Probing Axions Through Astrophysical Magnetic Phenomena

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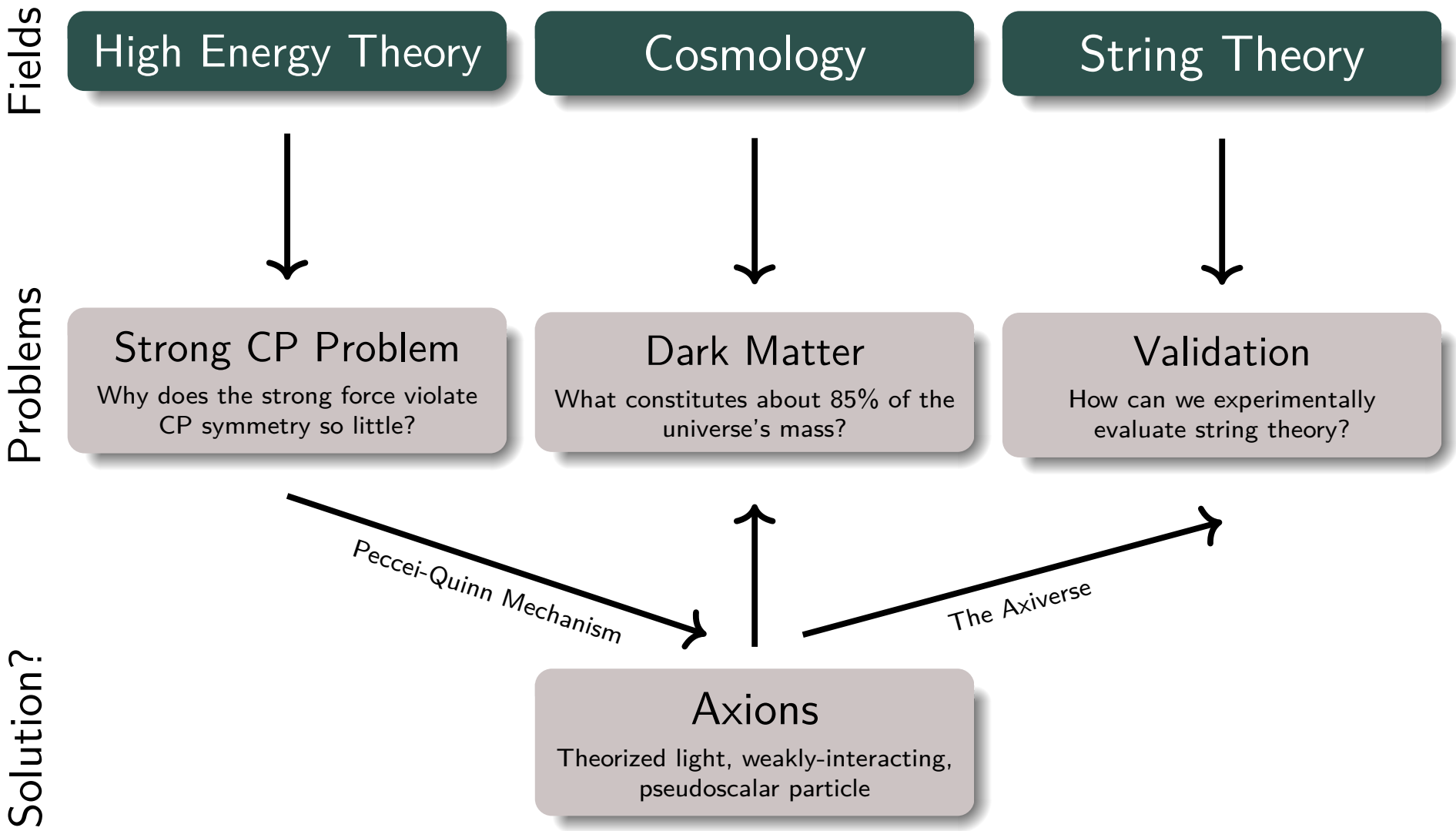
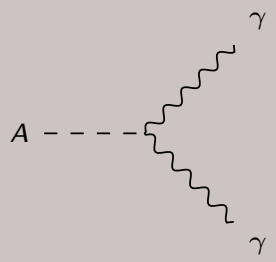
Project Motivation: Axions as Problem-Solvers

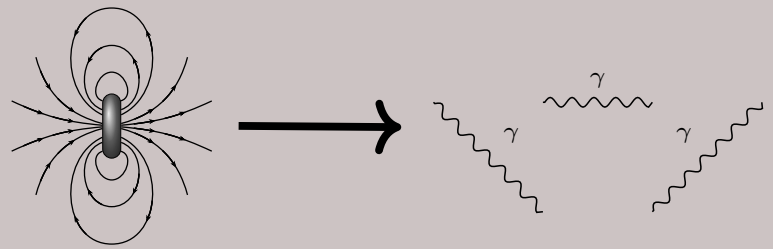


Approach: Axion-Photon Mixing

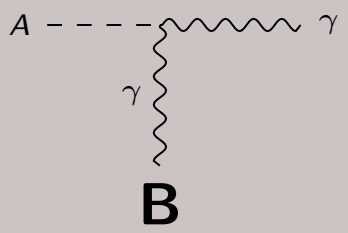
The $A\gamma\gamma$ interaction



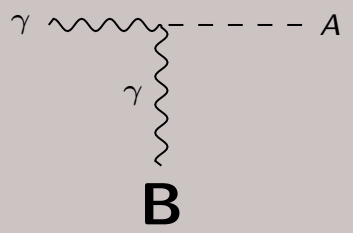
Magnetic Field Quantization



Magnetic Field-Induced $A\gamma$ Mixing



- Magnetic fields contribute a photon, allowing $A \to \gamma$, $\gamma \to A$ ("mixing")
- Yields studiable effects (photon luminosities, "light shining through walls"



Implementation: Astrophysical Magnetic Fields

Where do we find strong magnetic fields?

Humanmade Magnets

- MRI machines — 1-7 T
- ATLAS magnet (LHC) — $\sim$2 T
- CMS magnet (LHC) — 4 T
- FSU's NHMFL (record, continuous) — 45 T
- VNIIEF (record, pulsed) — $2.8 \cdot 10^3$ T

Natural Magnets

- Earth's magnetic field — $3 \cdot 10^{-6}$-$6 \cdot 10^{-6}$ T
- Neutron star — 10^6-10^8 T
- Magnetar — 10^8-10^{11} T

Figure: Compact Muon Solenoid Magnet

Figure: Florida State University Magnet

Figure: Neutron Star/Magnetar Depiction

Conclusion: astrophysical phenomena yield unique opportunities to study axions

Where I Fit In

Summer Objectives

- Study photon-axion mixing theory, primarily by deriving the results given in a classic paper by Raffelt and Stodolsky
- Perform numerical simulations of photon-axion mixing in astrophysical environments to constrain the axion parameter space (mass, photon coupling)

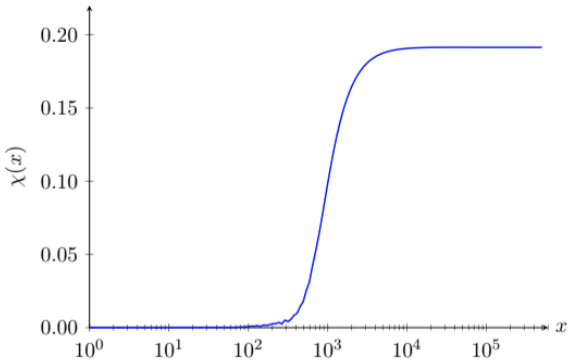


Figure: Axion "concentration" as a function of distance from magnetar

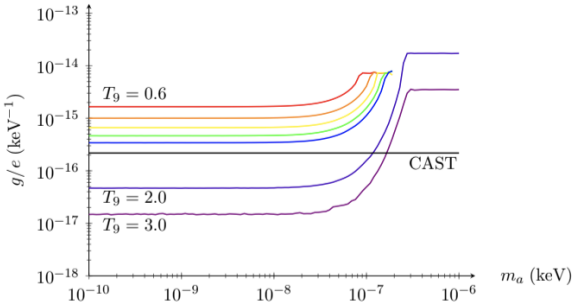


Figure: Inferred constraints on axion mass m_a and coupling to photons g (valid regions below contours)

Thank You!

Questions?