Probing Pairing Correlations with 2–Proton Transfer Reactions

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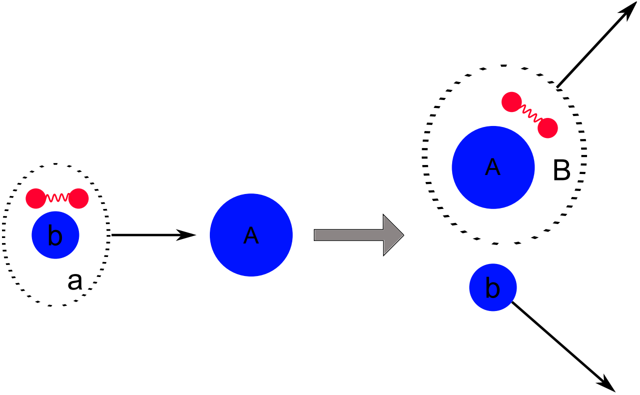
Introduction and Outline

We present a study of two–proton transfer reactions as a sensitive probe of proton pairing correlations.

Outline:

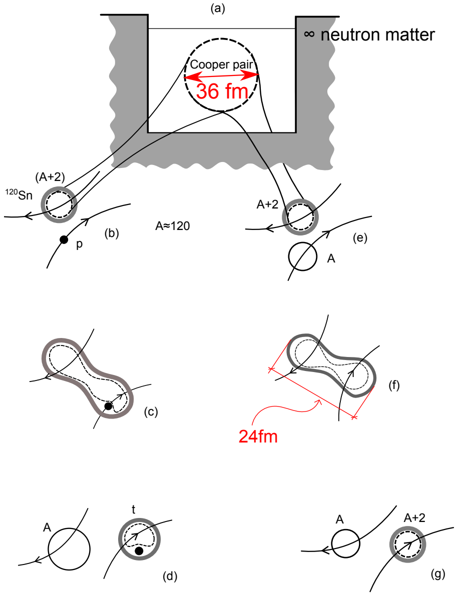
- Two–nucleon transfer as a well established tool to probe pairing correlations: the two–neutron transfer case.
- Introducing the two–proton transfer case: the ^{128}Te(^{3}He,n)^{130}Xe at TUNL.
- Obtaining the absolute values of the differential cross sections as an interplay between the structure and reaction description.

Two–Nucleon Transfer

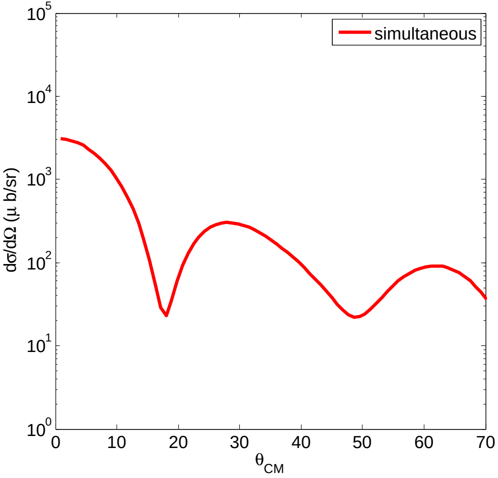


- Reaction $A + a(\equiv b + 2) \longrightarrow a + B(\equiv A + 2)$.
- Measure of the pairing correlations between the transferred nucleons.
- Need to correctly account for the correlated wavefunction.

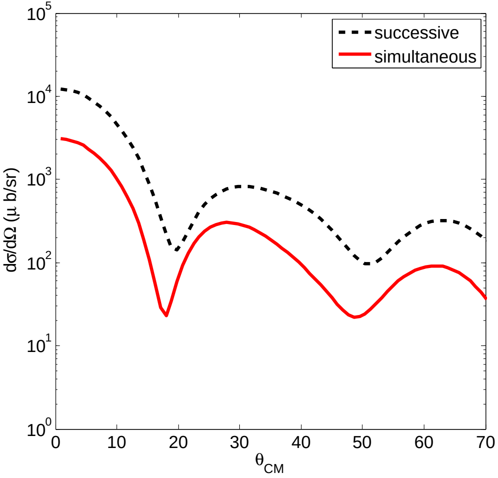
Delocalization of the pair transfer process



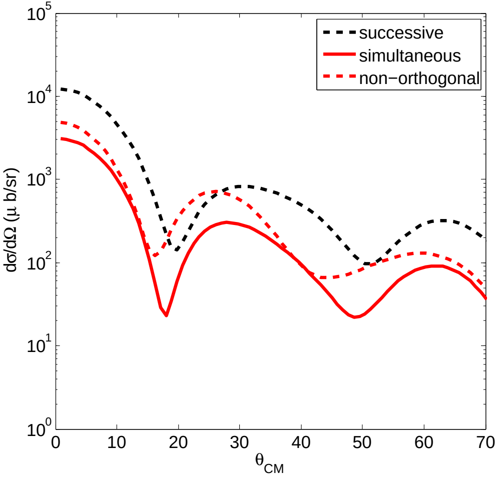
Contributions to the $^{112}Sn(p,t)^{110}$ total cross section



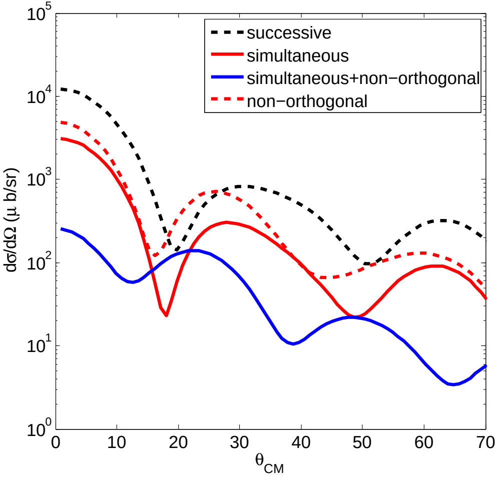
Contributions to the ^{112}Sn(p,t)^{110} total cross section



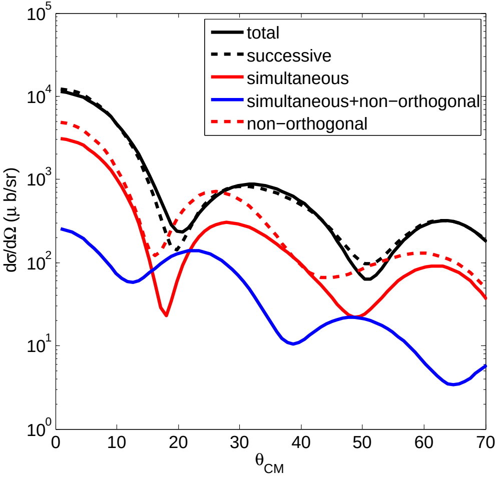
Contributions to the $^{112}Sn(p,t)^{110}$ total cross section



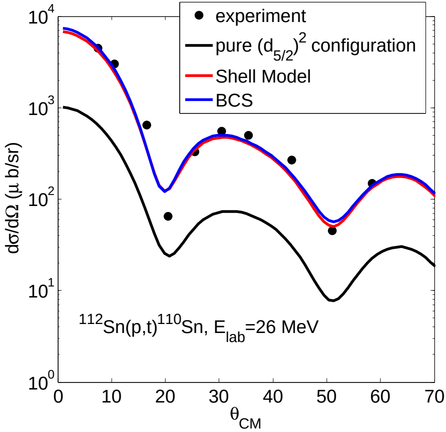
Contributions to the ^{112}Sn(p,t)^{110} total cross section



Contributions to the $^{112}Sn(p,t)^{110}$ total cross section



Essentially a successive process!

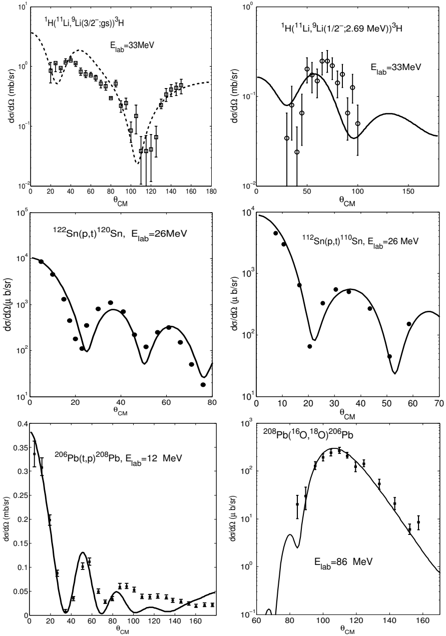


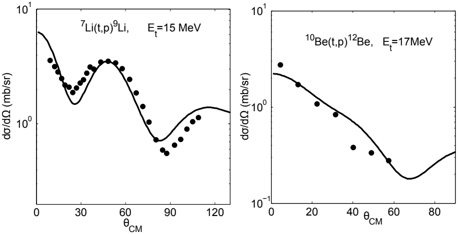
enhancement factor with respect to the transfer of uncorrelated neutrons: $\varepsilon = 20.6$

Experimental data and shell model wavefunction from Guazzoni *et al.* PRC **74** 054605 (2006)

experiment very well reproduced with mean field (BCS) wavefunctions

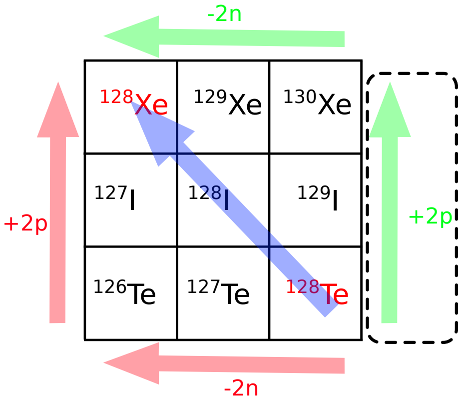
Examples of calculations





good results obtained for halo nuclei,
population of excited states,
superfluid nuclei,
normal nuclei (pairing vibrations),
heavy ion reactions...

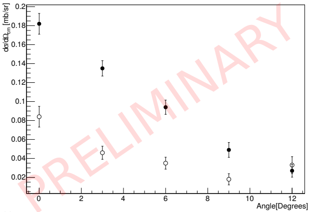
Charge–exchange and 2–nucleon transfer to constrain $\beta\beta0\nu$ nuclear matrix elements



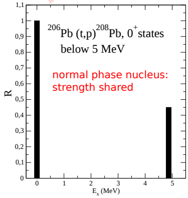
- 2–proton, 2–neutron, transfer reactions and double charge exchange reactions can constrain nuclear matrix elements of isotopes relevant for $\beta\beta0\nu$.

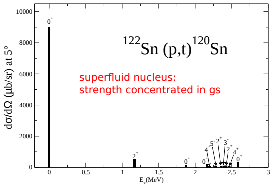
$^{128}Te(^{3}He,n)^{130}Xe$ at TUNL (North Carolina, USA)

Data by C. Howell and D. Combs at TUNL



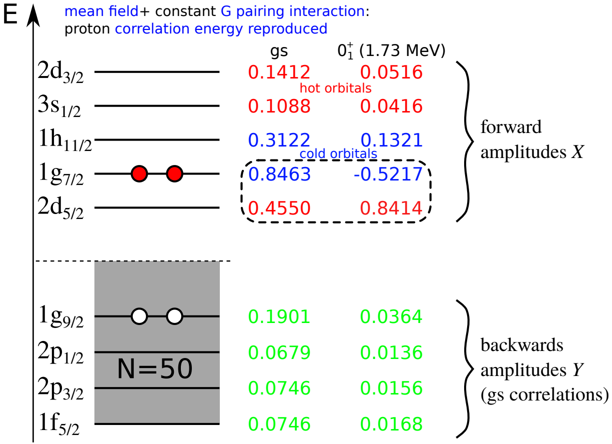
population of gs (black dots) and first excited 0^{+} (white dots) with ratio r=2.2





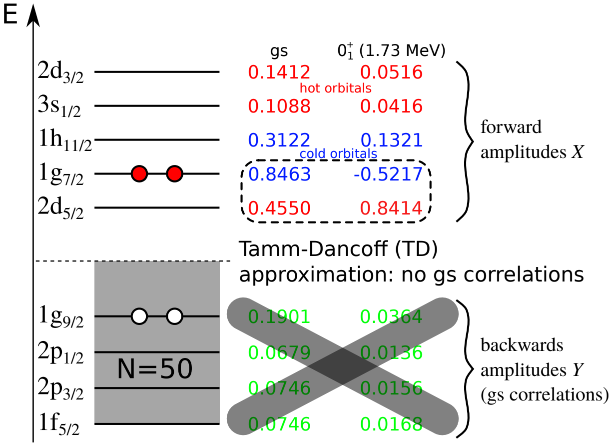
Experimental results strongly suggest a two–proton pairing phonon structure of ^{130}Xe

^{130}Xe structure in RPA



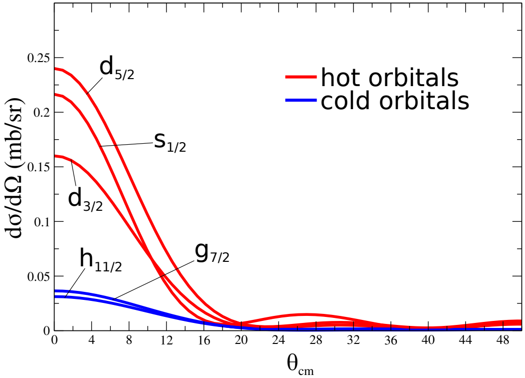
Structure calculations by R. A. Broglia and A. Idini.

^{130}Xe structure in RPA



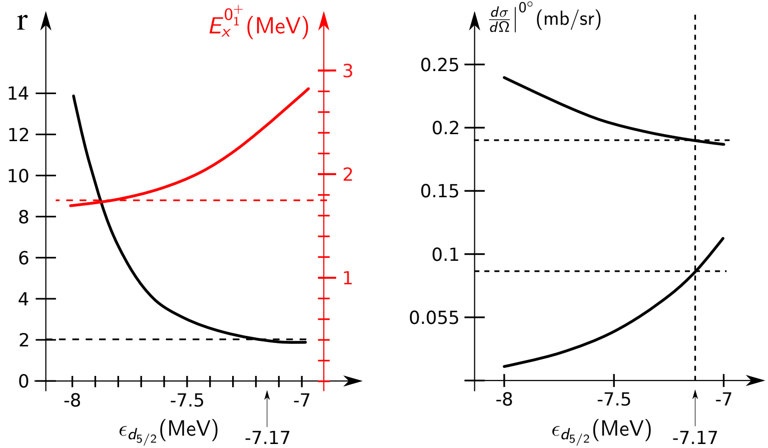
Structure calculations by R. A. Broglia and A. Idini.

Individual $j^2(0)$ contributions



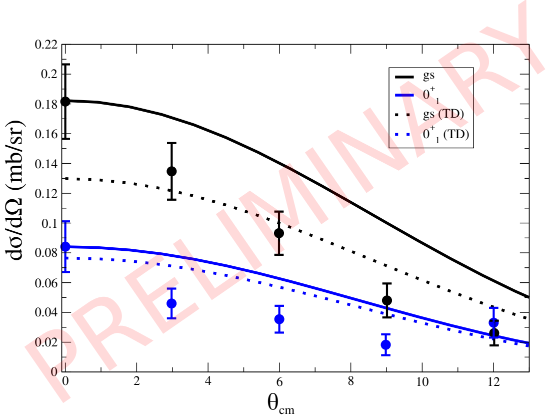
As a result of spatial quantization, the absolute value of the cross section will delicately depend on the relative occupation of "hot" and "cold" orbitals.

Tuning the $d_{5/2}$ orbital



Results are very sensitive to the (non–observable) energy of the "bare" $d_{5/2}$ orbital.

$^{128}Te(^3He,n)^{130}Xe$, results of the calculations



- Howell and Combs TUNL data at 0° are very well reproduced.
- Ground state correlations are important, specially for the very coherent ground state.
- Angular shapes still not completely understood.

Conclusions

Interplay of the right structure (spontaneous breaking of gauge symmetry) and reactions (successive transfer) physics can account for observed cross sections.

Two–nucleon transfer cross sections are very sensitive to the specific nature of pairing correlations.

main message

Two–nucleon transfer reactions are a promising tool to probe structure relevant for the calculation of $0\beta\beta$ nuclear matrix elements.

Thank You!