Direct Detection of Dark Matter



SUSY-withstood the test of time

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Search for Single Photons from Supersymmetric Particle Production 18 MARCH 1985

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A search in e^+e^- annihilation for final states which contain only a single energetic photon has been performed at $\sqrt{s} = 29$ GeV with the MAC detector at PEP. The upper limit on an anomalous signal has been interpreted in terms of mass limits for supersymmetric particles under the assumption of radiative pair production of either supersymmetric photons or neutrinos. For the supersymmetric electron (\tilde{e}) this limit is $m_{\tilde{e}} > 37$ GeV/ c^2 at the 90% confidence level if $m_{\tilde{e}_L} = m_{\tilde{e}_R}$ and the supersymmetric photon ($\tilde{\gamma}$) has $m_{\tilde{s}} = 0$.

8/26/15

Discoveries can take time - neutrino

The Average Energy of Disintegration of Radium E. By C. D. ELLIS, Ph.D., Lecturer in the University of Cambridge, and W. A. WOOSTER, B.A., Charles Abercrombie Smith Student of Peterhouse, Cambridge. (Communicated by Sir Ernest Rutherford, O.M., P.R.S.-Received August 3, 1927.) Proc. R. Soc. Lond. A 1927 117, doi: 10.1098/rspa.1927.0168, published 1 December 1927 ²¹⁰Bi Source, and Blank (b)Calorimeters \approx 30 years later to neutrino detection (Reines et al.) ≈ 60 years later to neutrino mass (Davis et al.) \approx 100 years later to complete mass matrix (?) (α)

8/26/15

FIG. 2.

Experimental Perspective of Direct Dark Matter Detection

- Shield a pure target of (matter, magnetic field) as best you can (underground, lead, water..)
- Understand the event rate in the target
- Signal Specifics...
 - Neutralino/WIMP... 0 to 200 keV deposited energy
 - Nuclear or electron recoils
 - Nucleus choice and technology choice
 - Magnetic Field axions RF signal processing
 - Astrophysical modulation(s)
- Ultimate Background instrumental... neutrinos

Grand Electron Recoil Comparison

(nucl. recoils: 10⁻⁹ 1-phase Ar; 5×10⁻³ 2-phase Xe TPC)



RPP 2014

missing: new Darkside-50, CDEX, CRESST-II, PandaX I, PICO, DAMIC



With some physics



Appropriate Technologies



High Mass WIMPs: Xenon

(Maria Elena Monzani)



Benchmark Process



Cross to LHC



Spin Independent





Two New Xenon-100 Results (Christopher Tunnel)

DM Electron Coupling

Expected Astrophysical Modulation



LUX: in-situ nuclear recoil calibration

(M. Szydagis)



LUX: reanalysis of existing data 4X exposure data run underway

(M. Szydagis)



Future 2-Phase Xenon Detectors





rry Nelson Commission in Fall (nT)

Xenon Future

• XENON1T- 2t active Xe; LZ – 7t active Xe (G2)



LZ: Funded, on line in 2018

(Maria Elena Monzani)

The LZ Dark Matter Experiment



Expected LZ Sensitivity

(1000 live days) (Maria Elena Monzani)



DEAP... operations imminent

(Ben Smith)



Detector design

- 3600kg LAr, 1000kg fiducial
- Acrylic vessel 85cm radius
- Surrounded by water shield





DEAP... assembly (Ben Smith)

Recent milestones

- Acrylic Vessel completed Nov 2013
- Inner detector instrumented Jun 2014.
- AV resurfacing complete Nov 2014
- Steel shell and veto PMTs Apr 2015
- Wavelength-shifter deposited Jun 2015
- Water tank completed Jul 2015
- Laserball calibration data Jul 2015

Liquid Noble Sensitivity Compared



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DarkSide Measurement of ³⁹Ar in Underground Argon



High Energy Community Neglected Nucleon (Fermi) Motion The Allowed EFT Operators

- SI Interaction
Cannot obtain
at lowest order $\mathcal{O}_1 = 1_{\chi} 1_N$ $\mathcal{O}_7 = \vec{S}_N \cdot \vec{v}^{\perp}$ Cannot obtain
at lowest order $\mathcal{O}_2 = (v^{\perp})^2$ $\mathcal{O}_8 = \vec{S}_{\chi} \cdot \vec{v}^{\perp}$ $\mathcal{O}_3 = i \vec{S}_N \cdot (\frac{\vec{q}}{m_N} \times \vec{v}^{\perp})$ $\mathcal{O}_9 = i \vec{S}_{\chi} \cdot (\vec{S}_N \times \frac{\vec{q}}{m_N})$ SD Interaction $\mathcal{O}_4 = \vec{S}_{\chi} \cdot \vec{S}_N$ $\mathcal{O}_{10} = i \vec{S}_N \cdot \frac{\vec{q}}{m_N}$ $\mathcal{O}_5 = i \vec{S}_{\chi} \cdot (\frac{\vec{q}}{m_N} \times \vec{v}^{\perp})$ $\mathcal{O}_{11} = i \vec{S}_{\chi} \cdot \frac{\vec{q}}{m_N}$ $\mathcal{O}_6 = (\vec{S}_{\chi} \cdot \frac{\vec{q}}{m_N})(\vec{S}_N \cdot \frac{\vec{q}}{m_N})$
- Each nuclear form factor F_{ij} associated with the allowed EFT operators can be written as a linear combination of five independent nuclear responses that depend ONLY on the nuclear physics: (arXiv:1203.3542)





4 New Nal Experiments

(slide from Walter Pettus, spoke here)



SABRE concept



US Program: G2, a Trinity of Direct Dark Matter Projects



SuperCDMS/SNOLAB: Far Lower Thresholds for the Low Mass WIMPs

Luke-Neganov Phonon Charge



Columbus



Christopher Columbus' CD-1 Review (Talavera Panel)



What you discover isn't always what started your journey.