TECHNISCHE UNIVERSITÄT DARMSTADT

Signatures of WIMP scattering inelastically off nuclei

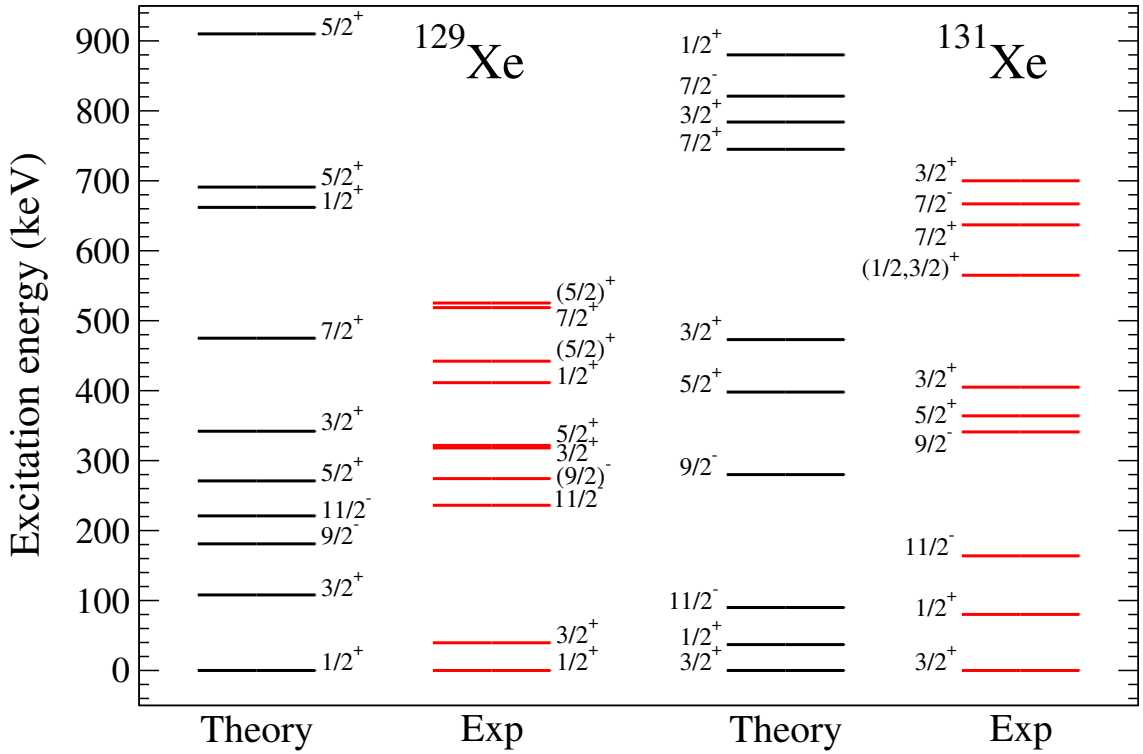
Philipp Klos

Baudis, Kessler, Lang, Menéndez, Reichard, Schwenk, PRD (2013)
Vietze, Menéndez, Haxton, Schwenk, arXiv to appear

INT DM Workshop
Seattle, Dec. 9, 2014

Inelastic scattering
Xenon spectra

TECHNISCHE UNIVERSITÄT DARMSTADT



- Excitation to low-lying first excited state (40 keV / 80 keV) possible
- Nuclear recoil + prompt deexcitation gamma can be observed

Types of WIMP-nucleon interactions
Spin-independent (SI)

TECHNISCHE UNIVERSITÄT DARMSTADT

Elastic scattering:

- All nucleons contribute (coherent)

$$\langle \text{initial} | \sum_{i}^{A} \mathcal{L}_{\chi N}^{\text{SI}} | \text{initial} \rangle \propto A$$

Inelastic scattering:

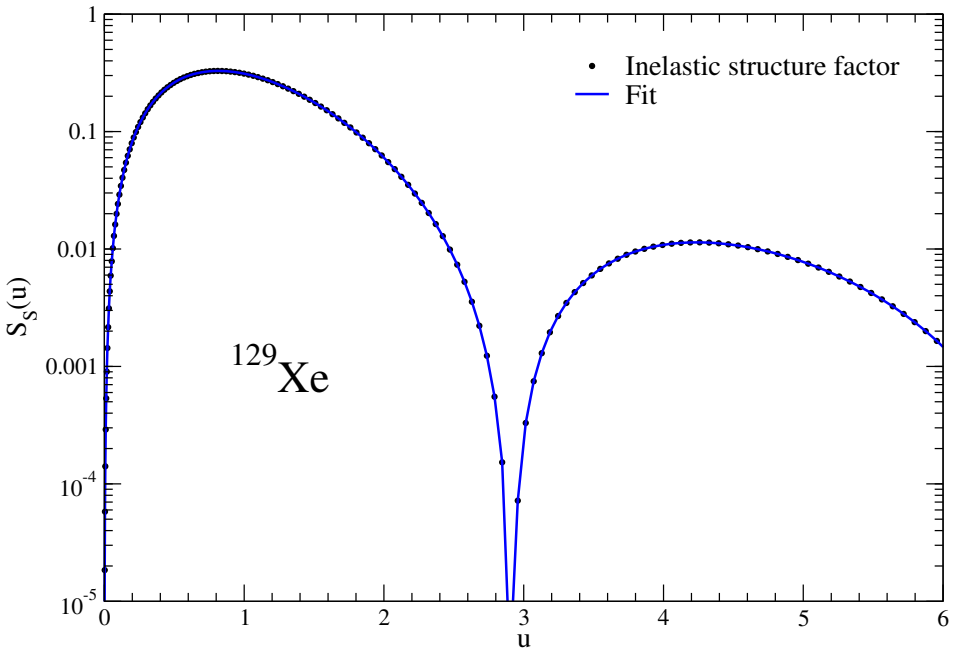
- For experimentally relevant isotopes transitions between ground state and first excited state are of single-particle nature

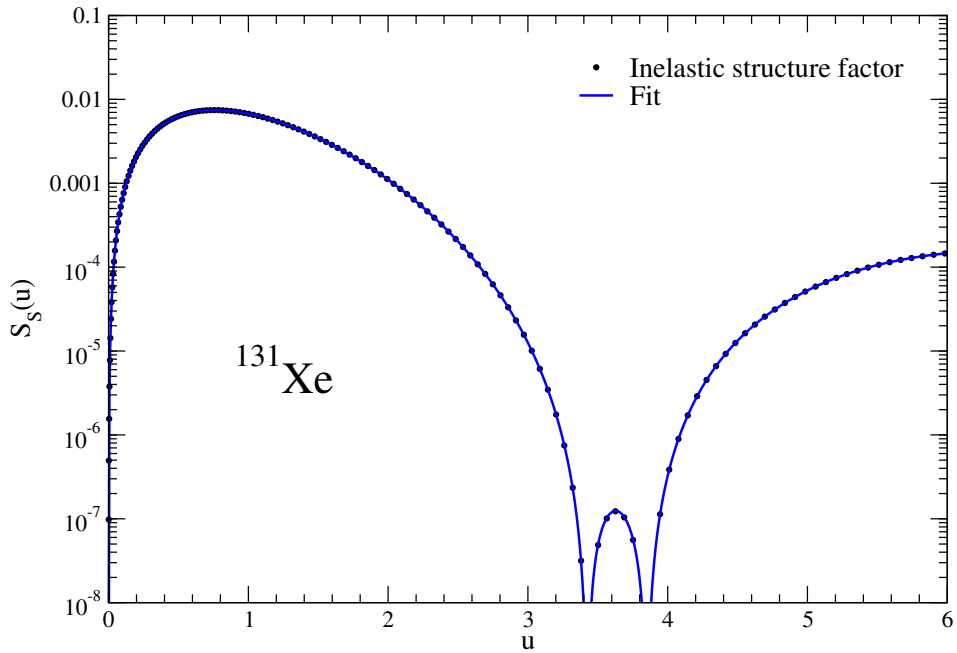
$$\langle \text{final} | \sum_{i}^{A} \mathcal{L}_{\chi N}^{\text{SI}} | \text{initial} \rangle \propto 1$$

- **For SI interaction, inelastic scattering strongly suppressed**

Structure factors: SI inelastic scattering

TECHNISCHE UNIVERSITÄT DARMSTADT





$u = p^2 b^2/2$ with harmonic oscillator length b

Vietze, PK, Menéndez, Haxton, Schwenk, arXiv to appear

- Suppressed by $A^{-2} \sim 10^{-4}$ compared to elastic

Types of WIMP-nucleus interactions
Spin-dependent (SD)

TECHNISCHE UNIVERSITÄT DARMSTADT

Elastic scattering

- Spin carried mostly by unpaired nucleons

$$\langle \text{initial} | \sum_{i}^{A} \mathcal{L}_{\chi N}^{\text{SD}} | \text{initial} \rangle \propto 1$$

Inelastic scattering

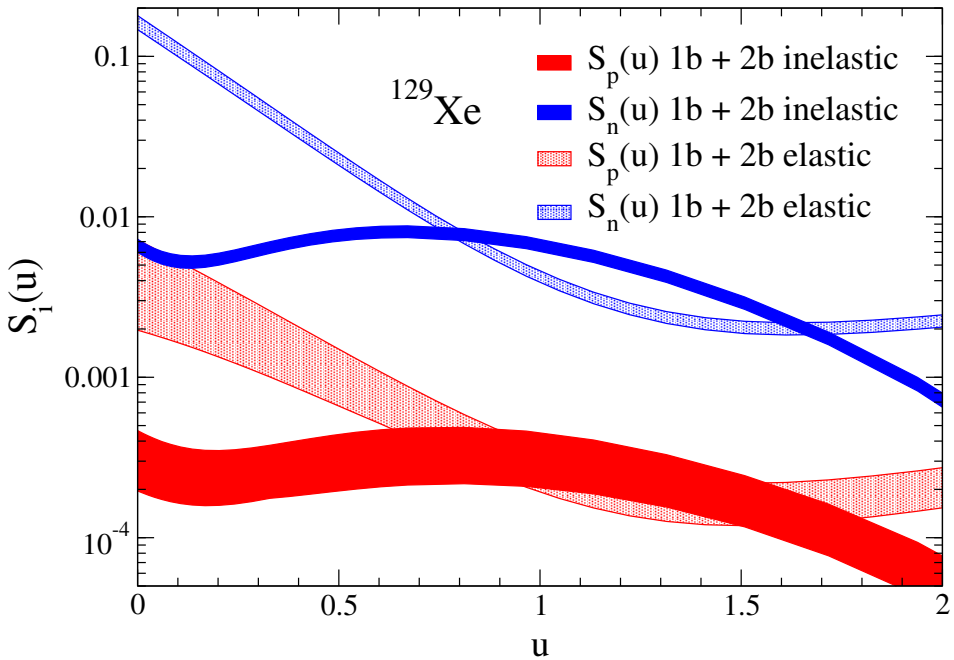
- Transition also of single-particle nature

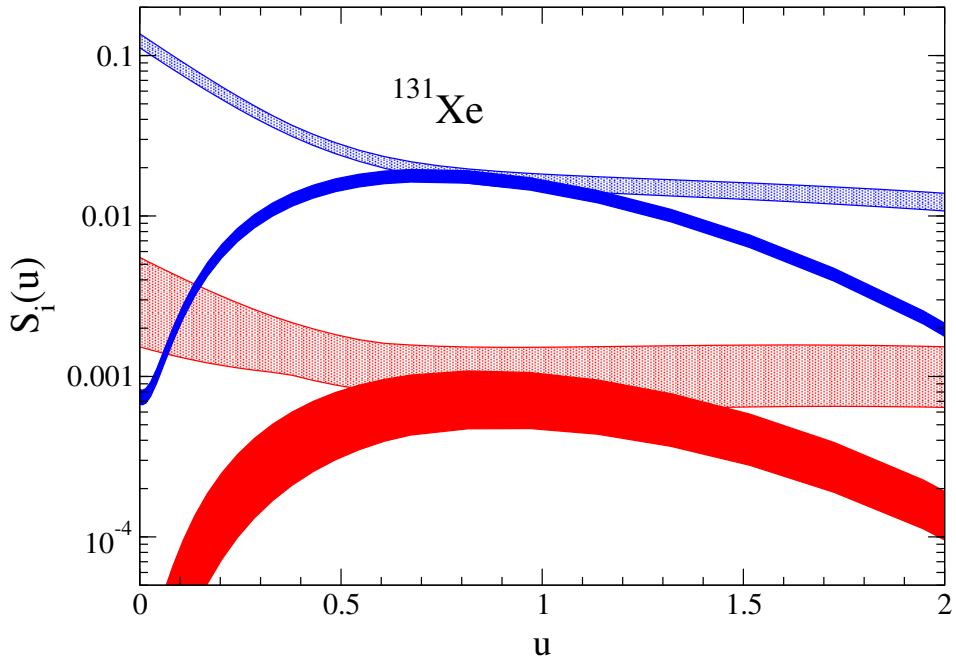
$$\langle \text{final} | \sum_{i}^{A} \mathcal{L}_{\chi N}^{\text{SD}} | \text{initial} \rangle \propto 1$$

- **SD channel sensitive to both elastic and inelastic scattering**

Structure factors: SD inelastic scattering

TECHNISCHE UNIVERSITÄT DARMSTADT





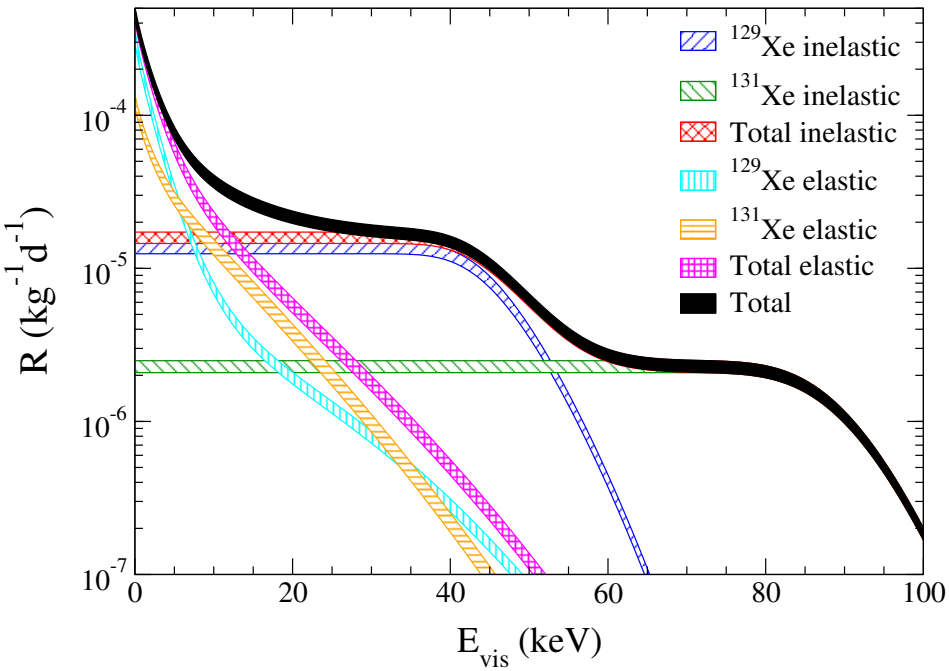
$u = p^2 b^2 / 2$ with harmonic oscillator length b

Baudis, Kessler, PK, Lang, Menéndez, Reichard, Schwenk, PRD **88**, 115014 (2013)

- Inelastic comparable to elastic scattering at $u \approx 1$ ($p \approx 125$ MeV)

Inelastic scattering
Integrated recoil spectra

TECHNISCHE UNIVERSITÄT DARMSTADT



Mass [GeV]	^{129}Xe	^{131}Xe	Total
10	–	–	–
25	5	–	5
50	7	17	9
100	7	24	12
250	9	32	19
500	11	35	24

TABLE II. Minimum energy E_{vis} in keV above which the observed inelastic spectrum for ^{129}Xe, ^{131}Xe and for the total spectrum starts to dominate the elastic one for various WIMP masses.

- One plateau per excited state
- Combined information from elastic and inelastic channel will allow to **determine dominant interaction channel** in one experiment
- **Inelastic excitation sensitive to WIMP mass**