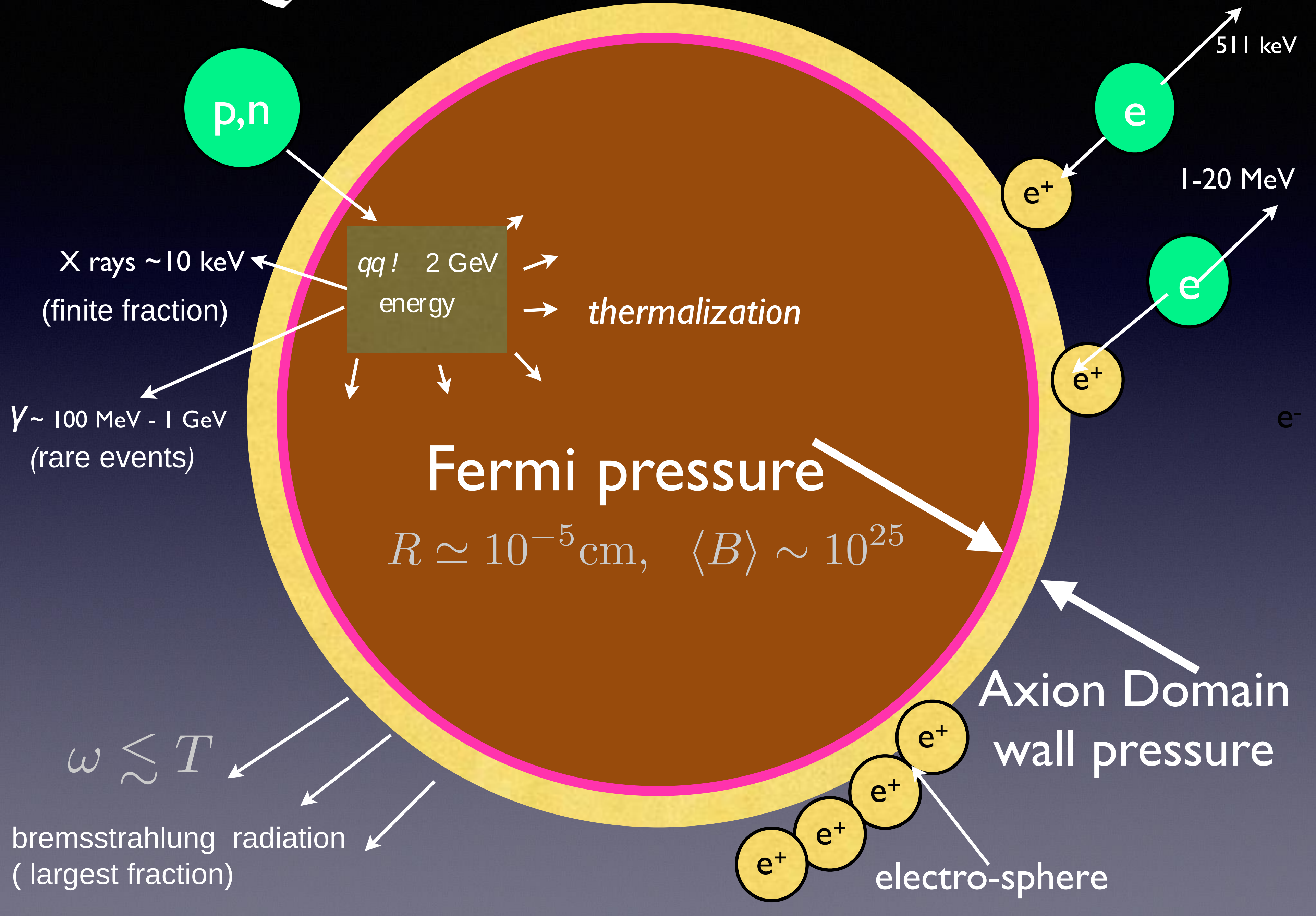
Witten; Glashow; Zhitnitsky : Axion quark nuggets (AQN) and antinuggets.

Spherical axion domain wall produces pressure keeping inside quarks or antiquarks in color superconducting state.

Solution for dark matter and bariogenesis within Standard Model + axion.

Equal number of quarks and antiquarks in Universe but antiquarks survived inside antinuggets only. Asymmetry between matter and antimatter due to initial theta.

AQN: Source of Emissions



Mass about 10 gram. For the given dark matter mass density, the number density of AQN is extremely low → never hits a detector

Detection of Axion Quark Antinuggets on ~ 100 km distance from AQN track

Axion Quark Nuggets and how a Global Network can discover them, Budker, V.F. , Liang, Zhitnitsky, Phys. Rev. D 2020, arXiv: 1909.09475
AQN passes through Earth, quark annihilation process generates axion wave which produces correlated effects in a network of devices (GNOME model)

Infrasonic, acoustic and seismic waves produced by the Axion Quark Nuggets. Budker, V. F. and Zhitnitsky, arxiv,2003.07363,
Detection of AQN using sound waves from antiAQN-matter annihilation, 10% of AQN mass annihilates during passage through Earth.
Detection by networks of seismic stations, network of optical fibers, infrared telescopes, radars. One candidate event has already been observed.
--
Indirect – possible manifestations
Primordial Lithium Puzzle and the Axion Quark Nugget Dark Matter Model. V.F. and Zhitnitsky, Phys. Rev. D 99, 023517 (2019), arXiv:1811.01965
Capture rate ~ $\exp(-Z^{AQN} Z e^2/RT)$, AQN captures Li (Z=3) and Be (Z=4), this explains factor of 3 suppression of the primordial Li abundance

Low-mass Spin-0 Dark Matter

Dark Matter

Scalars or quadratic axions

→ 'Slow' evolution and oscillating variation of fundamental constants

- Atomic clocks
- Laser interferometers
- Big Bang Nucleosynthesis, CMB

Improvement up to 15 orders!

Because effects are linear in small interaction constant

Pseudoscalars (Axions, ALPs): *Odd-parity*

→ Oscillating spin-dependent effects, *P*,*T*, Lorentz and Einstein symmetry violation

- Atomic magnetometry
- Ultracold neutrons
- Electric dipole moments

Improvement 3 orders

Relativistic effects increase ionisation by dark matter WIMP scattering on electrons by up to 3 orders of magnitude!

[Roberts, V.F., Gribakin, PRL 116, 023201 (2016)]

- Important for numerous existing and future underground dark matter detectors.
- Detailed relativistic many-body calculations in [Roberts, Dzuba, V.F., Pospelov, Stadnik, Phys. Rev. D 93, 115037, 2016, Roberts and V.F., Phys. Rev. D 2019,]
- Our calculations show tension between DAMA and XENON results. XENON use our calculations since their PRL 2017.

Ionisation of atoms inside underground detectors by absorption of axions, scalars, vectors, pseudovectors

Parity and time reversal violation in atoms, molecules and nuclei, tests of unification theories in atomic experiments

We perform accurate relativistic many-body calculations and

propose enhanced effects

Best limits on theta, EDM, Z'-boson