TOWARDS AN AB INTIO DESCRIPTION OF DARK MATTER SCATTERING

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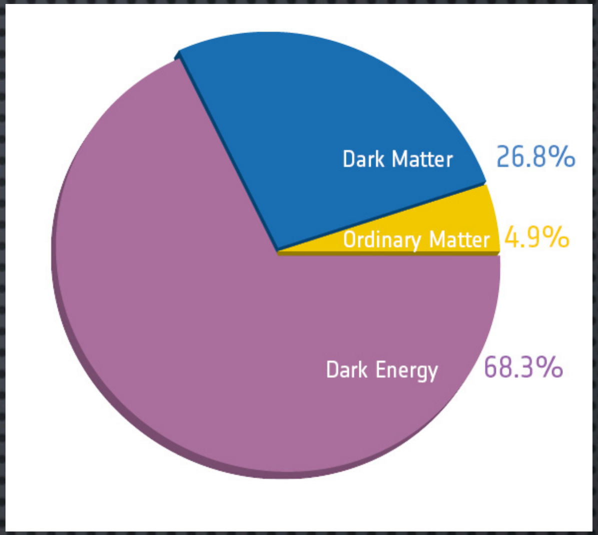
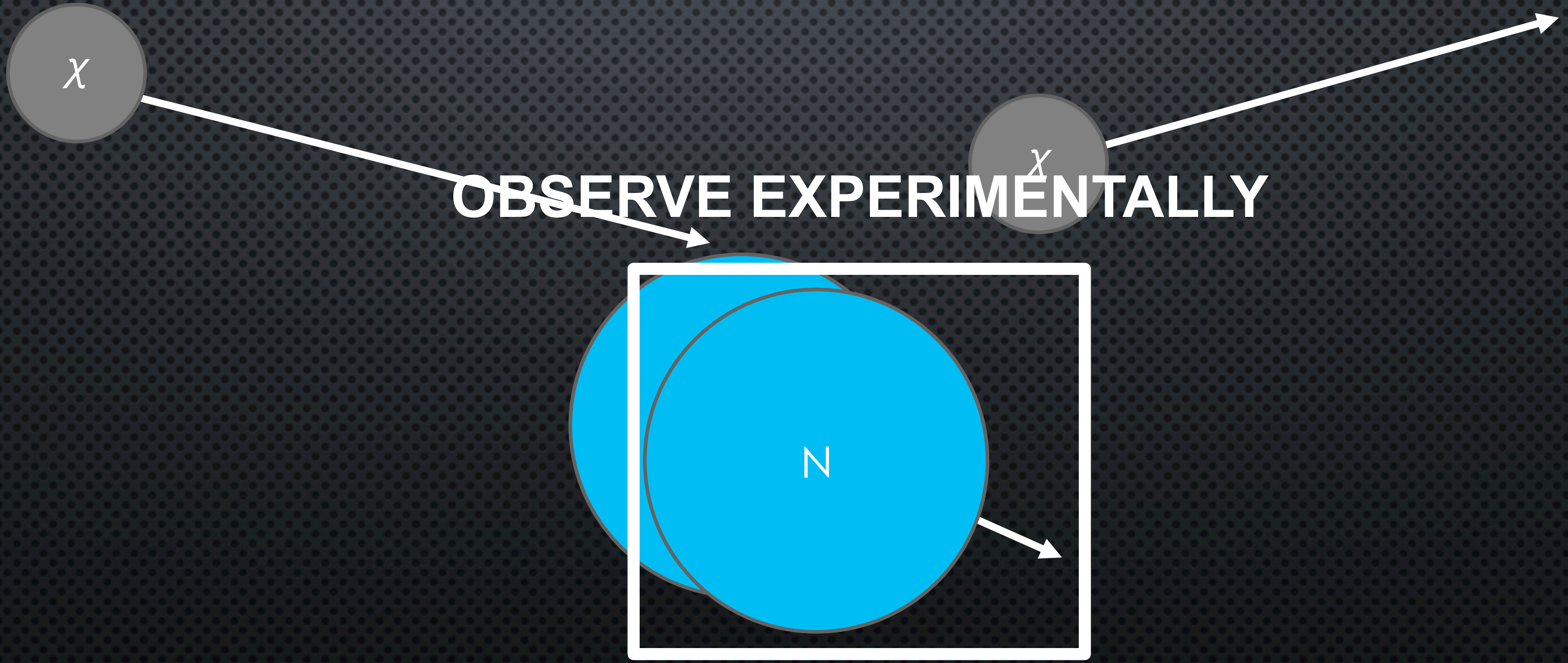
DARK MATTER AS A PARTICLE



- Cosmological observations suggest that our universe is composed of roughly 27% Dark Matter (DM)
- These observations are of the gravitational effects of DM
- DM is non-standard model matter which interacts very weakly, if at all, with standard model particles
- Many extensions to the standard model predict DM candidates called Weakly Interacting Massive Particles (WIMPs)
- If DM is composed of WIMPs, we should be able to see it scatter off of nuclei

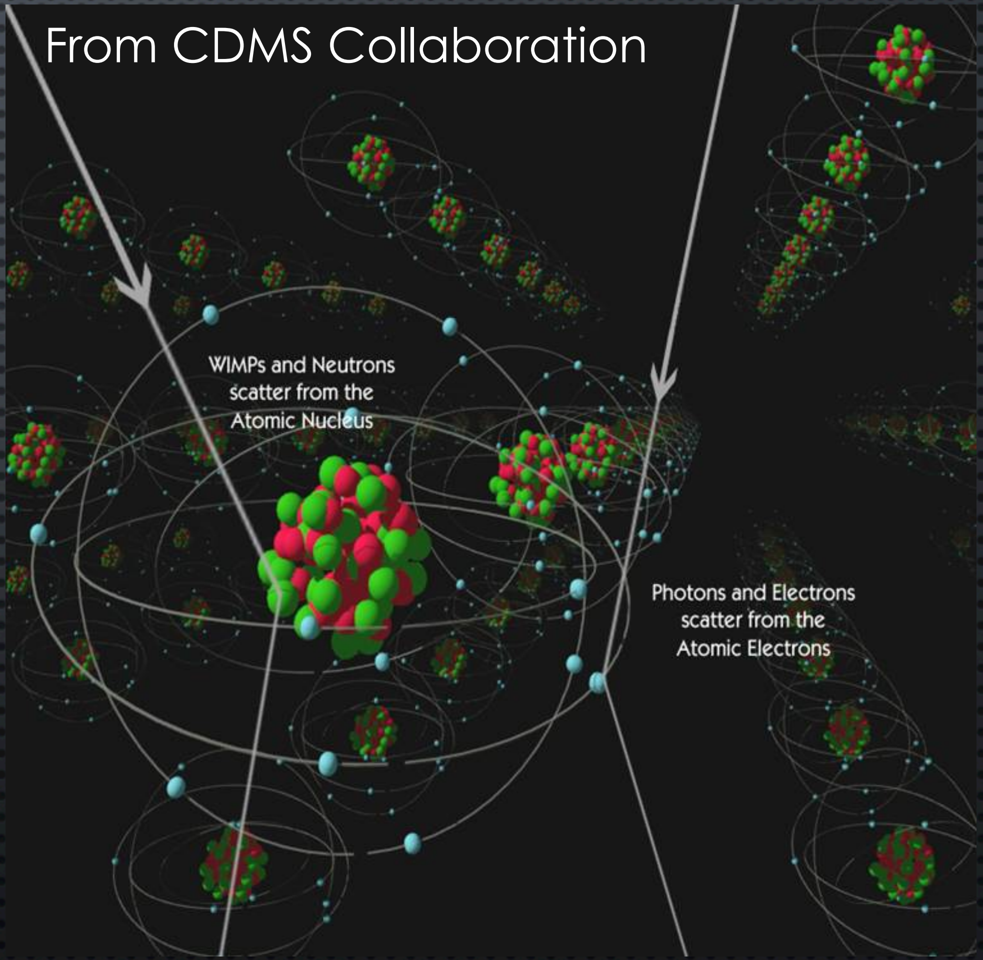
Planck Collaboration 2013 Results. http://planck.cf.ac.uk/results/cosmic-microwave-background
J. L. Feng, Annu. Rev. Astrophys. 48, 495 (2010).

DIRECT DETECTION EXPERIMENTS



DARK MATTER SEARCHES

- SuperCDMS (now at SNOLAB) – Uses Ge
- DEAP (SNOLAB) – Uses Ar
- DAMA/LIBRA (Gran Sasso, Italy) – Uses NaI
- PICO (SNOLAB) – Uses CCl_3F
- XENON (Gran Sasso, Italy) – Uses Xe
- LUX – Uses Xe
  (Sanford Underground Lab, North Dakota)



CDMS Collaboration. http://cdms.berkeley.edu/Education/DMpages/science/directDetection.shtml

DESCRIBING DARK MATTER SCATTERING

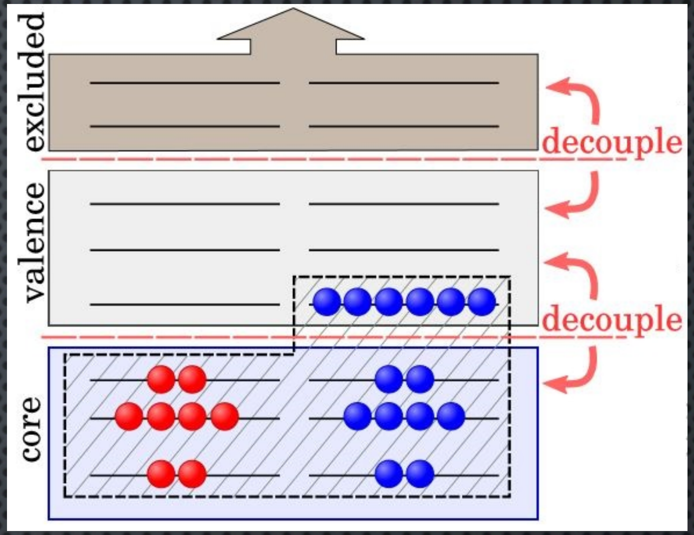
- For WIMPs predicted by supersymmetry, the most important contribution to scattering comes from axial and scalar currents
- The axial or "spin-dependent" scattering is much more sensitive to nuclear structure
- The axial structure was given the following decomposition by Engel, Pittel and Vogel:

$$S_A(p) = \langle f | \mathcal{L}^A | i \rangle = a_0^2 S_{00}(p) + a_0 a_1 S_{01}(p) + a_1^2 S_{11}(p)$$

Isoscalar Coupling   Isovector Coupling

J. Engel, S. Pittel, and P. Vogel, Int. J. Mod. Phys. E 1, 1 (1992).

Valence Space IMSRG

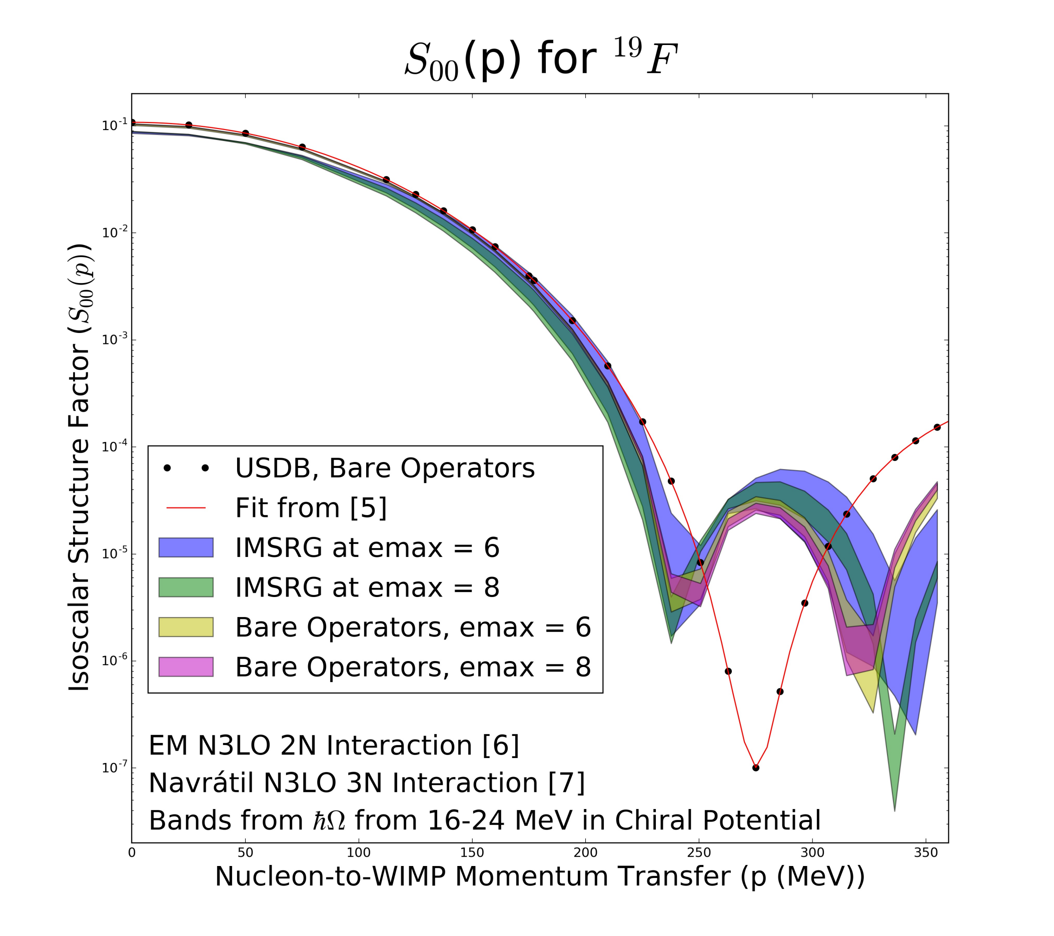


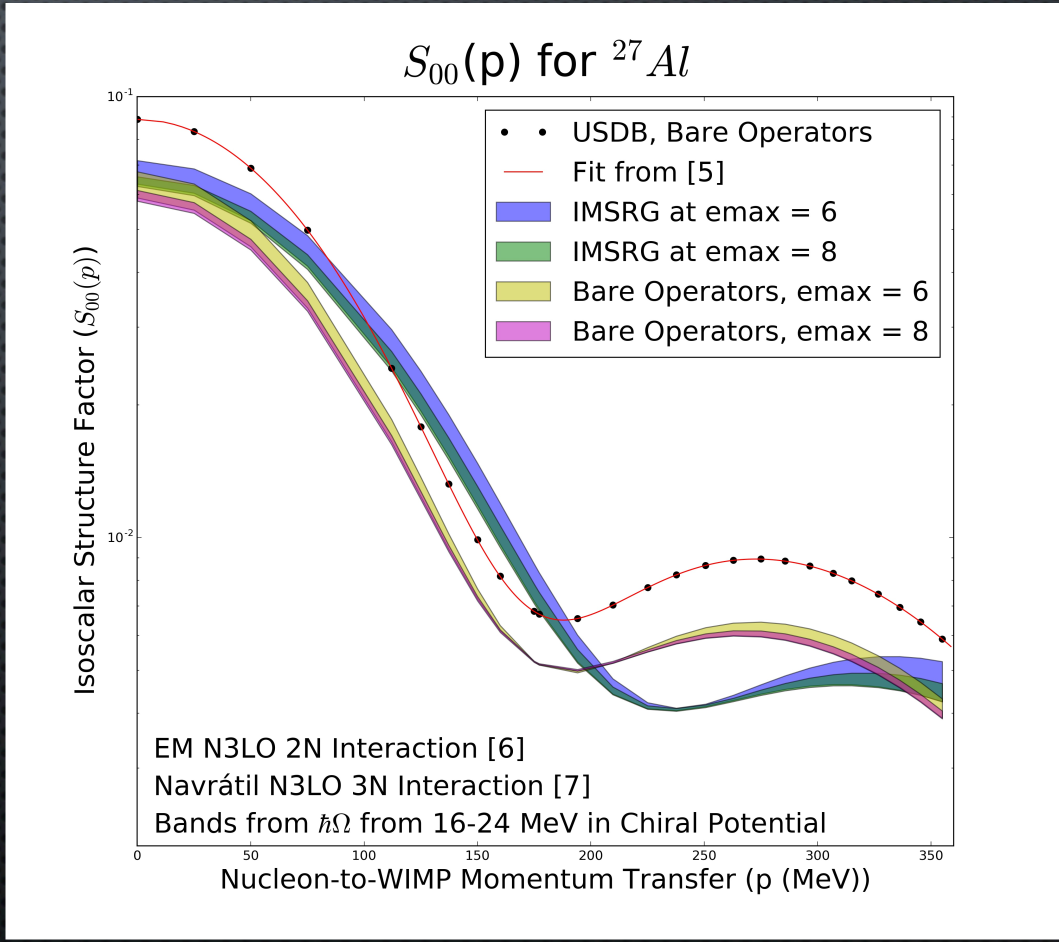
- Find an approximate ground state using Hartree-Fock and a chiral interaction
- Normal order all operators with the HF state as a reference
- Perform a unitary transformation decoupling a valence space in the Hamiltonian
- Simultaneously transform other operators
- Diagonalize the valence space Hamiltonian for the spectrum
- Compute matrix elements using transformed operators and new found states

- This framework easily allows for consistent ab initio calculations in heavy nuclei

S. R. Stroberg et al. Phys. Rev. Lett. **118**, 032502 (2017)

RESULTS





P. Klos, J. Menendez, D. Gazit, and A. Schwenk, Phys. Rev. D 88, 083516 (2013).
D. R. Entem, and R. Machleidt, Phys. Rev. C 68, 041001(R) (2003).
P. Navrátil, Few-Body Syst. 41, 117 (2007).

Future Directions

- Computation of the isovector pieces of the axial structure factor
- Inclusion of full two-body terms
- Study of uncertainties from chiral interactions and low energy constants
- Calculation in heavier nuclei: $^{129,131}Xe$, ^{127}I, ^{73}Ge