

Determining dark matter properties with direct detection experiments

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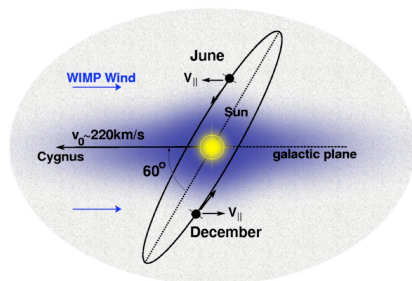


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- Dark matter (DM) direct detection
- Current strategies for the interpretation of direct detection data
- New! Determining the DM particle spin with next generation direct detection experiments
- DM direct detection at Chalmers
- Summary

- Motivation and strategy:

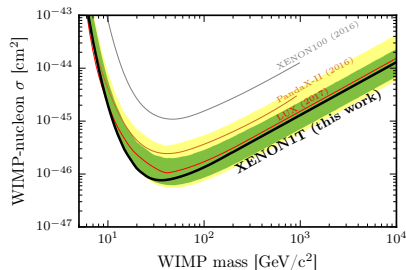


- **Differential rate** of dark matter-nucleus scattering events in terrestrial detectors

$$\frac{d\mathcal{R}}{dE_R} = \frac{\rho_\chi}{m_\chi m_T} \int_{|\mathbf{v}| > v_{\min}} d^3\mathbf{v} |\mathbf{v}| f_\chi(\mathbf{v} + \mathbf{v}_\oplus) \frac{d\sigma_T}{dE_R}$$

Current strategies for the interpretation of direct detection data, i.e. null results

- **Standard strategy:** set exclusion limits on SI and SD DM-nucleon interactions
- **Extended strategy:** set exclusion limits on the complete set of Galilean invariant DM-nucleon interactions
- Focus on the DM particle mass and couplings
- DM particle spin unconstrained



Aprile et al., 2017

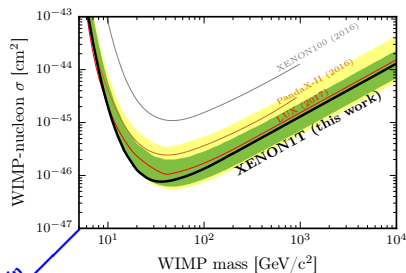
Our proposal: two strategies to extract the DM spin from data, i.e. signals

■ DM spin from directional detection

R. Catena, J. Conrad, C. Döring, A. D. Ferella
and M. B. Krauss, arXiv:1706.09471

■ DM spin combining direct detection and LHC

S. Baum, R. Catena, J. Conrad, K. Freese and
M. B. Krauss, arXiv:1709.06051

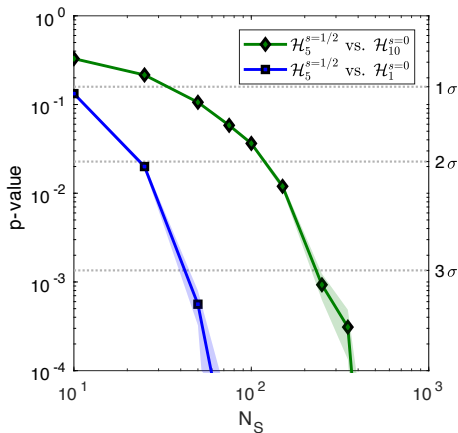
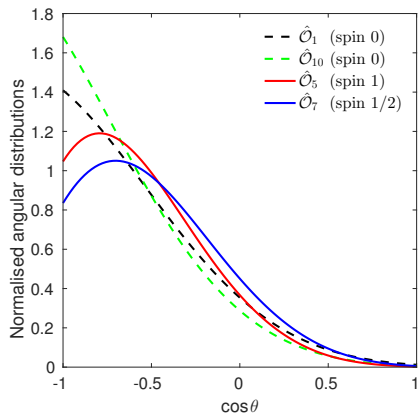


Aprile et al., 2017

- Start from an EFT for spin ≤ 1 DM-quark interactions arising from the exchange of spin ≤ 1 mediators
- Match this EFT onto a non-relativistic effective theory for DM-nucleon interactions
J. B. Dent, L. M. Krauss, J. L. Newstead and S. Sabharwal, Phys. Rev. D **92**, no. 6, 063515 (2015)
- Account for operator evolution and ChEFT corrections (more work needed along this direction)
F. D'Eramo and M. Procura, JHEP **1504**, 054 (2015)
F. Bishara, J. Brod, B. Grinstein and J. Zupan, JCAP **1702**, no. 02, 009 (2017)
- Restrict to simplified models characterised by 2 masses, 2 couplings and a leading DM-nucleon interaction

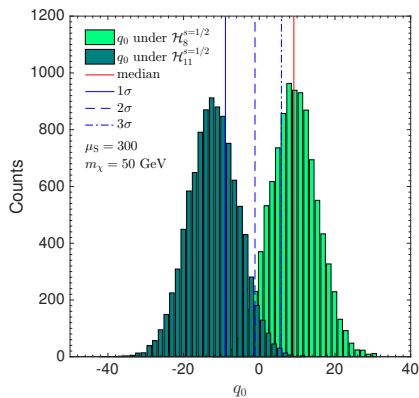
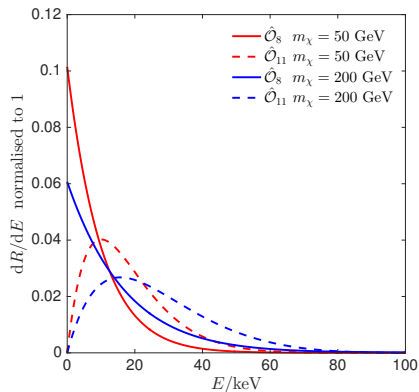
DM particle spin from directional detection

R. Catena, J. Conrad, C. Döring, A. D. Ferella and M. B. Krauss, arXiv:1706.09471



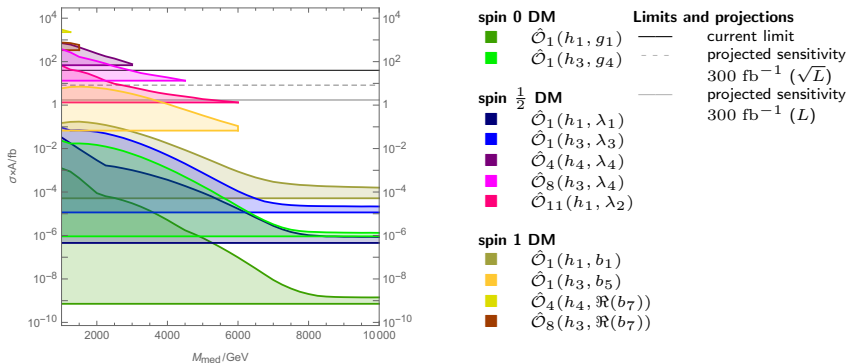
DM particle spin combining direct detection and LHC (I)

S. Baum, R. Catena, J. Conrad, K. Freese and M. B. Krauss, arXiv:1709.06051



DM particle spin combining direct detection and LHC (II)

S. Baum, R. Catena, J. Conrad, K. Freese and M. B. Krauss, arXiv:1709.06051



DM direct detection at Chalmers



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- At Chalmers, we also collaborate with, e.g.:
 - Nuclear Theory group (see Daniel Gazda's talk)
 - Gabriele Ferretti's Particle Physics group

- We are currently developing analysis strategies to extract the DM particle spin based upon the detection of a DM signal at direct detection experiments
- I briefly discussed two examples
 - DM spin from directional detection
 - DM spin combining direct detection and the LHC
- This research is performed within the Swedish Consortium for DM Direct Detection (SweDCube)
- SweDCube links theoretical groups at the Chalmers University of Technology with experimental groups at the Stockholm (XENON) and Lund universities.