OPTIMAL ANTI-FERROMAGNETS FOR LIGHT DARK MATTER DETECTION

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SUB-MEV DARK MATTER

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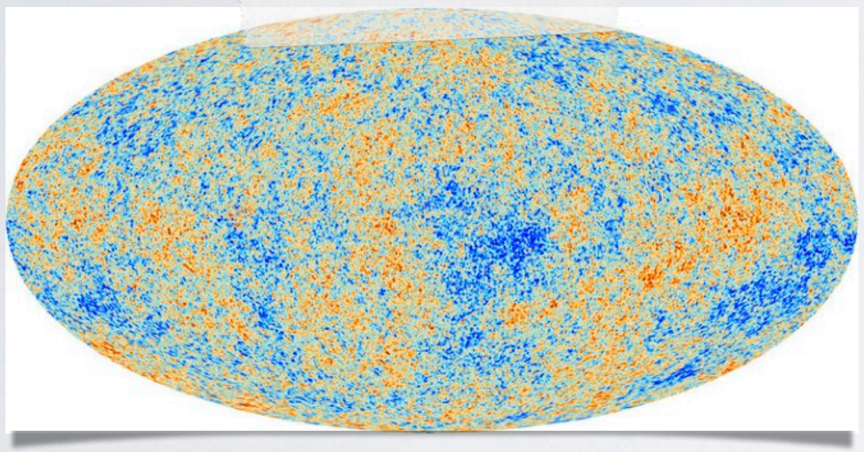

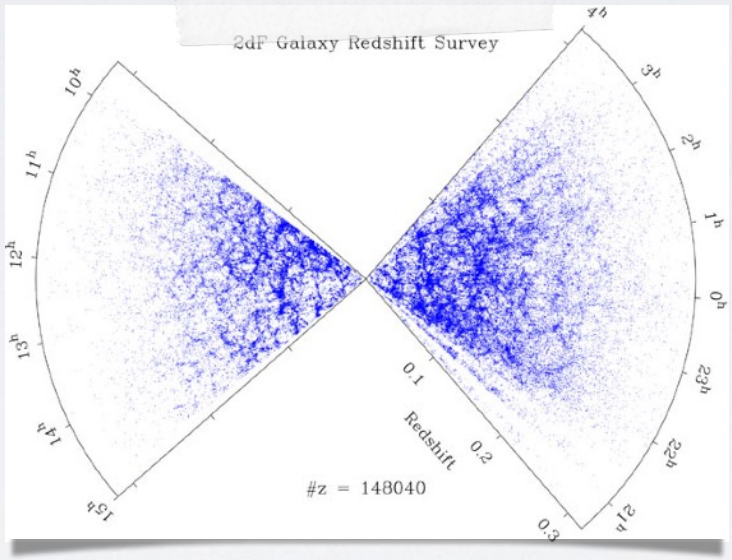

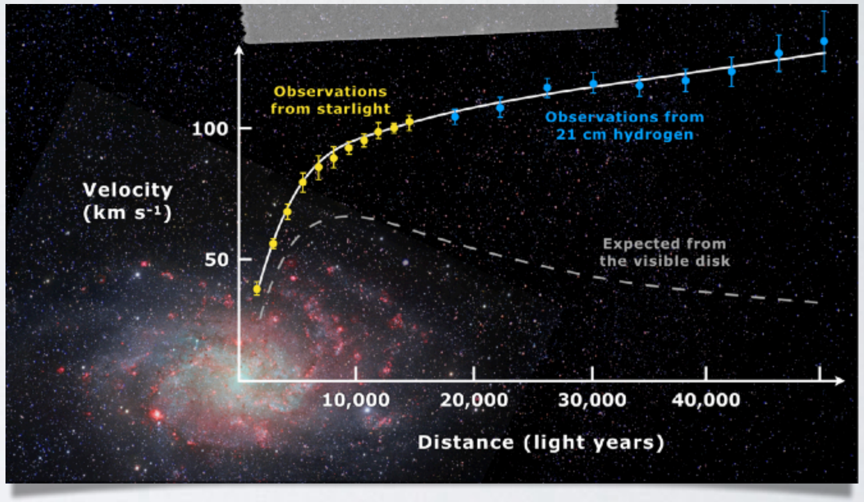

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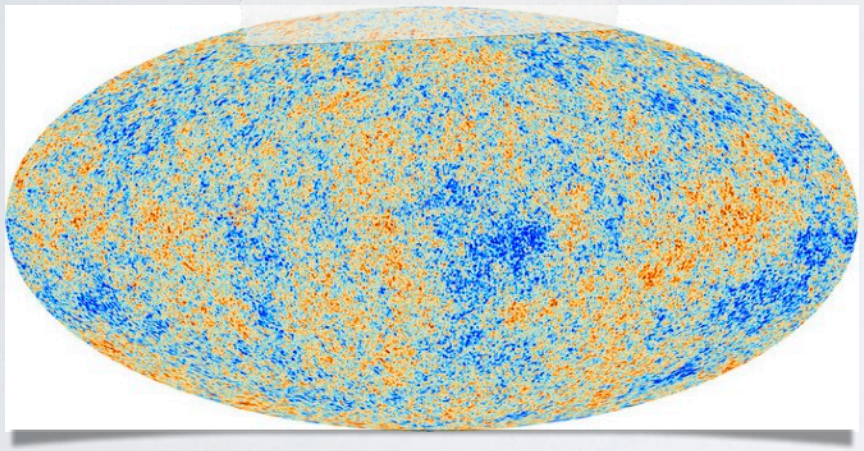

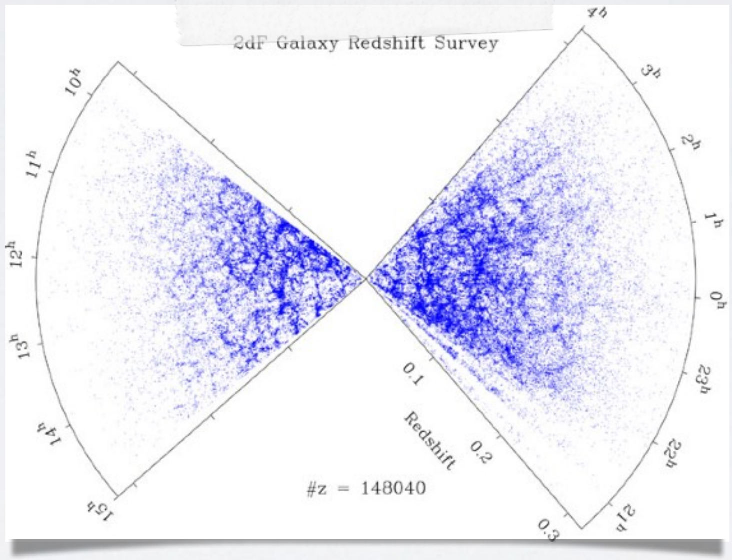

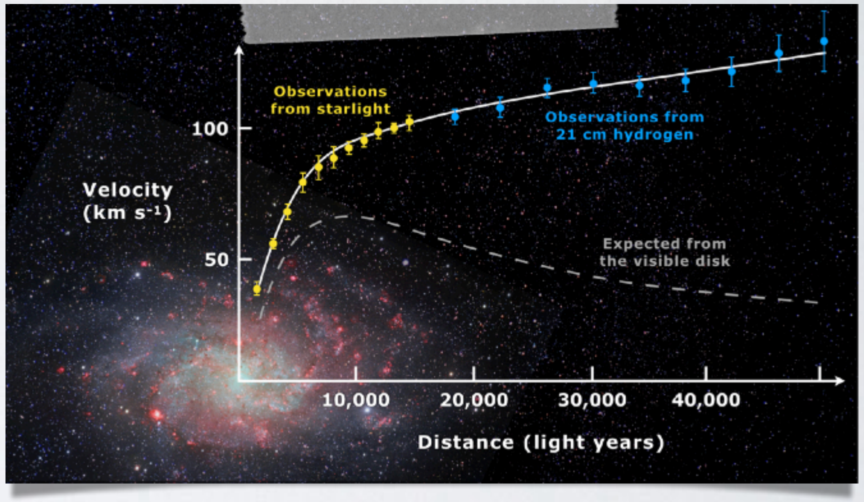

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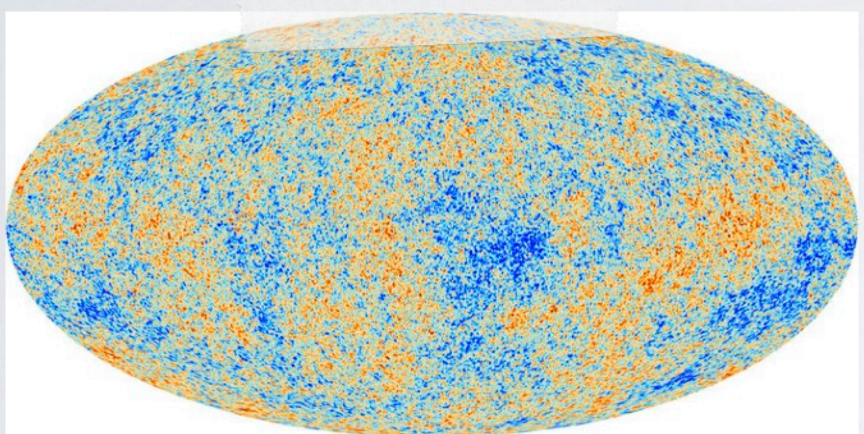

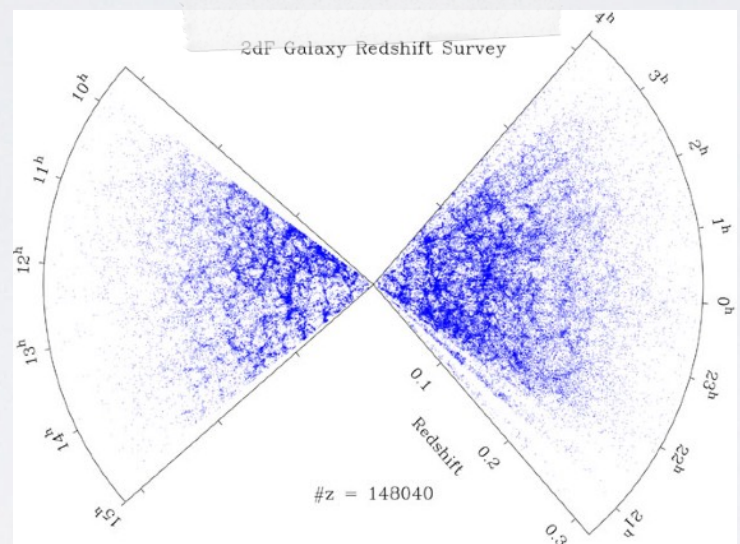

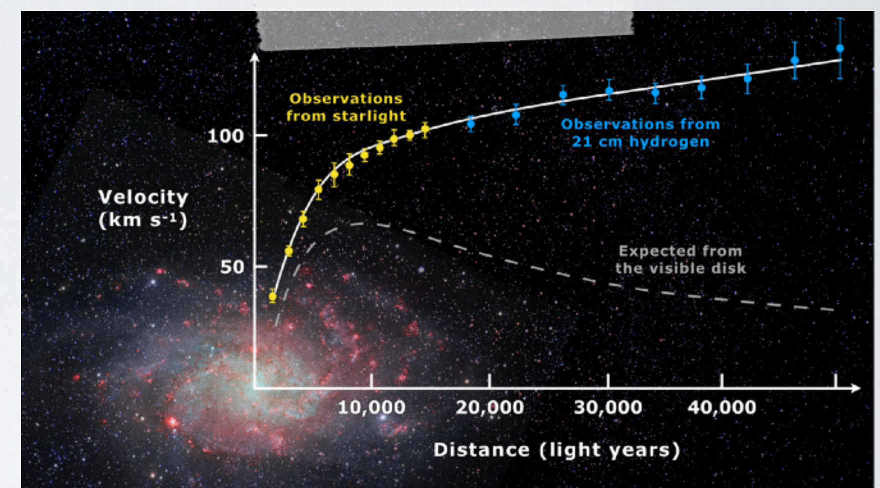

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- However… huge possible mass range → detection techniques vary widely depending on the dark matter mass

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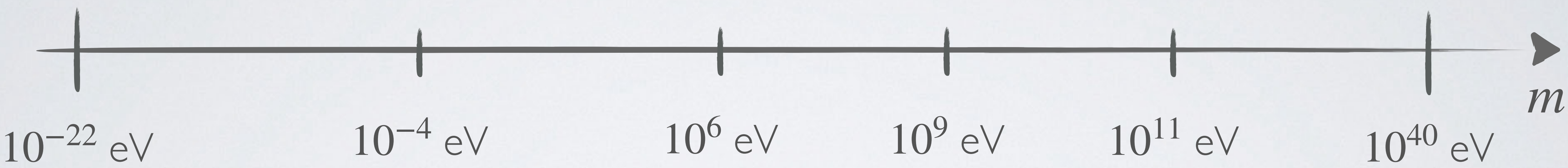

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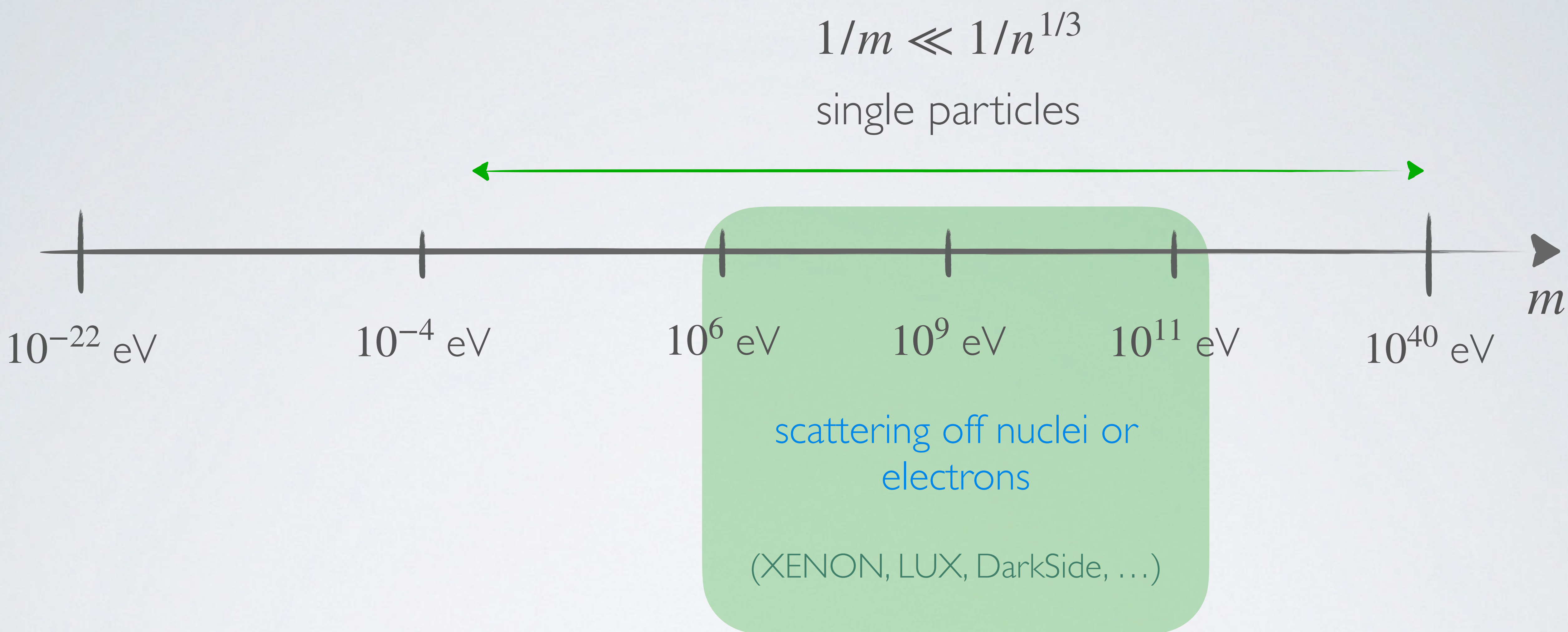

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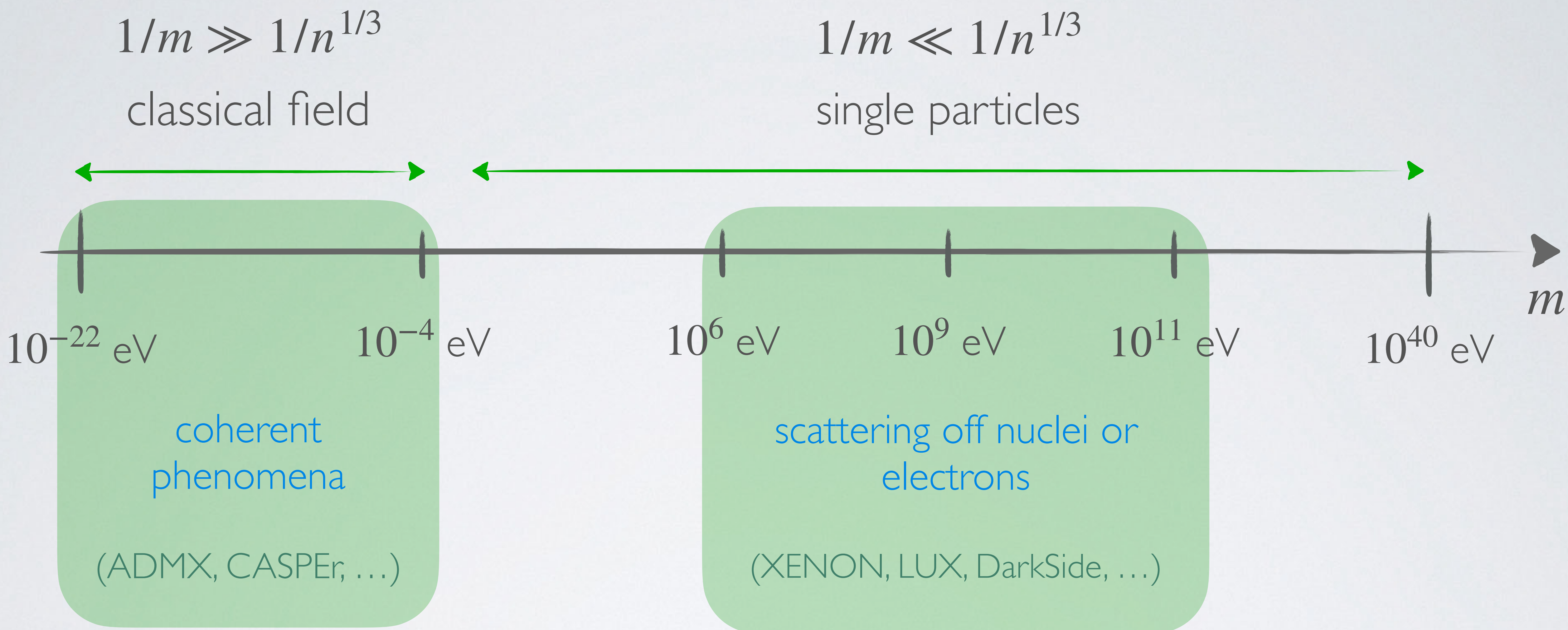

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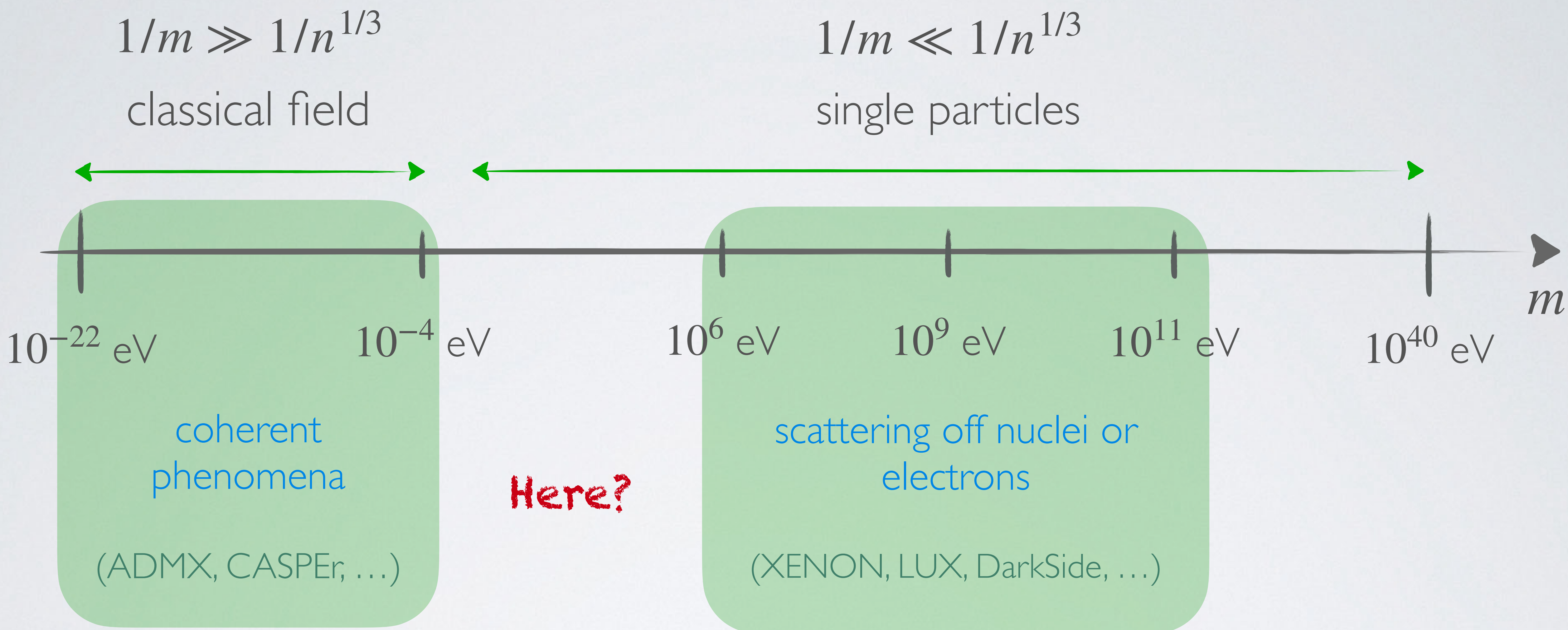

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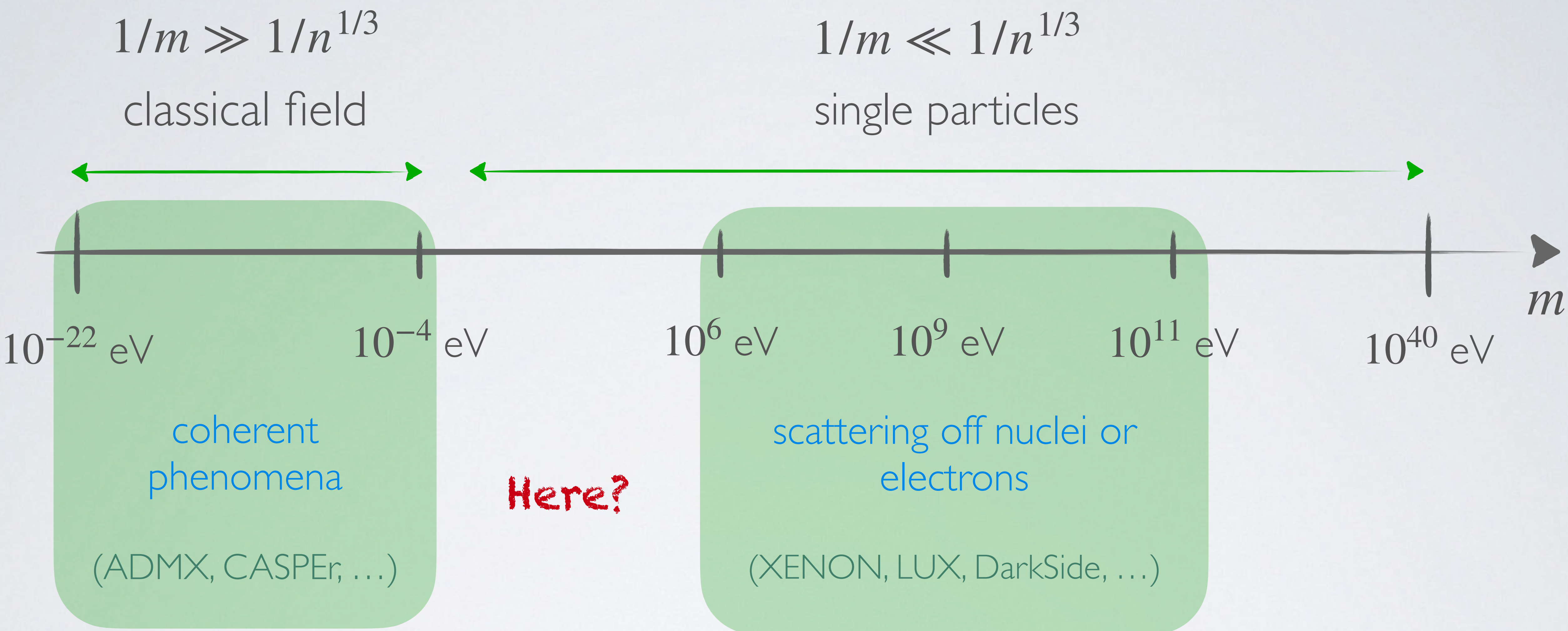

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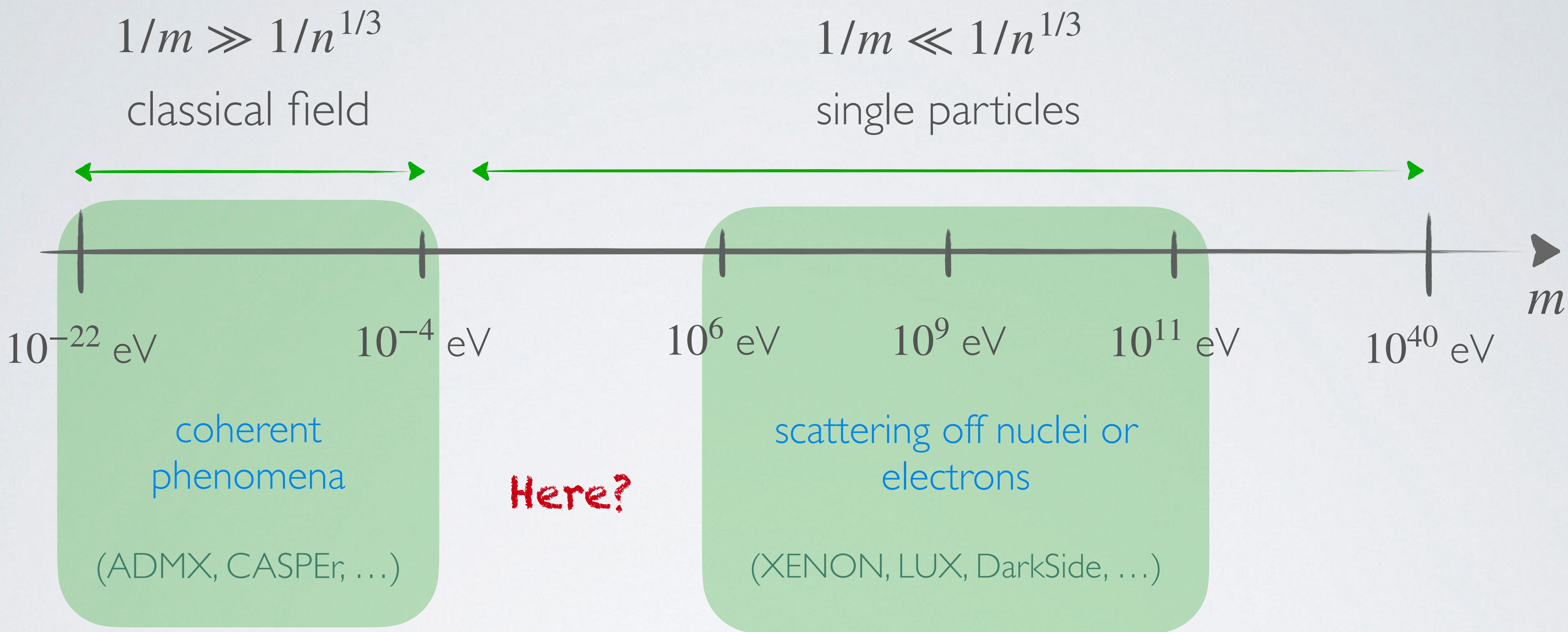

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- Need new materials and/or observables

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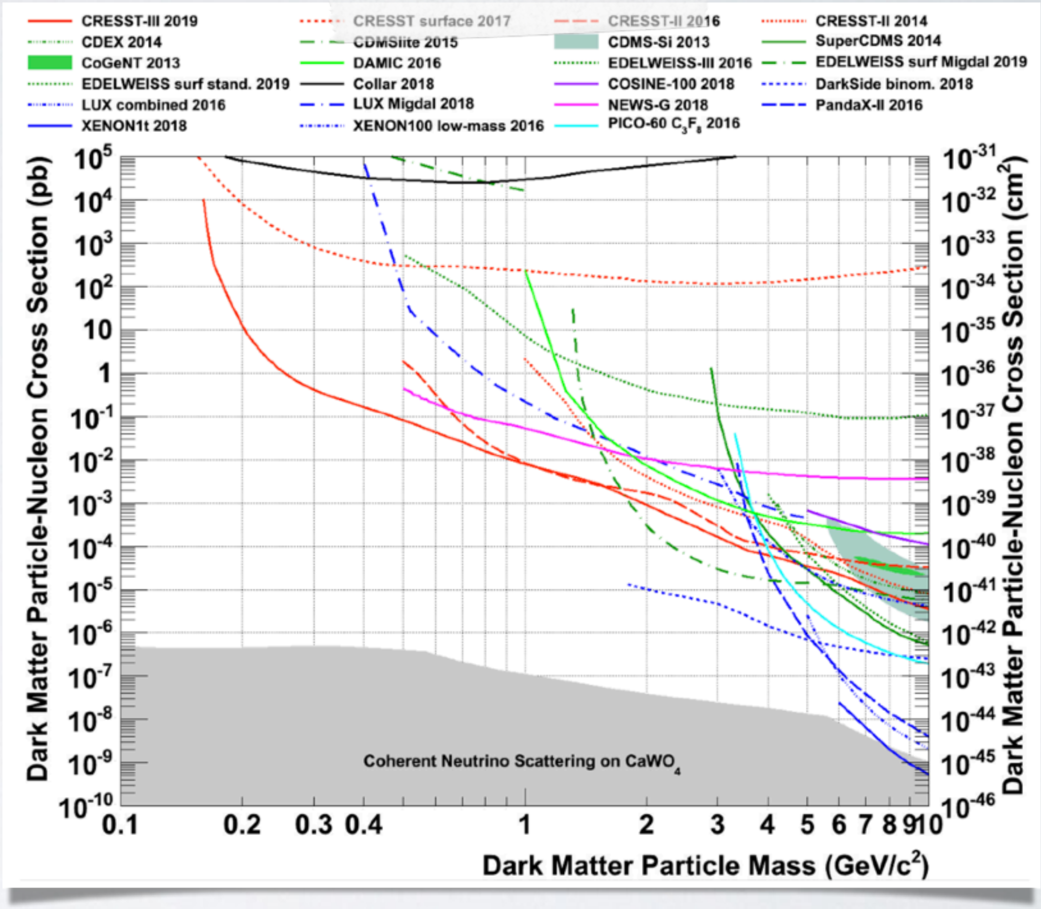

[CRESST — PRD 2019, 1904.00498]

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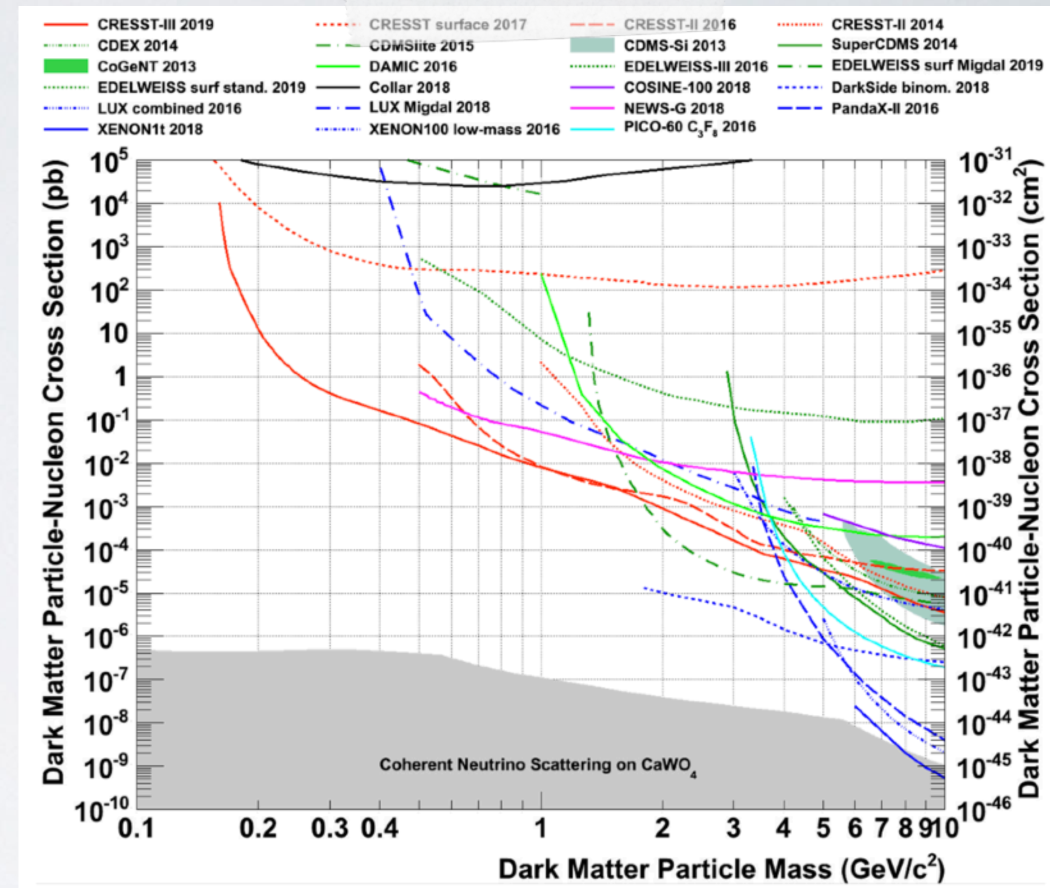

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- To evade this we must look into inelastic processes, which relax the kinematics constraints

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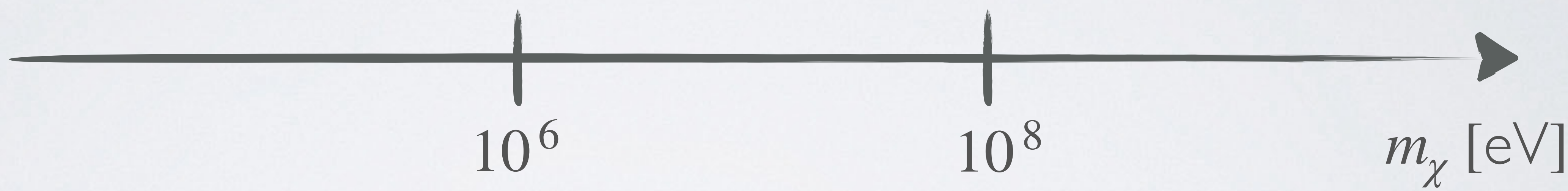

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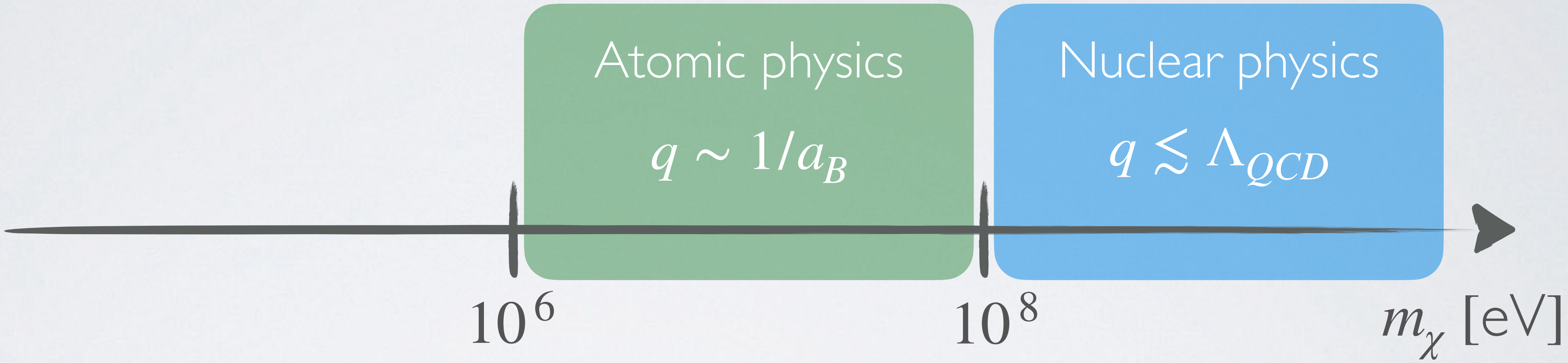

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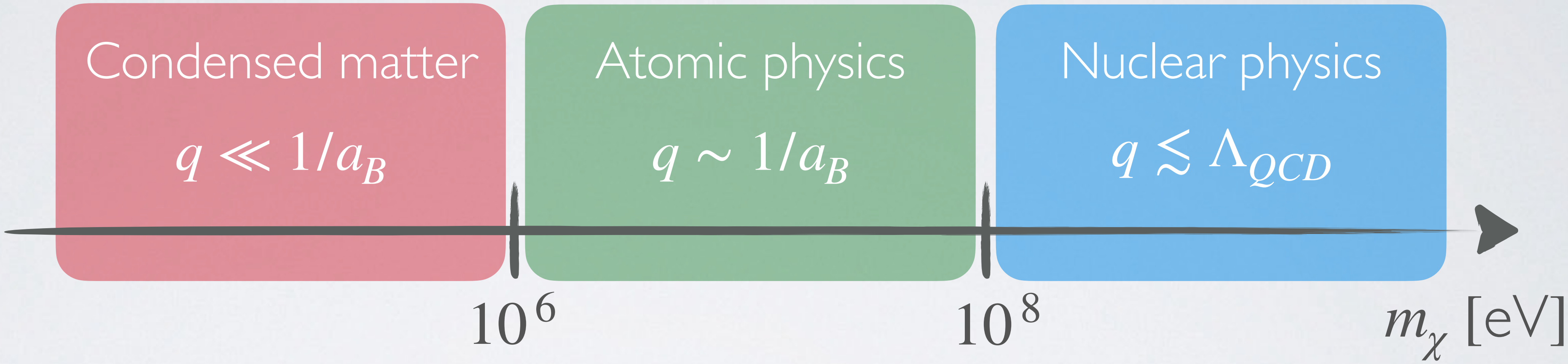

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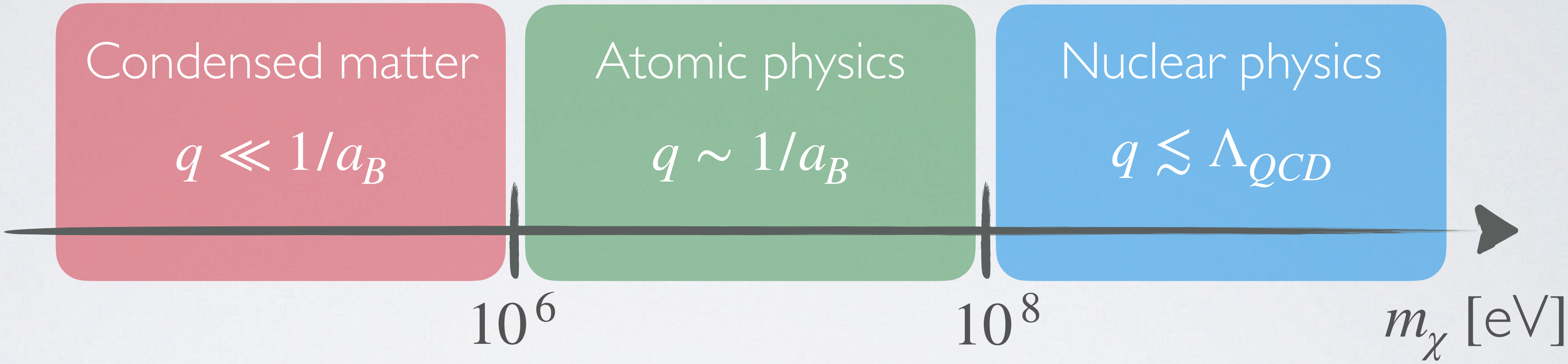

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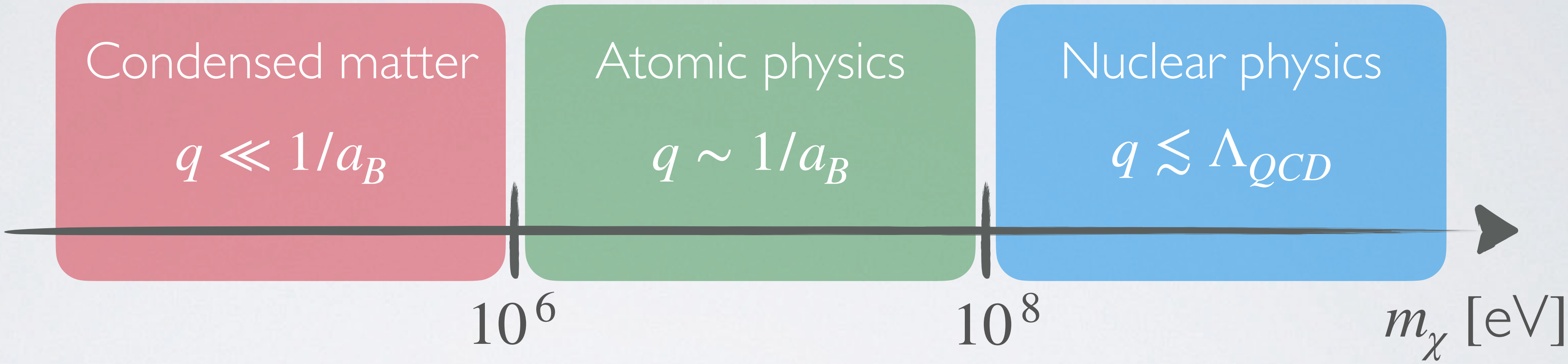

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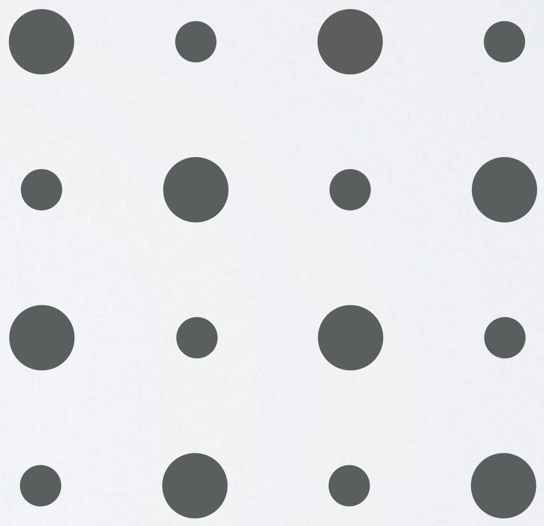

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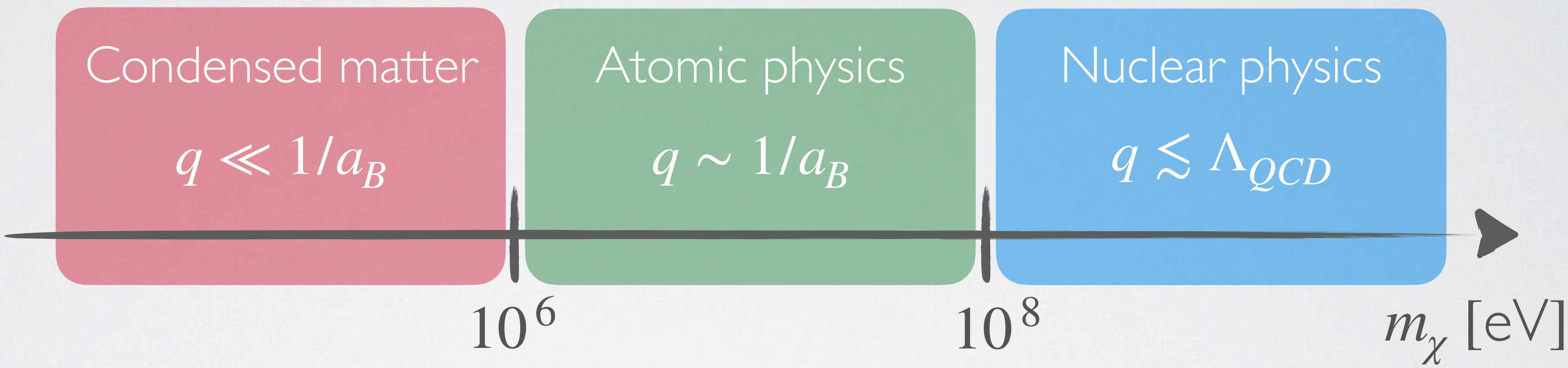

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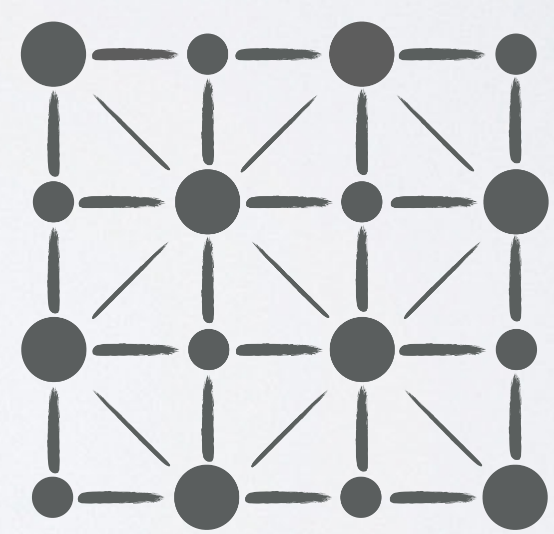

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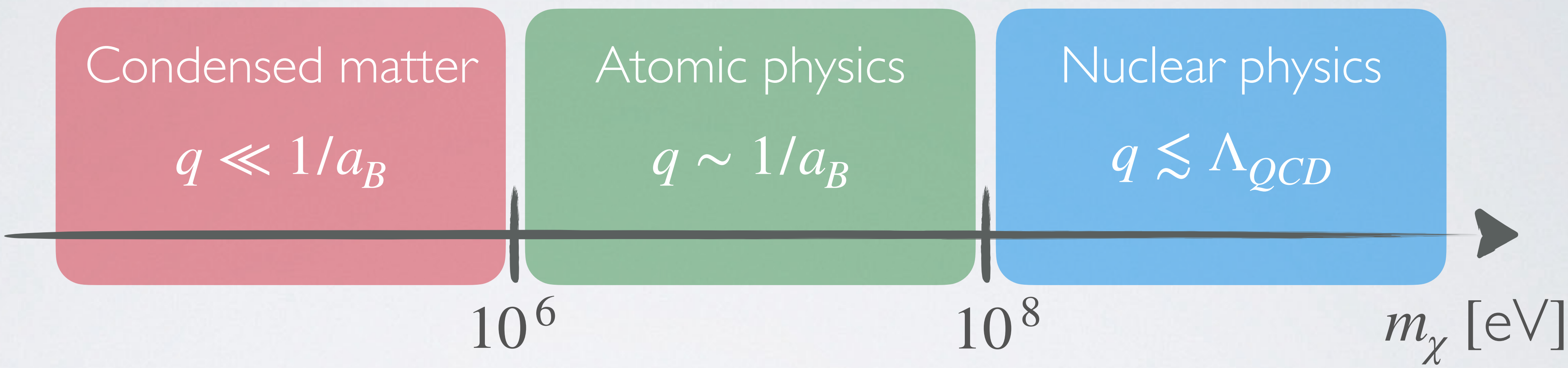

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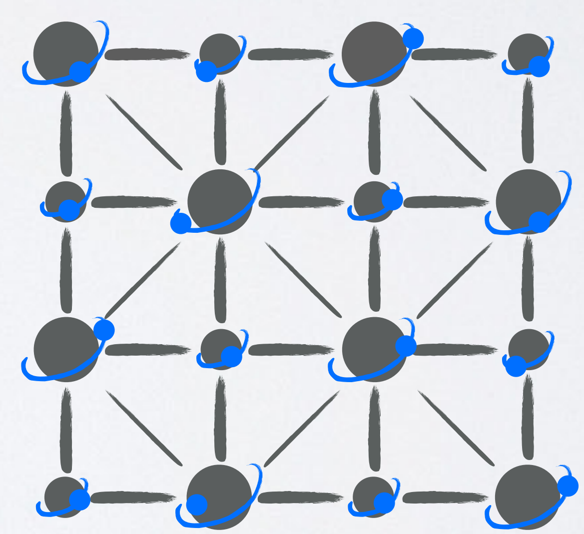

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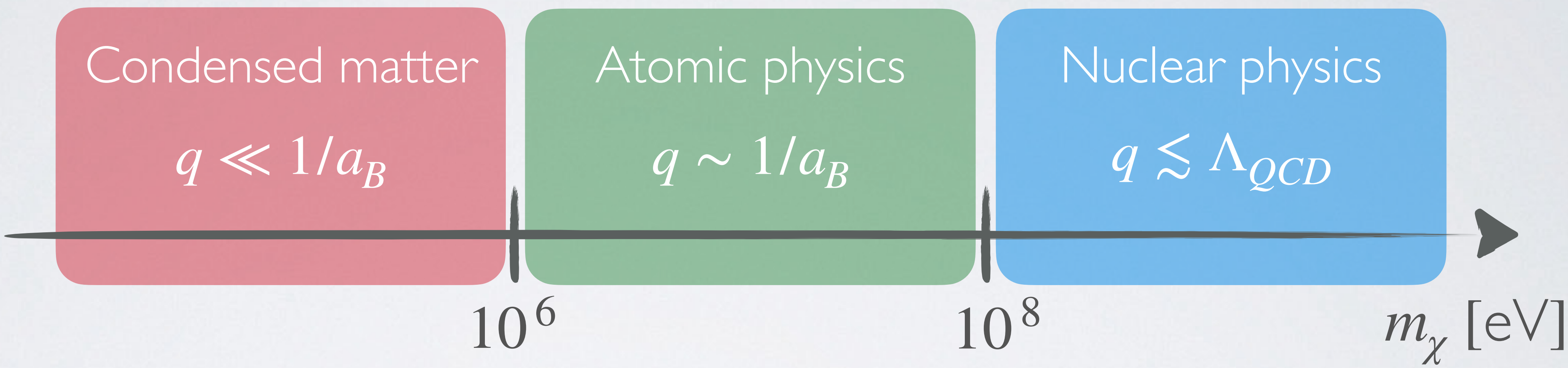

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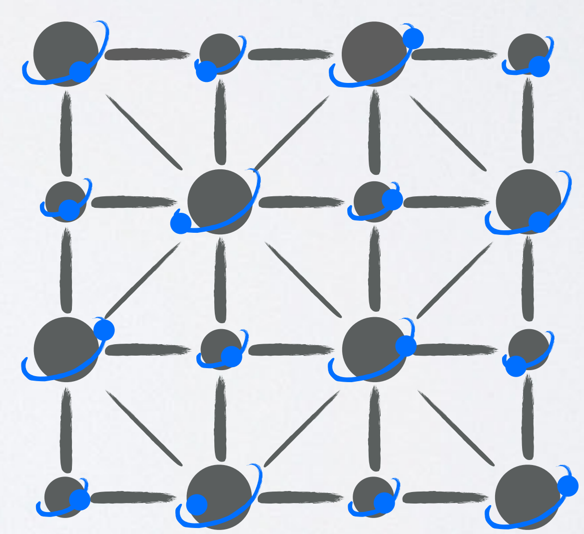

- Need theoretical tools that allow to solve or bypass these problems

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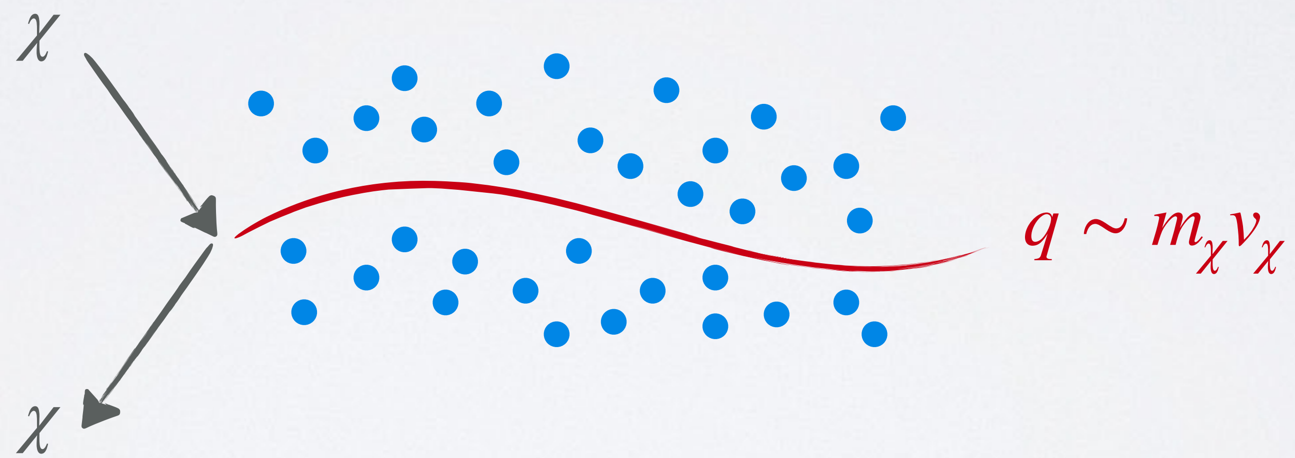

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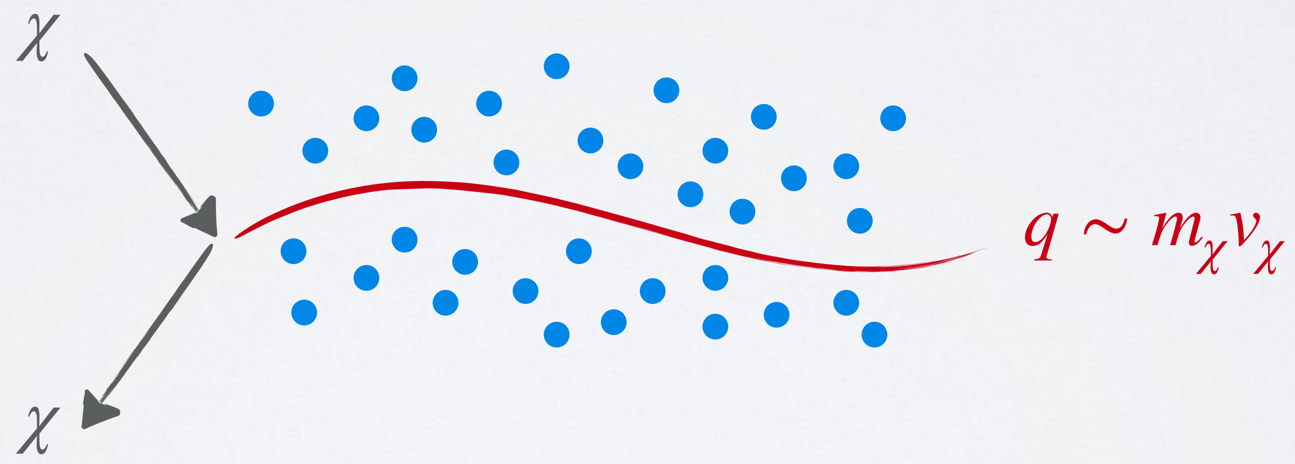

- Typically, no more single particle final states → signatures involve one or more collective excitations

[e.g., Trickle et al. — JHEP 2020, 1910.08092; Griffin et al. — PRD 2020, 1910.10716]

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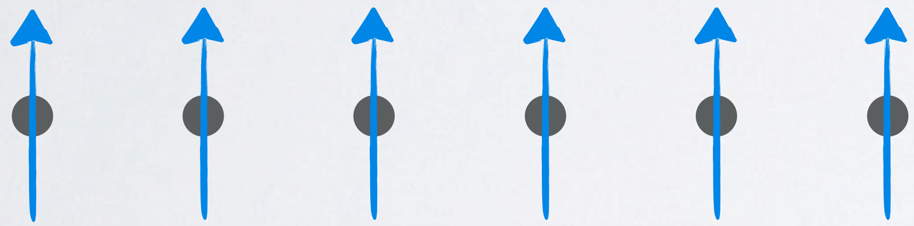

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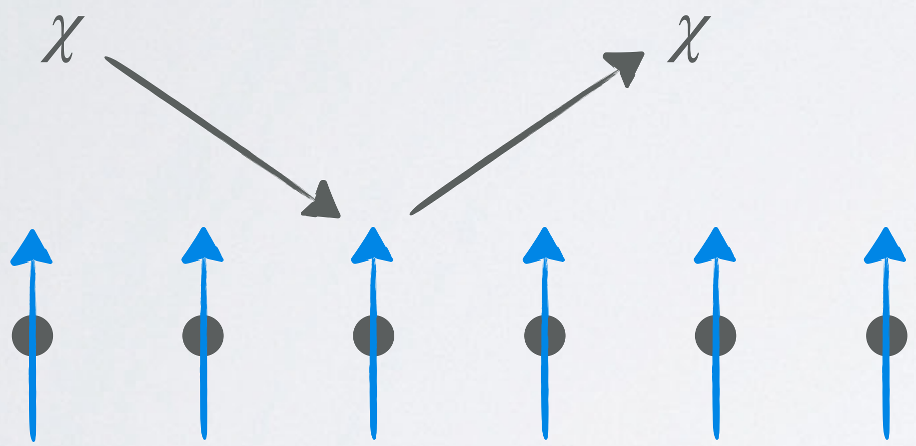

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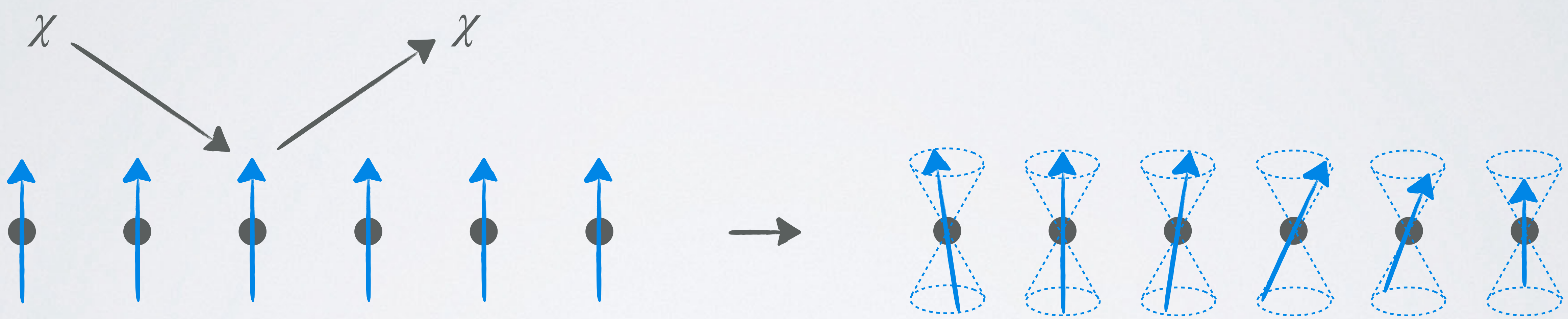

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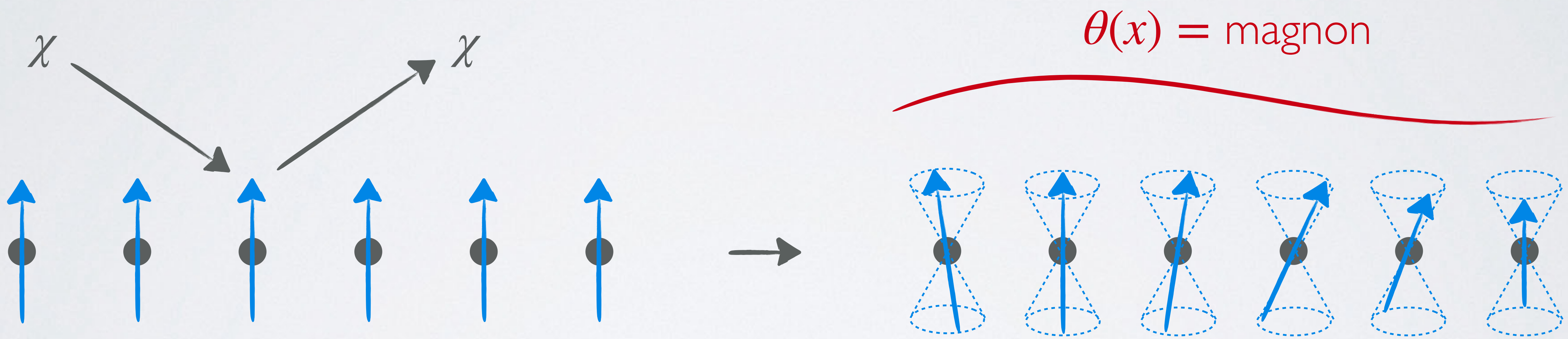

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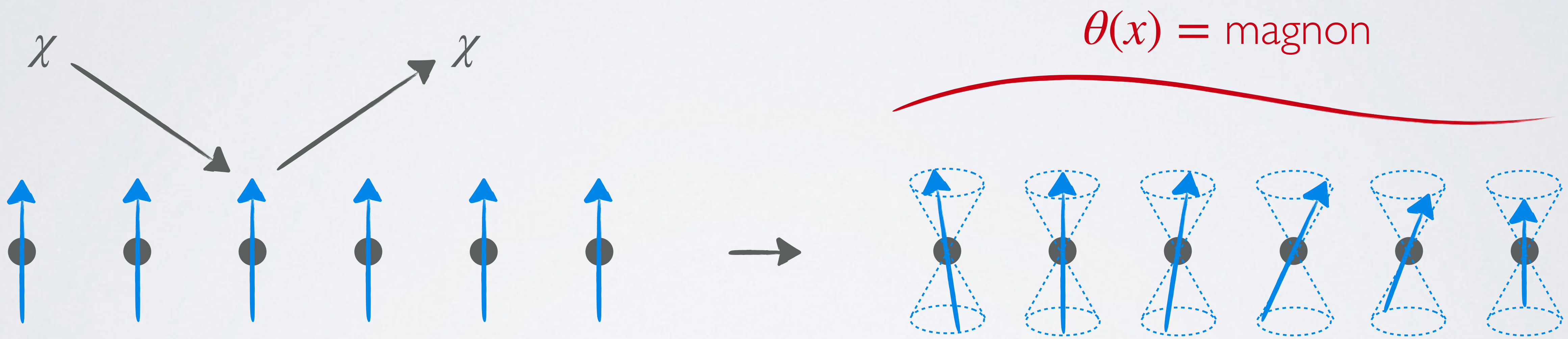

- Ways to detect few magnons have already been proposed (TES, MKID, quantum sensors)

[Trickle, Zhang, Zurek — PRL 2020, 1905.13744; Lachance-Quirion et al. — Science Advances 2017; Lachance-Quirion et al. — Science 2020]

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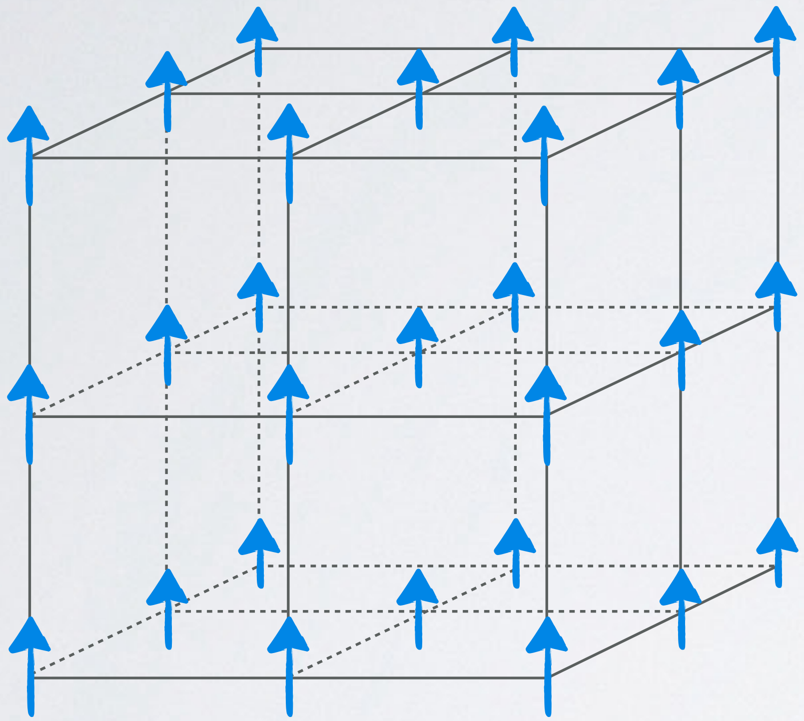

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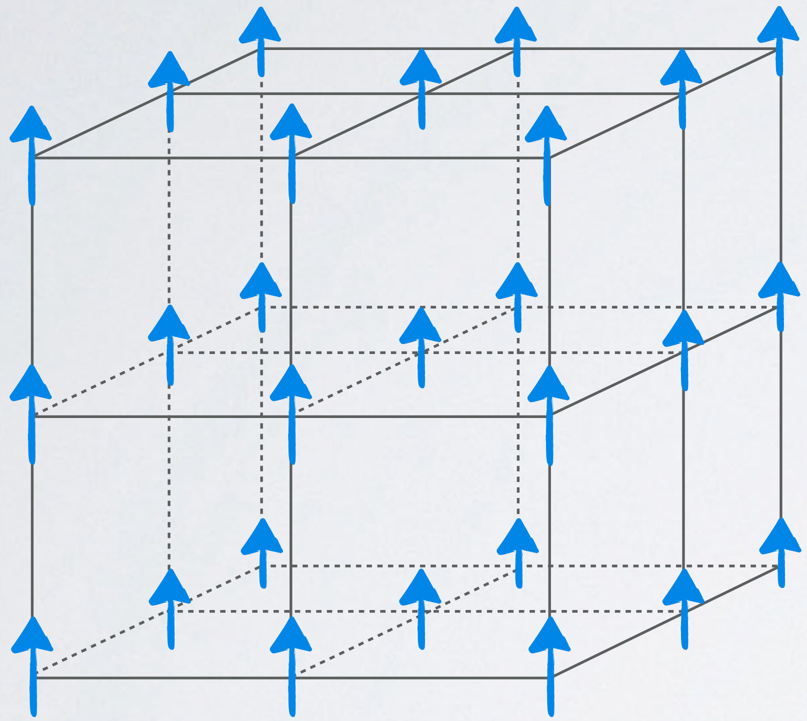

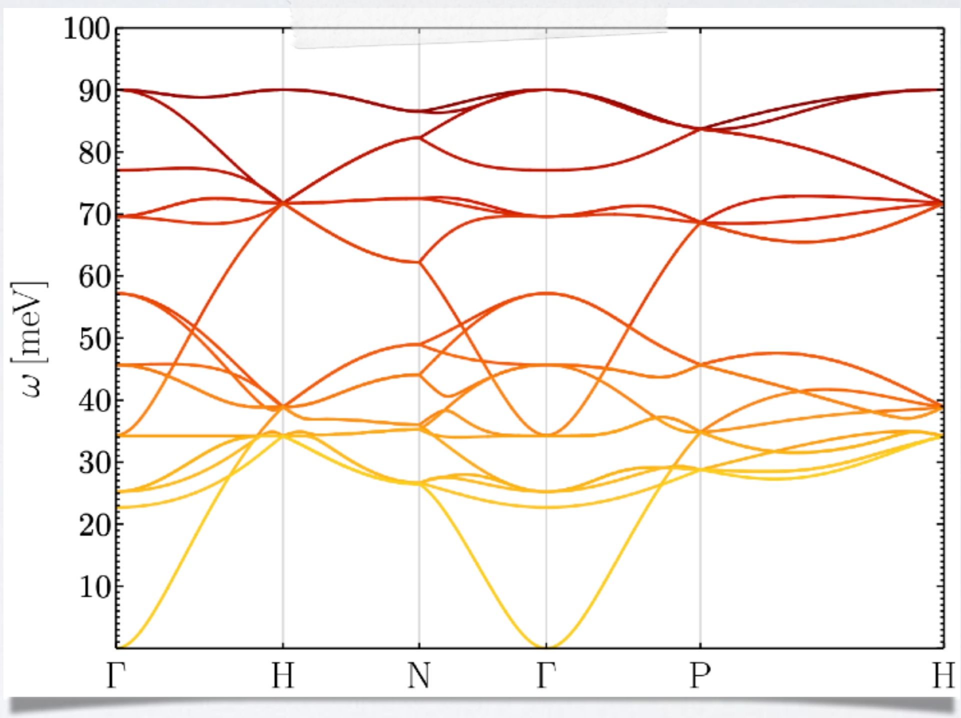

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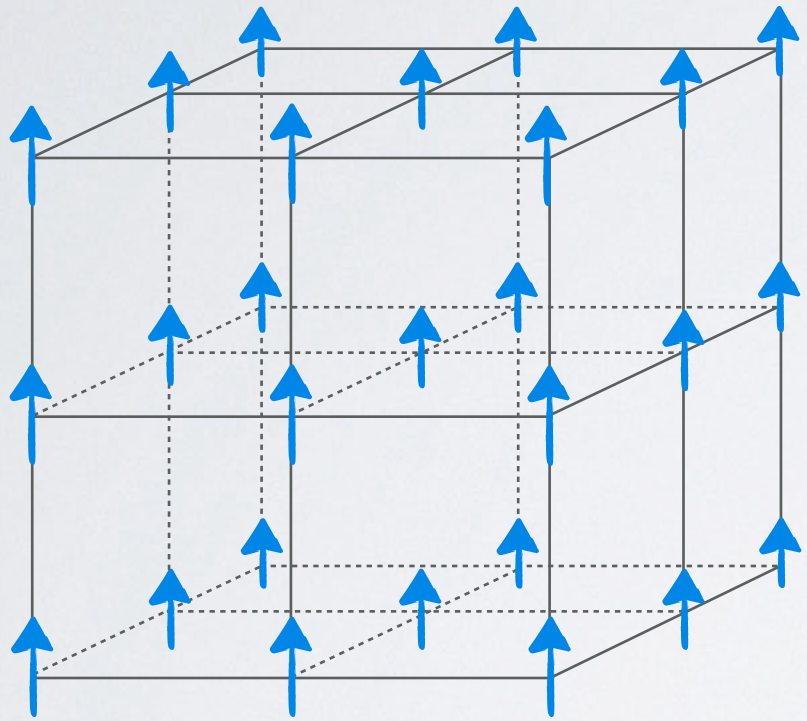

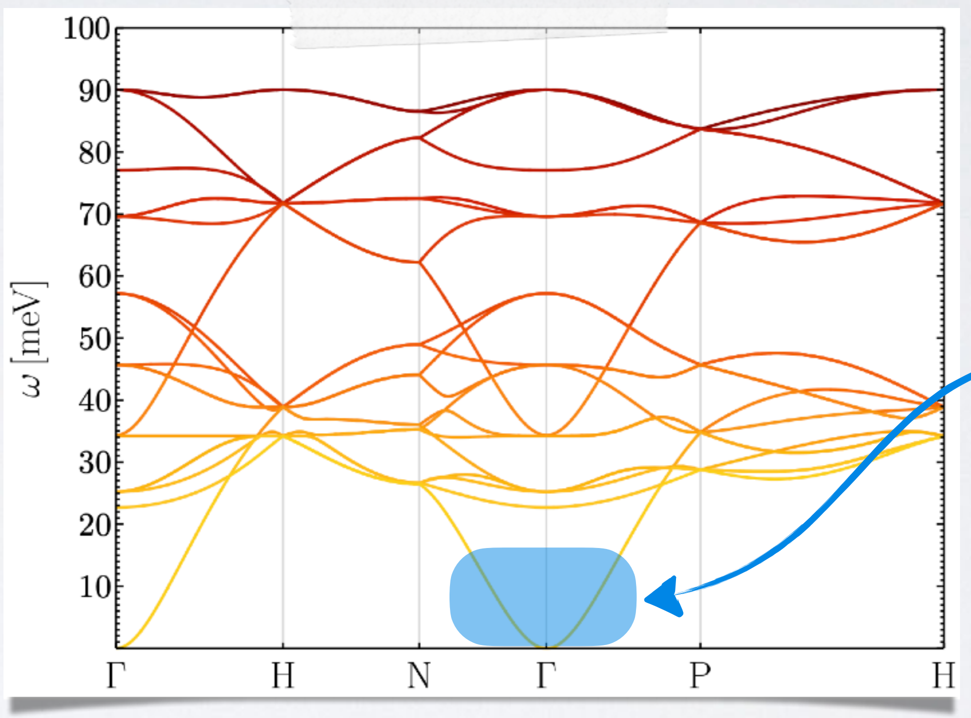

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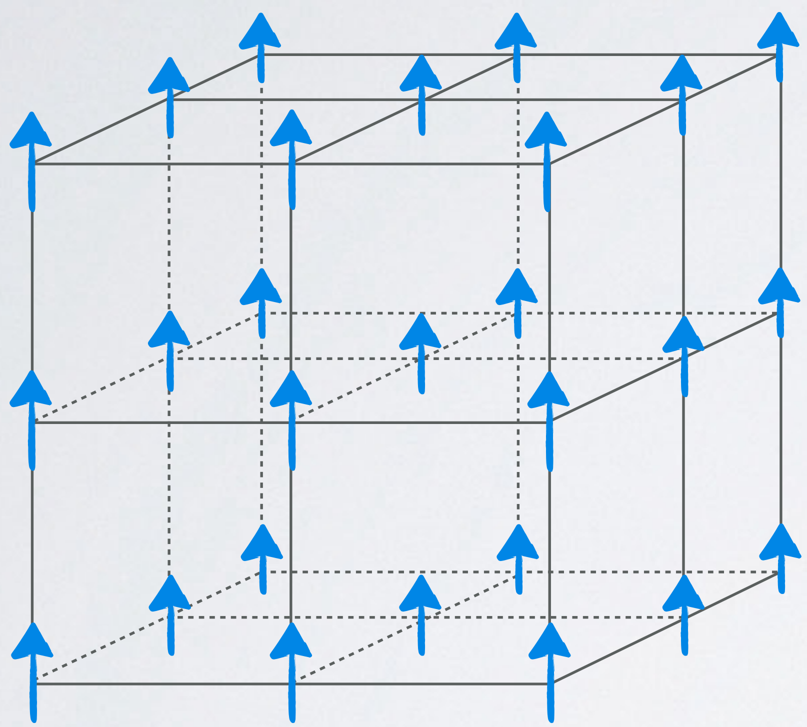

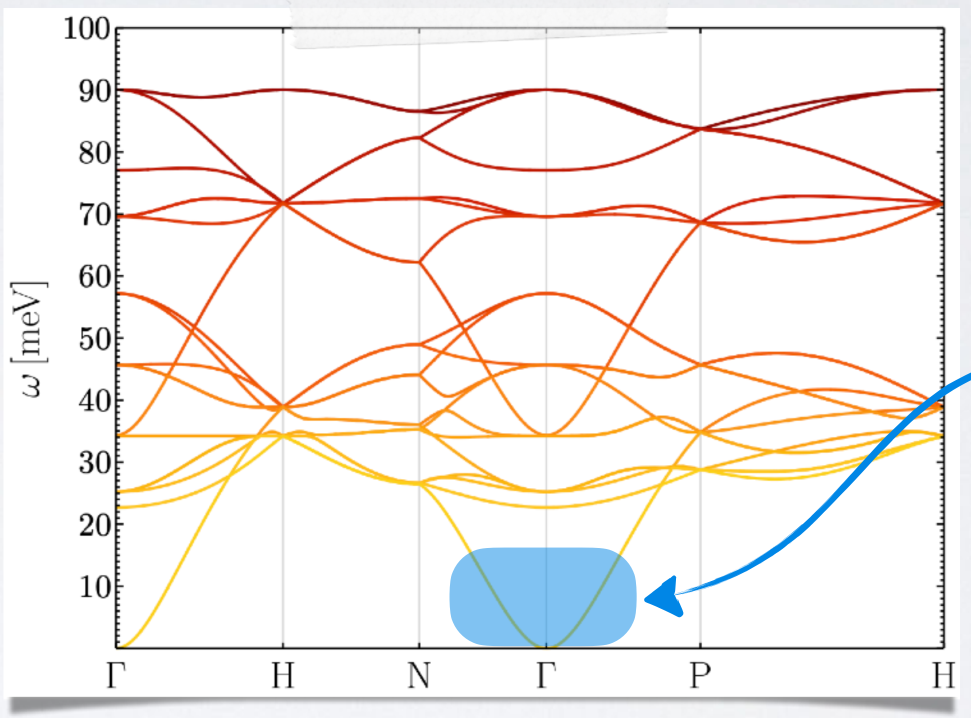

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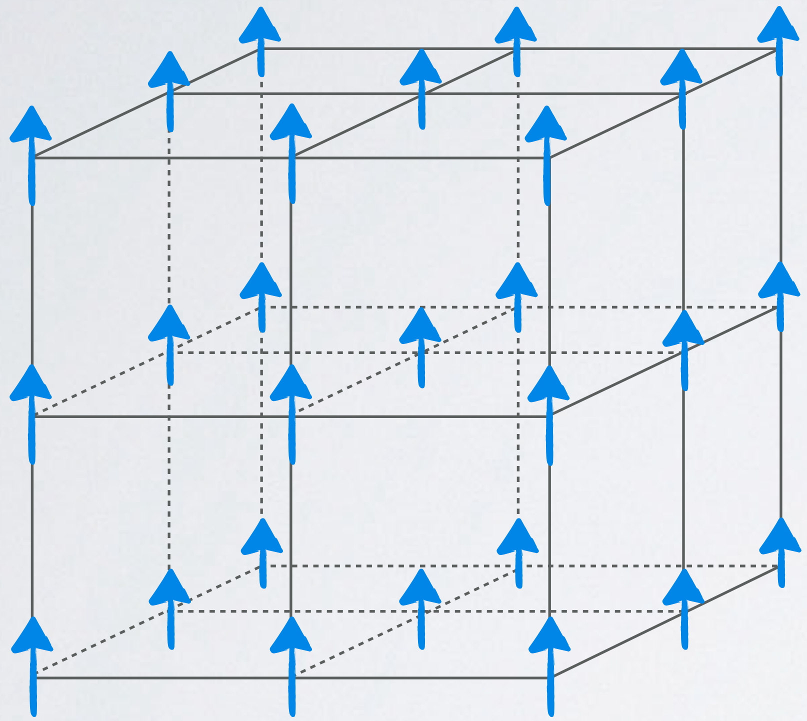

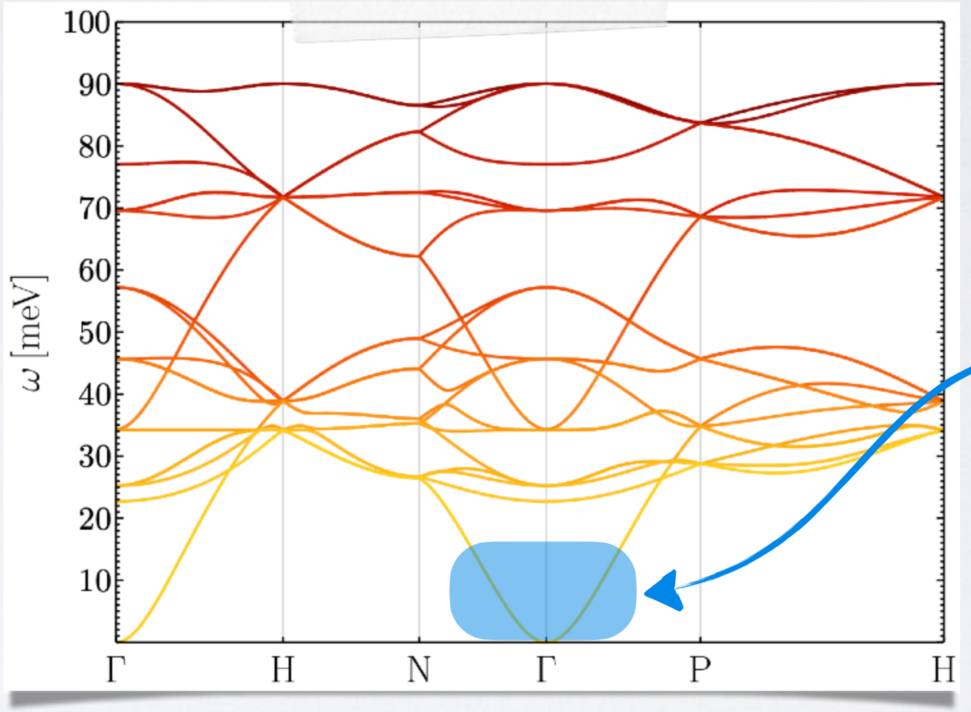

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$$\omega_{max} = E_\chi \frac{4\, m_\theta/m_\chi}{(1 + m_\theta/m_\chi)^2}$$ with $m_\theta \sim 1$ MeV → inefficient for $m_\chi \lesssim \mathcal{O}(\text{MeV})$

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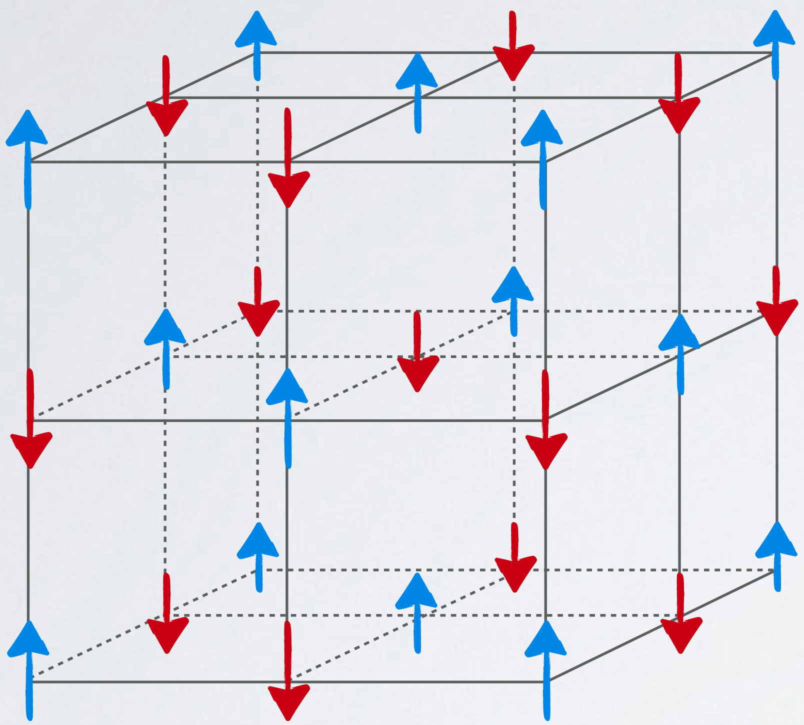

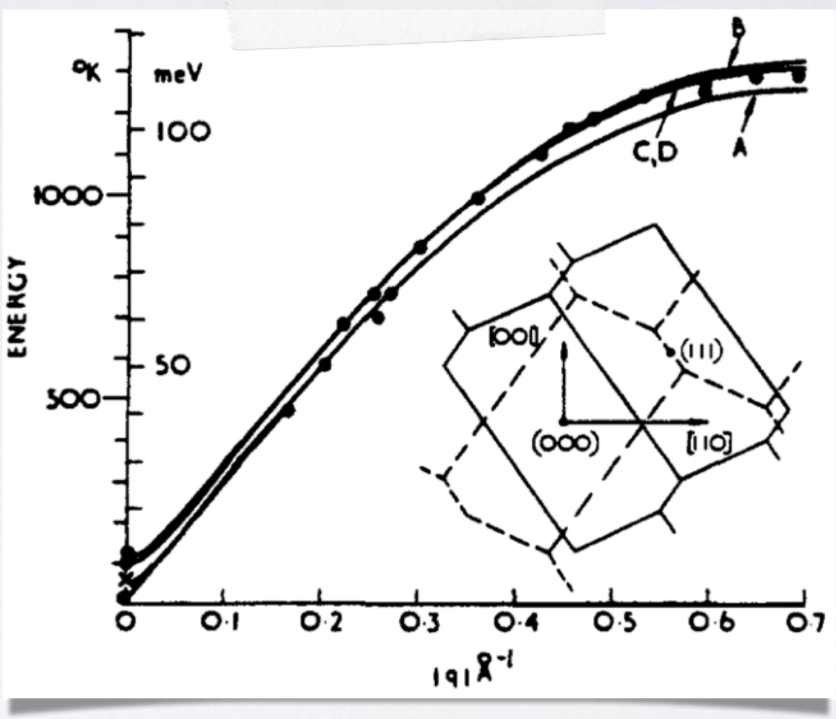

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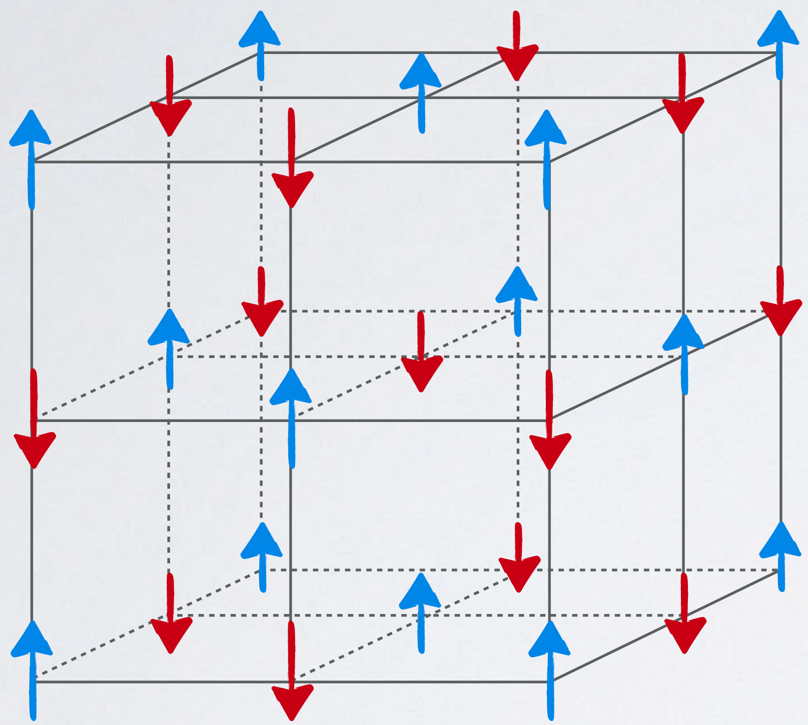

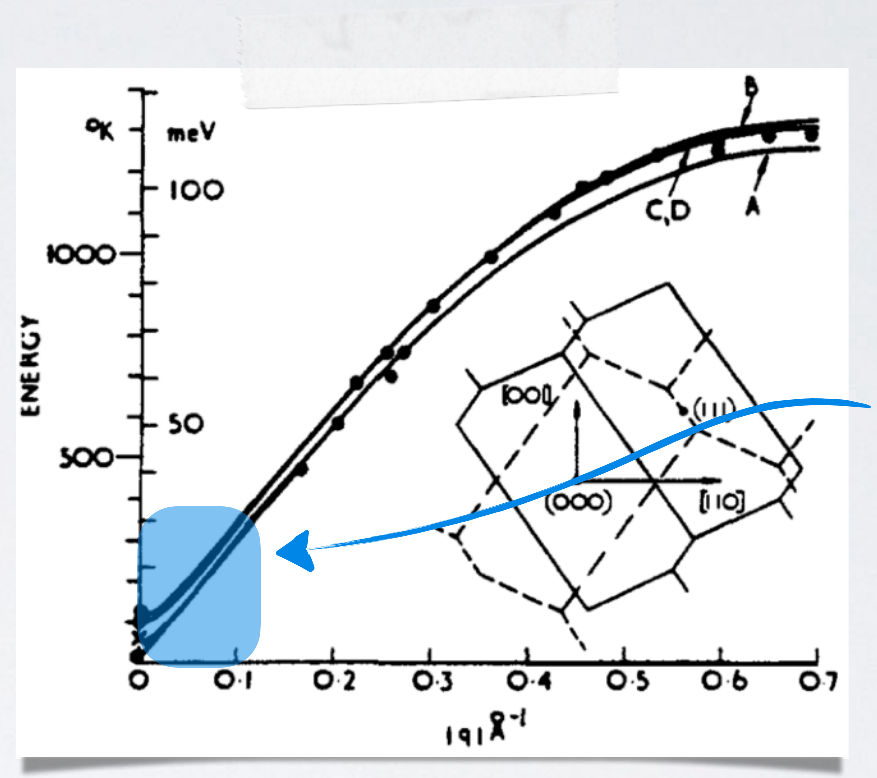

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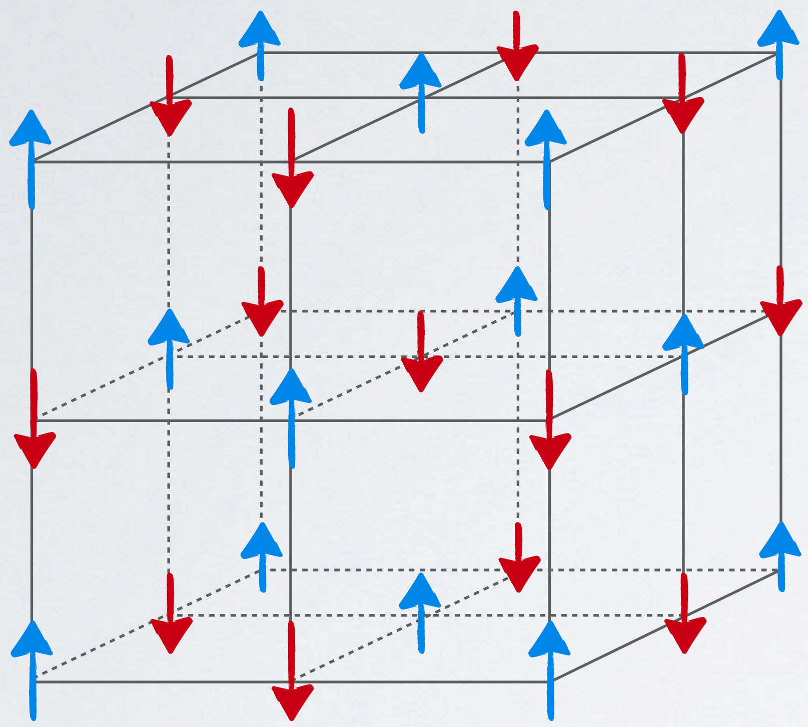

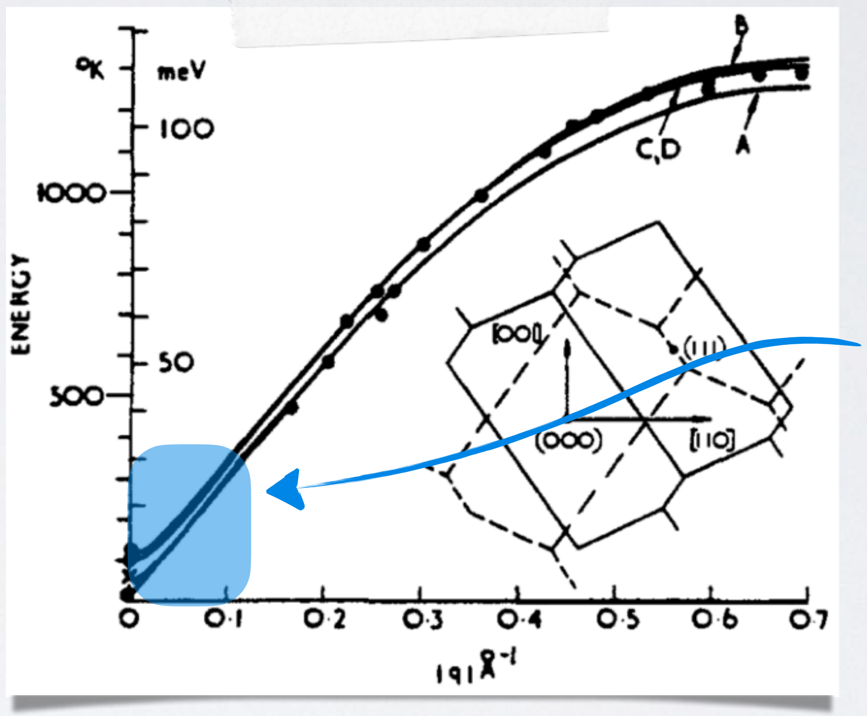

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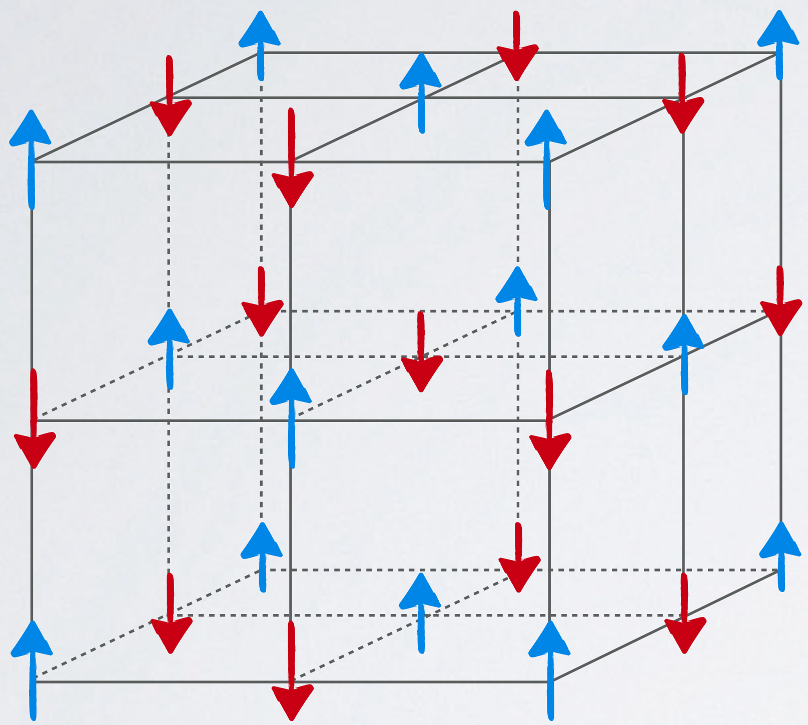

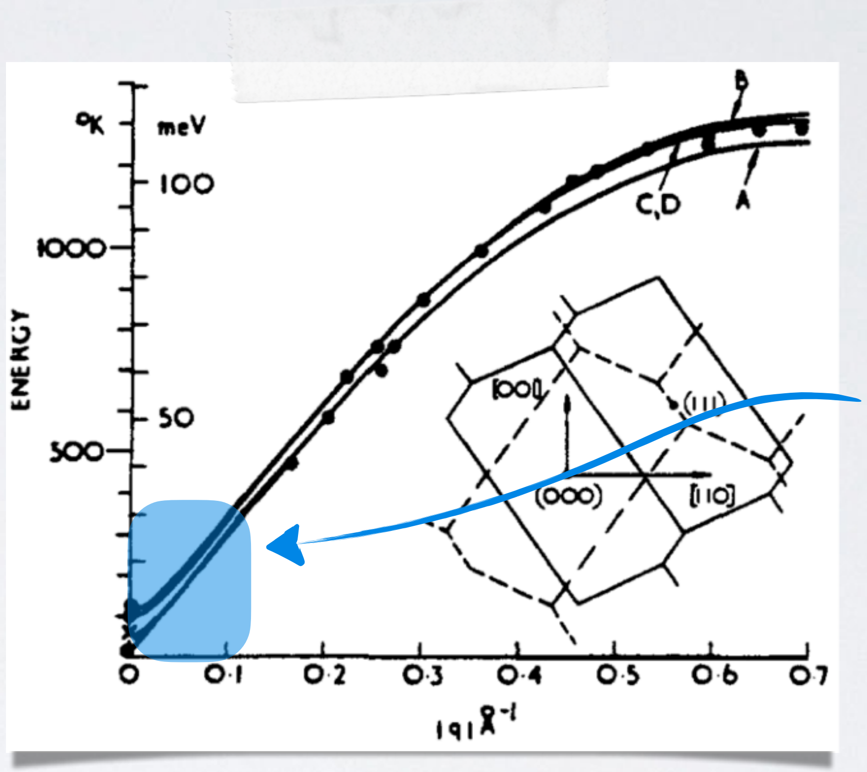

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- Nickel-oxide has $v_\theta \sim v_\chi$ → very efficient at absorbing dark matter energy [**AE**, Pavaskar — PRD (2023), 2210.13516]

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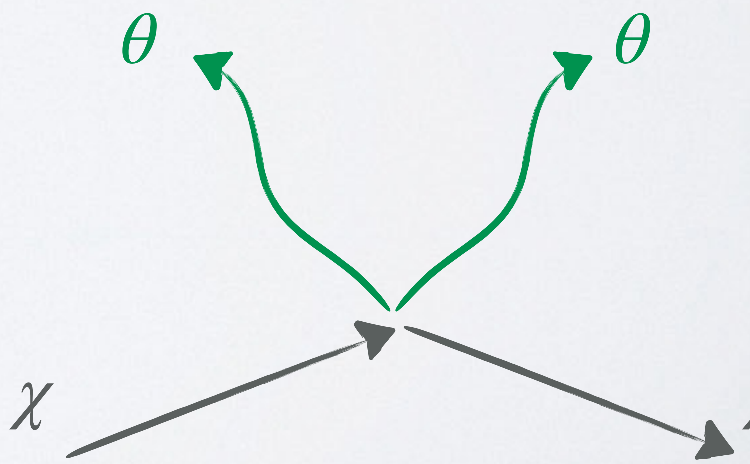
- Multi-magnon emission process evade the kinematical constraints and get down to $m_\chi \sim \mathcal{O}(\text{keV})$



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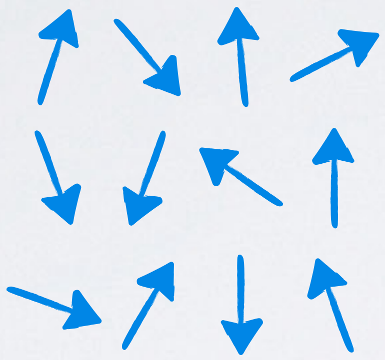

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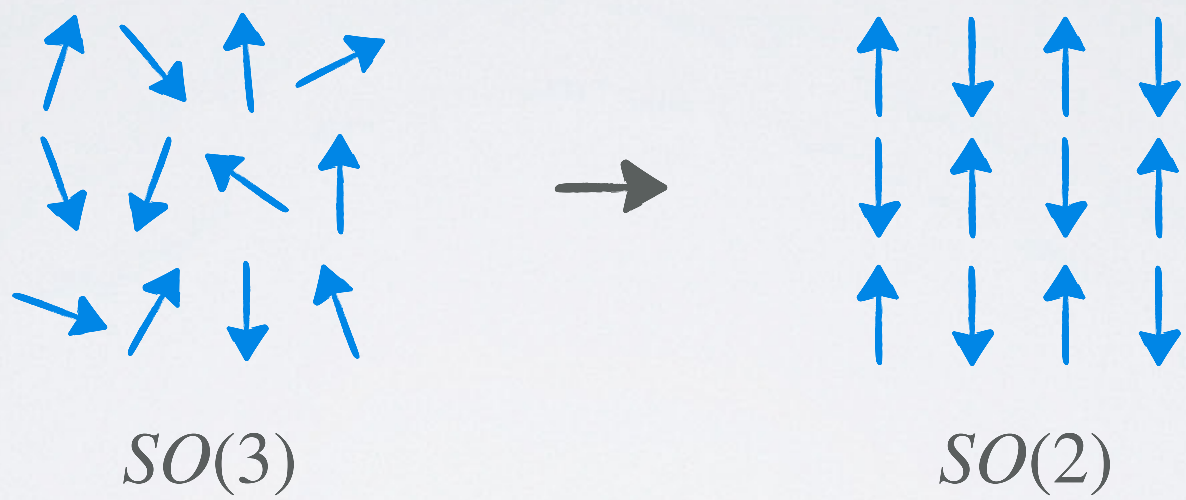

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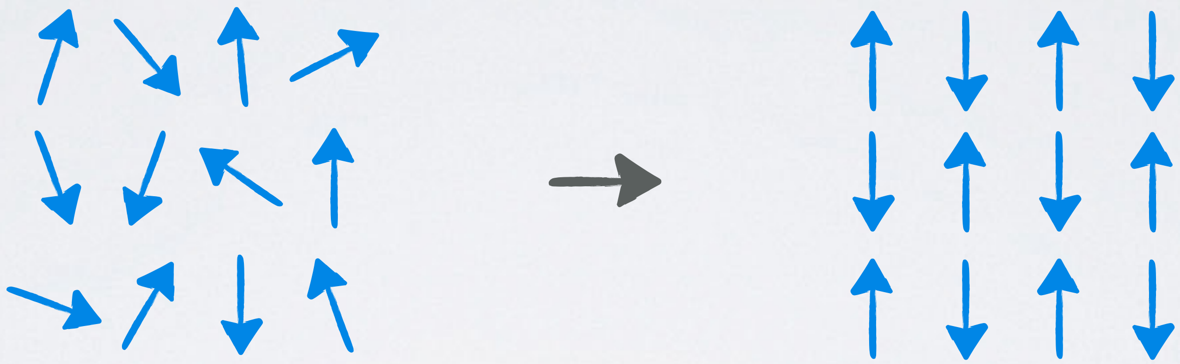

$SO(3)$ $SO(2)$

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- At low energies/momenta magnons can be described by an EFT, invariant under the full symmetry group

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can be extracted from dispersion relation + neutron scattering data

$$v_\theta = c_2 / c_1$$

$$\sigma_n \propto c_1$$

[Burgess — Phys. Rept. (2000), hep-th/9808176; **AE**, Pavaskar — PRD (2023), 2210.13516]

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- This allows to bypass difficulties in the standard treatment (failure of the Holsten-Primakoff approach) [Dyson — Phys. Rev. 1956]

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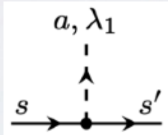
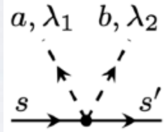


$$= -\frac{g_\chi g_e \sqrt{c_1}}{m_e}\omega \times \begin{cases} \frac{4}{\Lambda_\chi} P_{ia}(\boldsymbol{q})\sigma^i & \text{m.d.} \\ q^a/q^2 & \text{p.m.} \end{cases},$$



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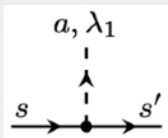

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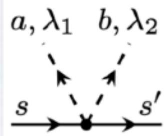

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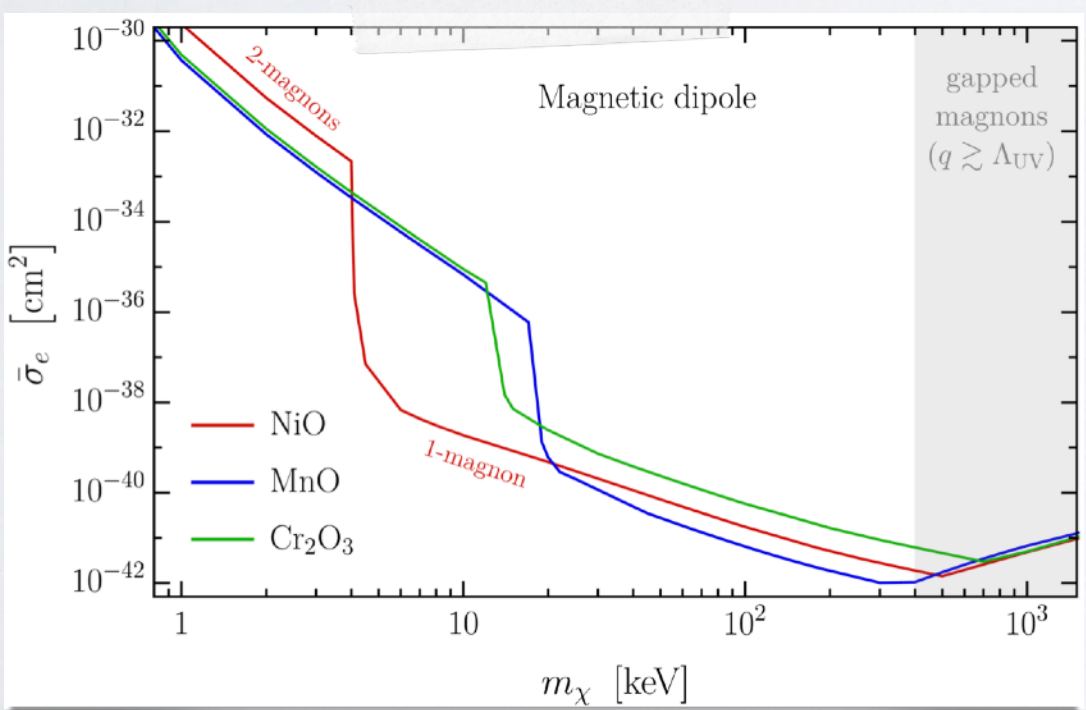

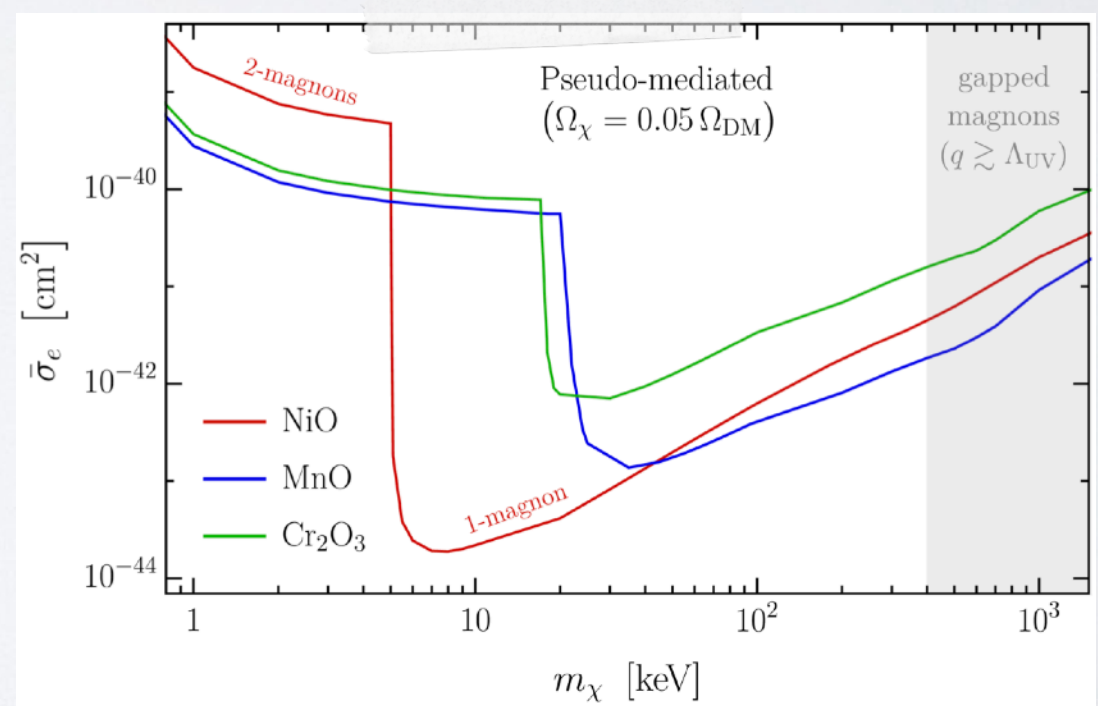

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