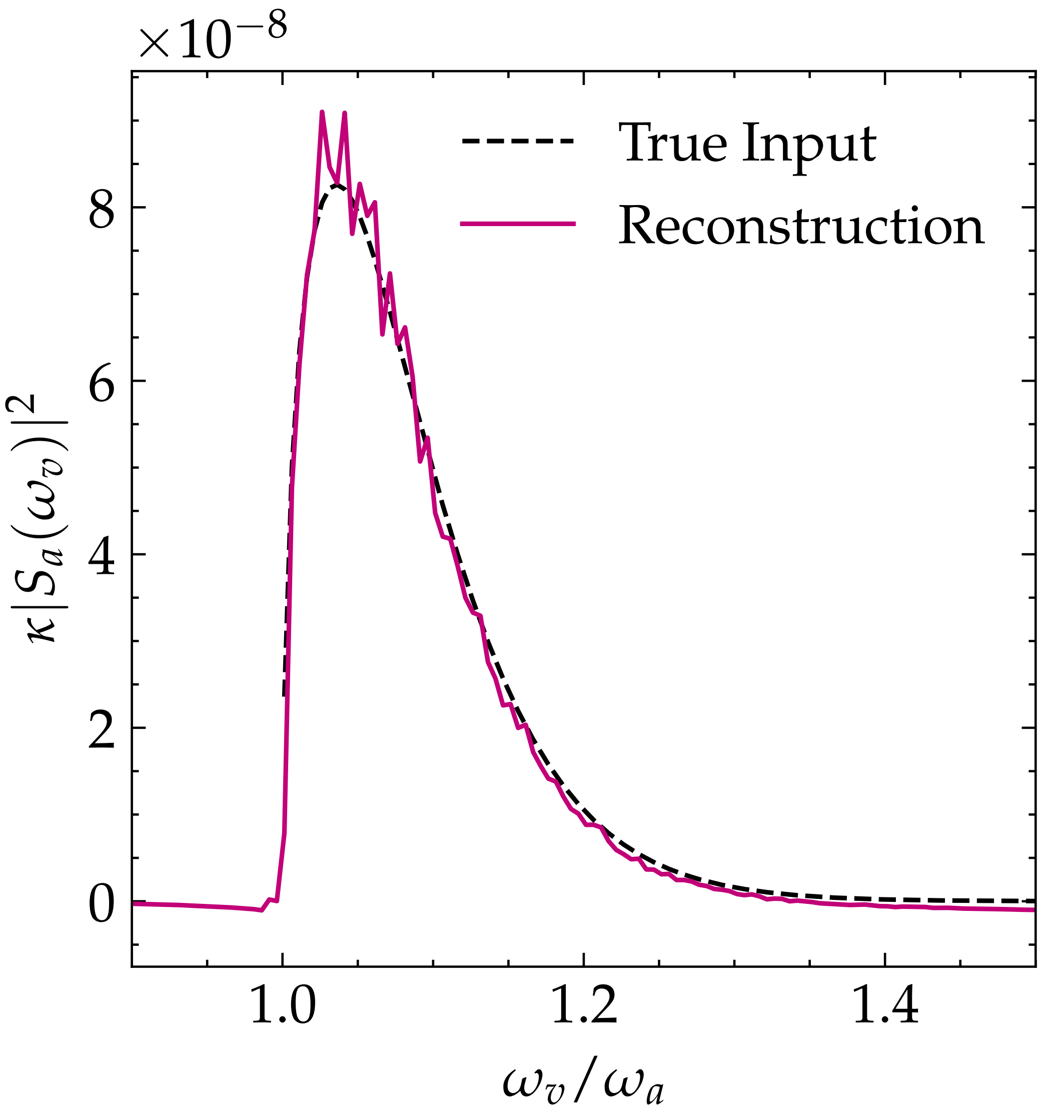
Can we measure this with CASPEr?

Dynamics governed by Bloch equations

$$\dot{\boldsymbol{M}}(t) = \boldsymbol{A}(t) \cdot \boldsymbol{M}(t)$$

Linearize by using ω_c/m_a

$$\boldsymbol{M}(t) \approx (1 + \int_0^t \boldsymbol{A}(t')\, dt') \cdot \boldsymbol{M}_0$$



Result is a linear inverse Problem

$$|S_{meas}(\omega_m)|^2 = K_{m,n} \cdot \kappa|S_a(\omega_n)|^2$$

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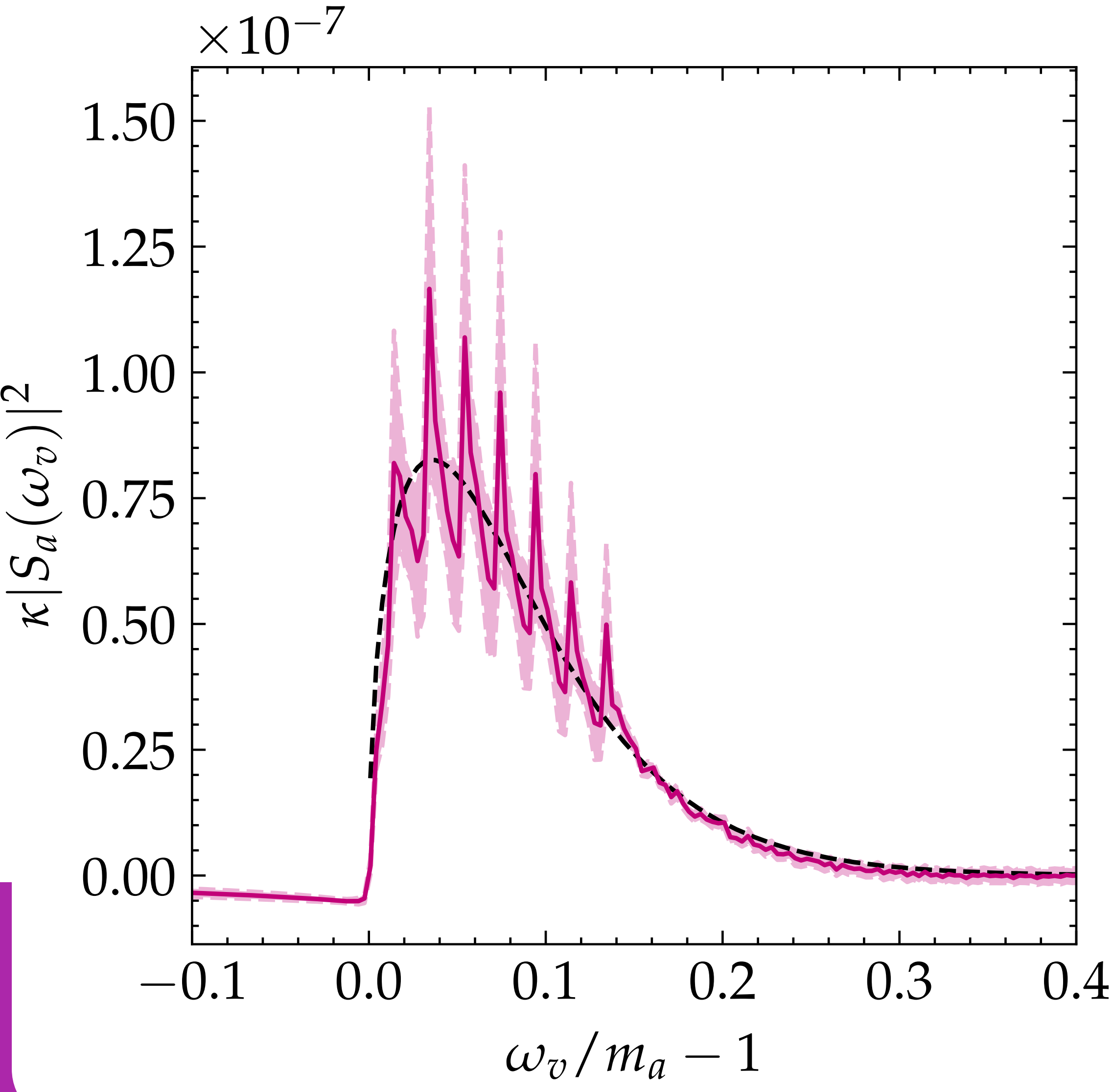

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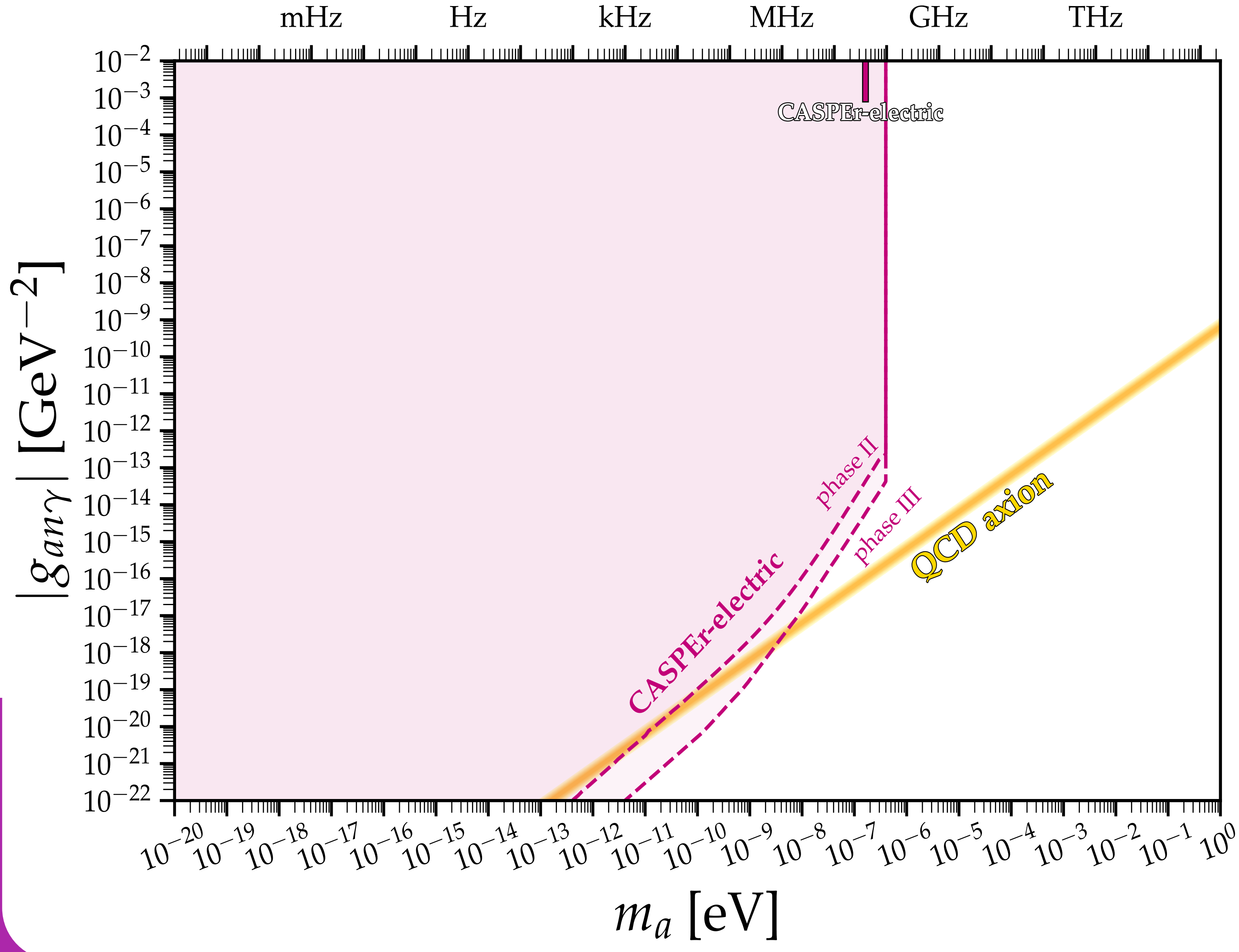
Now to reality…

- For which masses?
- What about noise?

$$\tau_a \sim m_a^{-1} \ll T_{meas}$$

Analysis w.r.t noise will yield g_d sensitvity



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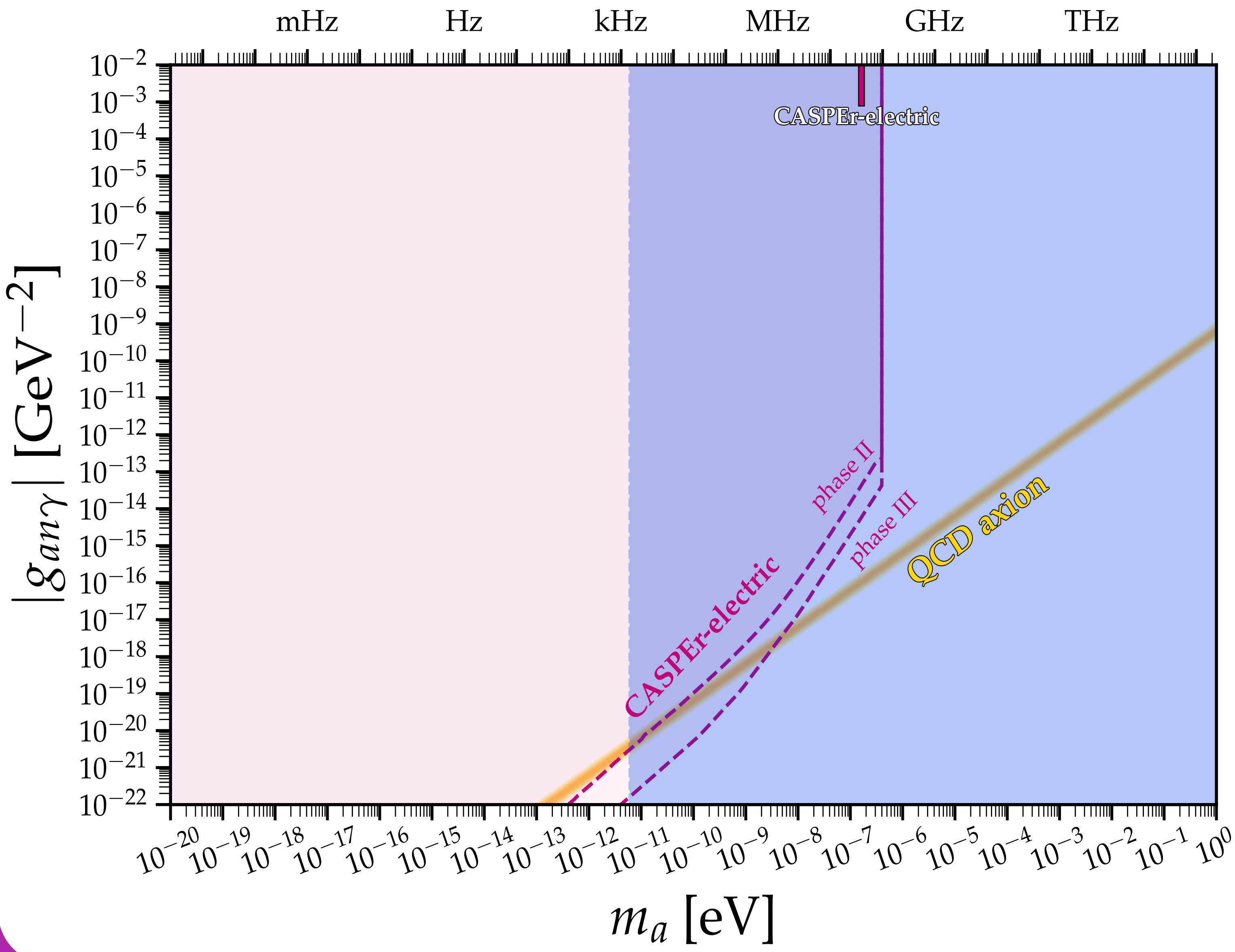

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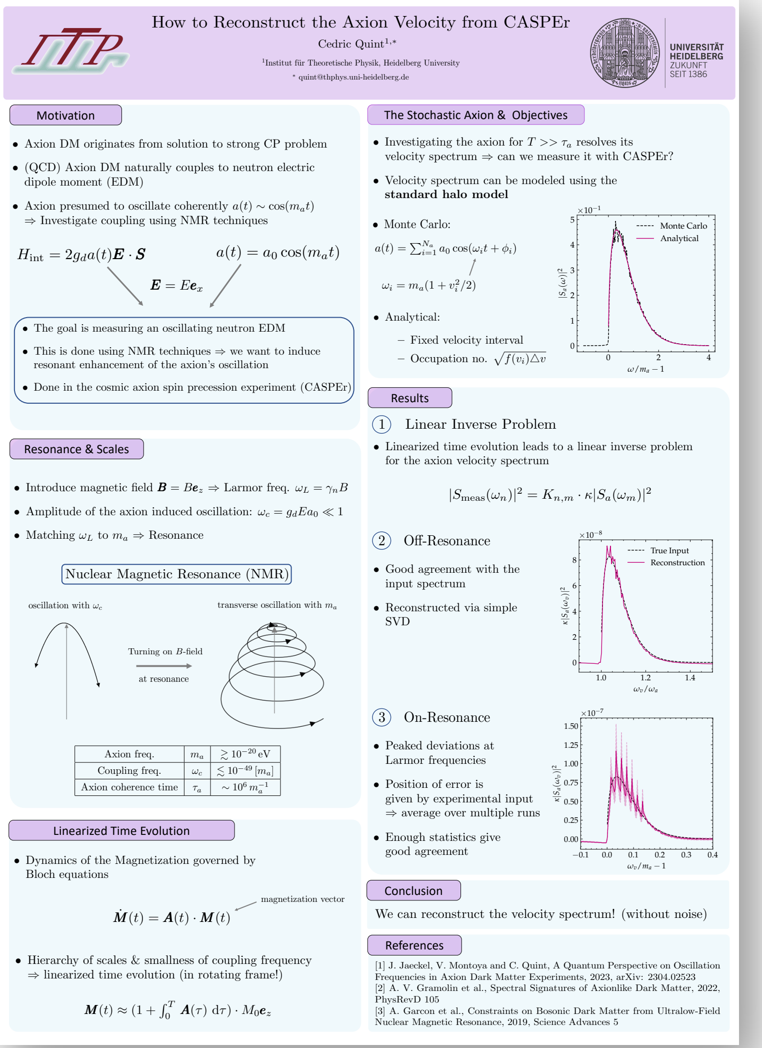
The Takeaway:

One can measure the axion DM velocity with CASPEr

(In principle)



TODO:

Include experimental noise

Ask me about oscillations