The ppp Correlation Function

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Introduction

- We start with the definition of the pp correlation function:

$$C_{pp}(k) = \int d^3y \; S_R(y)|\Psi|^2$$

with S_R the source function defined as

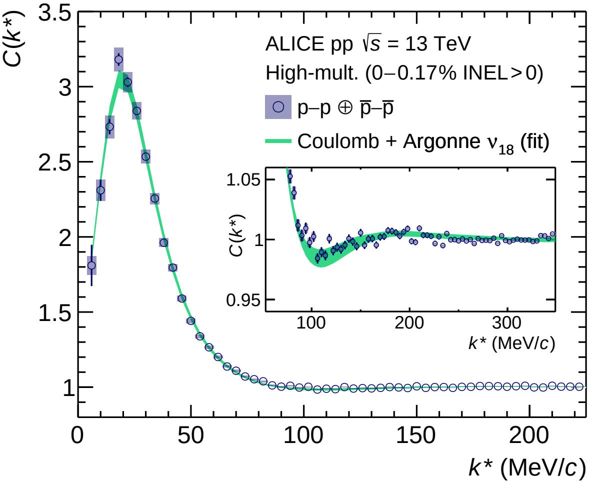
$$S_R(y) = \frac{1}{(4\pi R^2)^{3/2}} e^{-(y/2R)^2}$$

and Ψ the pp scattering wave function

$$\Psi = \sum_{[LSJ]} u_{LSJ}(y)[Y_L(\hat{y})\chi_S]_J = \Psi^0 + \sum_{[LSJ]}^{\overline{J}} \Psi_{LSJ}$$

with Ψ^0 the free scattering wave function. In Ψ_{LSJ} the interaction has been considered up to $\overline{J}$.

The pp Correlation Function



Phys. Lett. B 805, (2020) 135419

Introduction

- We now consider the pd correlation function:

$$C_{pd}(k) = \int d^3y \; S_R(y) \, | < pd|\Psi_{pd} > |^2$$

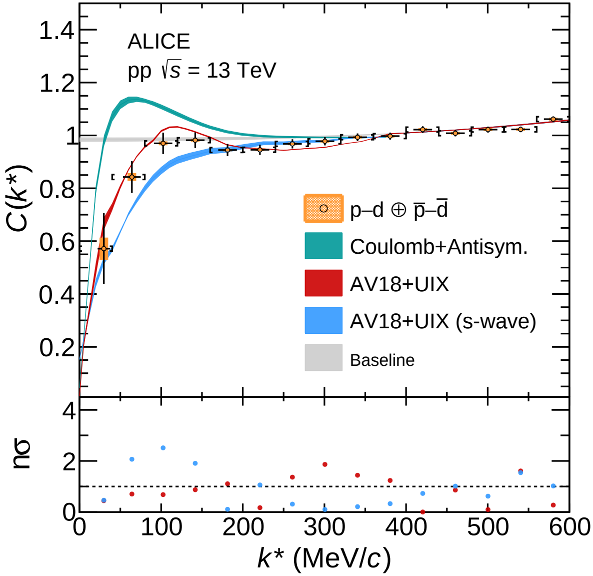
with S_R the source function defined as

$$S_R(y) = \frac{1}{(4\pi R^2)^{3/2}} e^{-(y/2R)^2}$$

Ψ_{pd} is the pd scattering wave function

$$\Psi_{pd} = \sum_{[K]} u_{[K]}(\rho)\mathcal{B}_{[K]}(\Omega) = \Psi^0_{pd} + \sum_{[LSJ]}^{\overline{J}} \Psi_{LSJ}$$

$[\rho, \Omega]$ are the hyperspherical coordinates, $[K]$ the set of quantum numbres and Ψ^0 is the free scattering wave function. In Ψ_{LSJ} the interaction has been considered up to $\overline{J}$.


ALICE
pp √s = 13 TeV
p–d ⊕ p̄–d̄
Coulomb+Antisym.
AV18+UIX
AV18+UIX (s-wave)
Baseline
C(k*)
nσ
k* (MeV/c)
1.4
1.2
1
0.8
0.6
0.4
0.2
4
2
0
0
100
200
300
400
500
600

Introduction

- Finally we consider the ppp correlation function:

$$C_{ppp}(Q) = \int \rho^5 d\rho d\Omega \; S_{\rho_0}(\rho)|\Psi_{ppp}|^2$$

with Q the hyper-momentum, S_{ρ_0} the source function defined as

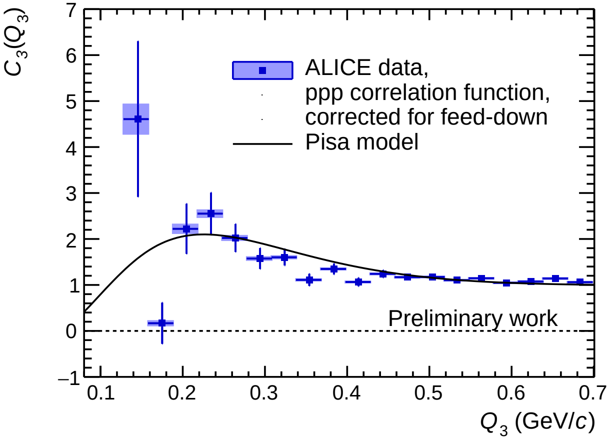
$$S_{\rho_0}(\rho) = \frac{1}{\pi^3 \rho_0^6} e^{-(\rho/\rho_0)^2}$$

Ψ_{ppp} is the ppp scattering wave function

$$\Psi_{ppp} = \sum_{[K]} u_{[K]}(\rho)\mathcal{B}_{[K]}(\Omega) = \Psi^0 + \sum_{J,[K]}^{\overline{J},\overline{K}} \Psi^J_{[K]}$$

To be noticed that Ψ^0 is not well known. In $\Psi^J_{[K]}$ the interaction has been considered up to $\overline{J}$ and $\overline{K}$

Comparison to data (preliminary)

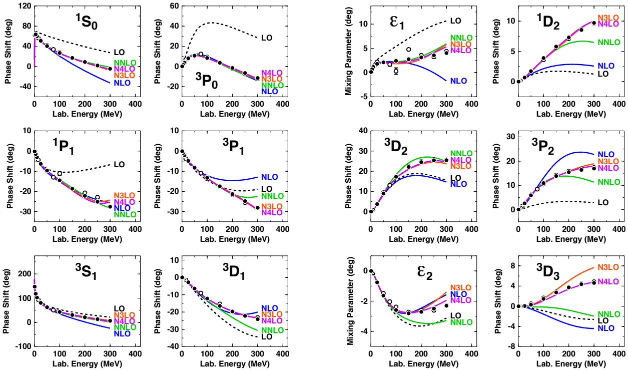


Introduction

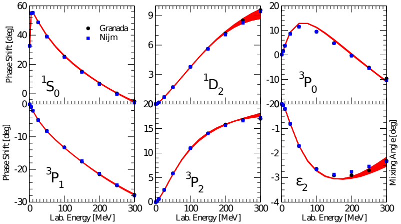
- In the pp correlation function the main ingredient is the Ψ_{pp} scattering function. Accordingly $C_{pp}(k)$ is sensitive to the NN interaction.
- The NN interaction is described using Chiral pertubation theory. The strength of the different terms, the low-energy constants (LECs), are set to describe the world NN data, around 5000 scattering data plus the deuteron binding energy.
- In the pd and ppp correlation functions the main ingredients are the Ψ_{pd} and Ψ_{ppp} scattering functions. Accordingly $C_{pd}(k)$ and $C_{ppp}(Q)$ should be sensitive to the NN interaction (and NNN interaction).
- The three-nucleon system has played a central role in our understanding of the nuclear interaction. It is the next, simpler system in which the capability of this interaction to describe the nuclear dynamics can be analyzed.
- The pertubative series includes many-body forces, in particular three-body forces. They play a fundamental role in the correct description of the three-nucleon system (and heavier systems).

The NN interaction

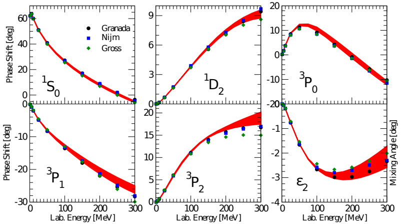
- In the 90's the first realistic potentials appeared, phenomenological and, few years later, based on the chiral perturbative series
- They describe the NN scattering data with a $\chi^2 \approx 1$



The NN interaction



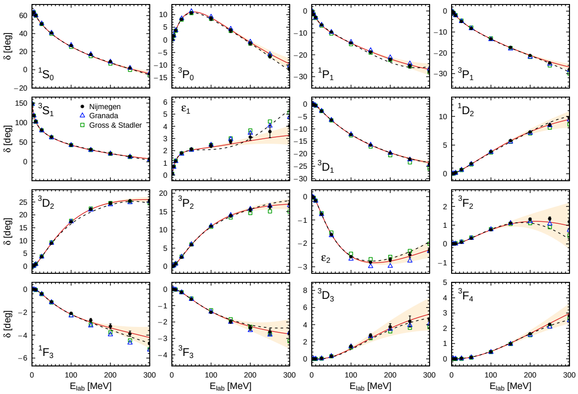
S-, *P*-, and *D*-wave *pp* phase-shifts



S, *P*-, and *D*-wave *np* phase-shifts

Minimally nonlocal NN potential including Δ resonances
M. Piarulli et al, Phys. Rev. C 91, 024003 (2015)

The NN interaction



np phase-shifts

NN potential up to fifth order N4LO$^+$

P. Reinert, H. Krebs and E. Epelbaum, Eur. Phys. J. A54, 86 (2018)
E. Epelbaum, H. Krebs, P. Reinert, Front. Phys., 8:98 (2020)

The Three-Nucleon System

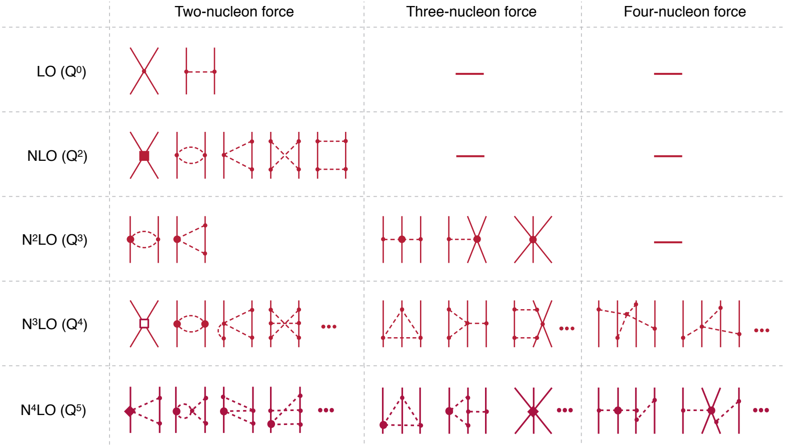
- In parallel with the studies in the *NN* system, strong efforts have been done to solve the three-nucleon system
- The solution of the Faddeev and Faddeev-Yakubovsky equations in configuration and momentum space are one of the reference methods in the solution of the three- and four-nucleon problem.
- New methods appeared using the variational principle, among them the Hyperspherical Harmonic expansion resulted of great flexibility to study the discrete and the continuum spectrum of the three- and four-nucleon systems.
- Other methods very useful in heavier systems are the GFMC method and the NCSM method
- Different groups using different methods have produced benchmarks useful to set the theoretical uncertanties.

^{3}H and ^{4}He Bound States and $n-d$ scattering length

Potential(NN)	Method	^{3}H[MeV]	^{4}He[MeV]	$^2a_{nd}$[fm]
AV18	HH	7.624	24.22	1.258
	FE/FY Bochum	7.621	24.23	1.248
	FE/FY Lisbon	7.621	24.24	
CDBonn	HH	7.998	26.13	
	FE/FY Bochum	8.005	26.16	0.925
	FE/FY Lisbon	7.998	26.11	
	NCSM	7.99(1)		
N3LO-Idaho	HH	7.854	25.38	1.100
	FE/FY Bochum	7.854	25.37	
	FE/FY Lisbon	7.854	25.38	
	NCSM	7.852(5)	25.39(1)	

Potential(NN+NNN)				
AV18/UIX	HH	8.479	28.47	0.590
	FE/FY Bochum	8.476	28.53	0.578
CDBonn/TM	HH	8.474	29.00	
	FE/FY Bochum	8.482	29.09	0.570
N3LO-Idaho/N2LO	HH	8.474	28.37	0.675
	NCSM	8.473(5)	28.34(2)	
Exp.		8.48	28.30	0.645±0.010

The Chiral Expansion

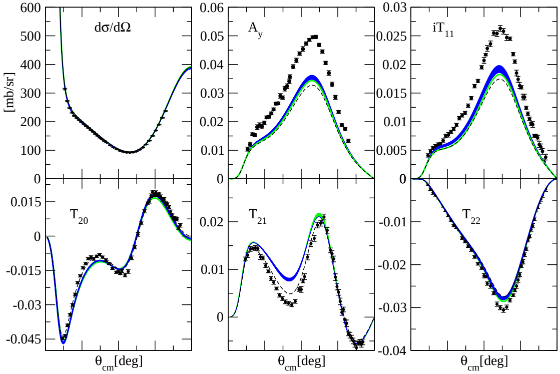


The Three-Nucleon Force

- The NN interaction has been constructed from a detailed description of the NN scattering data. The perturbative series has been extended to fifth order (N4LO) and more than 20 LECs have been used to fit the data and deuteron binding energy.
- The three-nucleon interaction (TNI) appears at N2LO with two LECS determined in order to reproduce two observables, for example the ^{3}He binding energy and the *nd* scattering length.
- The extension of the three-nucleon interaction (TNI) to consider higher terms in the chiral expansion is at present an intense subject of research.

Nd Scattering

- Applications of the realistic NN interaction plus three-nucleon forces to describe the 3N scattering data result in a $\chi^2 >> 1$



p-d scattering at 3 MeV with JNV2a and JNV2a + TNI

Nd Scattering

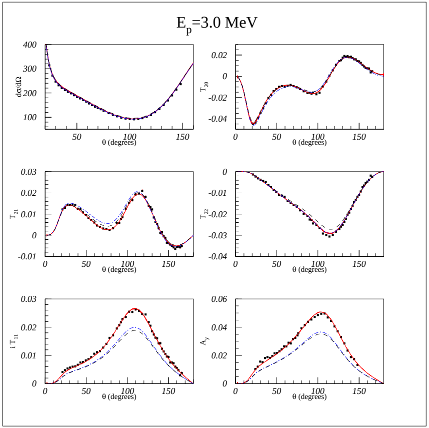
χ^2 per datum obtained in the description of the *pd* vector and tensor analyzing powers

Energy	potential	A_y	iT_{11}	T_{20}	T_{21}	T_{22}
1 MeV	AV18	276	112	3.5	4.5	2.8
	AV18+UR	190	61	1.0	2.5	0.7
	N3LO Idaho	197	68.7	4.0	2.5	1.5
	N3LO+N2LO	139.9	49.5	2.7	2.5	0.9
3 MeV	AV18	313	205	4.8	6.7	12
	AV18+UR	271	144	5.4	11	2.4
	N3LO	186	108.3	1.9	2.8	4.4
	N3LO+N2LO	114	85.8	3.6	8.3	1.6
5 MeV	AV18	211	99	6.8	12	7.8
	AV18+UR	186	59	26	36	1.5
7 MeV	AV18	303	90	19	38	1.9
	AV18+UR	239	56	40	81	4.2
9 MeV	AV18	292	165	42	70	38
	AV18+UR	218	134	63	86	7.2
10 MeV	AV18	288	29	10	6.2	24
	AV18+UR	224	23	13	6.1	7.6

- The complicate structure of the three-nucleon force has to be further analysed
- Recently the contact three-nucleon interaction at N4LO has been worked out
- The spin structure is sufficient flexible to guarantee a better description of the polarization observables at low energies.
- Would be possible to fit these three-body LECs to *pd* scattering data in order to obtain values of the χ^2 per datum similar to those obtained in the two-nucleon sector?

The Three-Nucleon Force

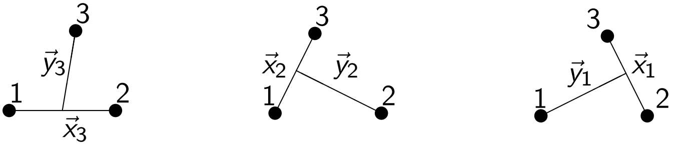
p-d scattering at 3 MeV fitting the subleading TNI terms obtaining a χ^2 per datum ≈ 1.7



L. Girlanda, A. Kievsky, L. E. Marcucci, and M. Viviani Phys. Rev. C 102, 064003 (2020)

The Three-Nucleon System

The Jacobi coordinates ($\vec{x}_i$, $\vec{y}_i$)



The Jacobi coordinates allow to separate the center of mass motion

$$H = T + V = T_{CM} - \frac{\hbar^2}{m}\left(\nabla^2_{x_1} + \nabla^2_{y_1}\right) + \sum_{i<j} V(i,j) + \sum_{i<j<k} W(i,j,k)$$

The Three-Nucleon System

The three-nucleon wave function:

$$\Psi(\vec{x},\vec{y}) = \psi(\vec{x}_1,\vec{y}_1) + \psi(\vec{x}_2,\vec{y}_2) + \psi(\vec{x}_3,\vec{y}_3)$$

The amplitudes $\psi(\vec{x}_i,\vec{y}_i)$ are called Faddeev amplitudes. They can be decomposed in angular-spin-isospin channels

$$\psi(\vec{x}_i,\vec{y}_i) = \sum_\alpha \phi(x_i,y_i) \left[[Y_{l_1}(\hat{x}_i) Y_{l_2}(\hat{y}_i)]_L \otimes \chi_S^{S_{jk}} \right]_{JJ_z} \xi_{TT_z}^{T_{jk}}$$

$\chi_S^{S_{jk}}$ and $\xi_{TT_z}^{T_{jk}}$ are the spin and isospin functions of the three nucleons.

- Each channel $\alpha = [l_1, l_2, L, S_{jk}, S, T_{jk}, T]$ is compatible with J and parity.
- $l_1 + S_{jk} + T_{jk} =$ odd for antisymmetrization.
- The two-dimensional amplitudes $\phi(x_i,y_i)$ can be obtained solving the Faddeev equations or by a variational description.
- The number of channels is not limited and some truncation criteria is needed (convergence in some observables).

The Hyperspherical Harmonic Functions

The kinetic term of the center of mass Hamiltonian

$$T = -\frac{\hbar^2}{m}\left(\nabla^2_{x_1} + \nabla^2_{y_1}\right)$$

can be written as

$$T = -\frac{\hbar^2}{m}\left(\frac{\partial^2}{\partial\rho^2} + \frac{5}{\rho}\frac{\partial}{\partial\rho} + \frac{\Lambda^2(\Omega)}{\rho^2}\right)$$

We have introduced the hyperradius and the hyperspherical coordinates $[\rho, \Omega] = [\rho, \phi, \hat{x}_i, \hat{y}_i]$

$$\begin{cases} x_i = \rho\cos\phi_i \\ y_i = \rho\sin\phi_i \end{cases}$$

and the grand angular operator $\Lambda^2(\Omega)$.

The Hyperspherical Harmonic Functions

The eigenvectors of $\Lambda^2(\Omega)$ are the hyperspherical harmonic (HH) functions

$$\left(\Lambda^2(\Omega) + K(K+4)\right) Y_{[K]}(\Omega) = 0$$

The HH functions, having well defined angular momentum, are

$$Y_{[K]}^{LM}(\Omega_i) = \mathcal{N}_{n,l_1,l_2}\, {}^{(2)}P_n^{l_1,l_2}(\phi_i)\left[Y_{l_1}(\hat{x}_i) Y_{l_2}(\hat{y}_i)\right]_{LM}$$

The set of quantum numbers is $[K] = [n, l_1, l_2, L, M]$. The HH functions form a complete basis useful to expand the three-nucleon wave function.

$$\psi(\vec{x}_i, \vec{y}_i) = \sum_{[K]} u_{[K]}(\rho) \mathcal{Y}_{[K]}^{J\pi}(\Omega_i)$$

The functions $\mathcal{Y}_{[K]}^{J\pi}(\Omega_i)$ are hyperangular-spin-isospin function

$$\mathcal{Y}_{[K]}^{J\pi}(\Omega_i) = \left[Y_{[K]}^{LM}(\Omega_i) \otimes \chi_S^{S_{jk}}\right]_{JJ_z} \xi_{TT_z}^{T_{jk}}$$

with quantum numbers $[K] = [n, l_1, l_2, L, M, S_{jk}, S, T_{jk}, T]$.

The pd Three-Nucleon Wave Function

$$\Psi_{LSJ}(\vec{x},\vec{y}) = \sum_{[K]} u_{[K]}(\rho) \sum_{i} \mathcal{Y}^{J\pi}_{[K]}(\Omega_i) +$$
$$+ \sum_{iL'S'} \left[[\phi_d(\vec{x}_i) \otimes \chi_{1/2}]_{S'} \, Y_{L'}(\hat{y}_i) \right]_J [\delta_{LL'}\delta_{SS'} F_L(y_i) + \mathcal{T}^{LS}_{L'S'} \mathcal{O}_{L'}(y_i)]$$

here $\phi_d(\vec{x}_i)$ is the deuteron wave function and $\mathcal{T}^{LS}_{L'S'}$ is the T-matrix.
For energies below the deuteron breakup $u_{[K]}(\rho \to \infty) \to 0$ whereas for energies above the deuteron breakup it describes the breakup amplitude. The transition amplitude is

$$M^{SS'}_{S_z S'_z}(\theta) = f_c(\theta)\delta_{SS'}\delta_{S_z S'_z} + \frac{\sqrt{4\pi}}{k} \sum_{LL'J} C_{LL'J} \, \mathcal{T}^{LS}_{L'S'} Y_{L'M'}(\theta, 0)$$

with f_c the Coulomb amplitude. For example, the unpolarized cross section is
$d\sigma/d\Omega(\theta) = tr(MM^\dagger)/6$ and $A_y(\theta) = tr(M\sigma_y M^\dagger)/6$

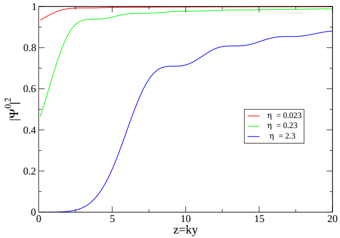
pd Correlation Analysis

a) The free case: The free scattering wave function for *pd* is

$$\Psi_s^0 = \frac{4\pi}{\sqrt{6}} \sum_{\ell m S} i^\ell [\phi_d(\vec{x}) \otimes \chi_{1/2}]_S \frac{F_\ell(\eta, ky)}{ky} Y_{\ell m}(\hat{y}) Y^*_{\ell m}(\hat{k})$$

with $F_\ell(\eta, ky)$ a regular Coulomb wave function and $\eta = e^2/(3\hbar^2 k/4m)$.
Integrating on spin, deuteron and angular variables, the norm results

$$|\Psi_s^0|^2 = \sum_\ell (ky)^{-2} F_\ell^2(\eta, ky)(2\ell+1)$$



pd Correlation Analysis

b) Considering antisymmetrization

$$\Psi_s^0 = \Psi_1^0 + \Psi_2^0 + \Psi_3^0 = \frac{4\pi}{\sqrt{3}} \sum_{i\ell mS} i^\ell [\phi_d(\vec{x}_i) \otimes \chi_{1/2}]_S \frac{F_\ell(\eta, ky_i)}{ky_i} Y_{\ell m}(\hat{y}_i) Y^*_{\ell m}(\hat{k})$$

where ϕ_d is the deuteron wave function and $\vec{k}$ is the relative momentum between the two clusters.

The correlation function is defined as

$$C^0_{pd}(k) = 3 \times \frac{1}{6} \int d^3y \; S_R(y) \sum_{spin} \int d^3x \; | < \phi_d(1,2)\chi(3)|\Psi^0_s > |^2$$

and the normalization condition

$$\lim_{k\to\infty} C^0_{pd}(k) = \int d^3y \; S_R(y) \frac{1}{6} \sum_{spin} \int d^3x |\phi_d(1,2)|^2 = 1 \; ,$$

since ϕ_d is normalized and $\int d^3y \; S_R(y) = 1$.

The interacting case

The interacting pd wave function is

$$\Psi_{m_2,m_1} = \sqrt{4\pi} \sum_{LSJ} i^L \sqrt{2L+1} e^{i\sigma_L} (1 m_2 \frac{1}{2} m_1 | S J_z)(L 0 S J_z | J J_z) \Psi_{LSJ}(\vec{x}, \vec{y})$$

where Ψ_{LSJ} is the three-body wave functions

$$\Psi_{LSJ}(\vec{x}, \vec{y}) = \sum_{[K]} u_{[K]}(\rho) \mathcal{B}^{J^\pi}_{[K]}(\Omega) +$$
$$+ \sum_{iL'S'} \left[[\phi_d(\vec{x}_i) \otimes \chi_{1/2}]_{S'} \, Y_{L'}(\hat{y}_i) \right]_J (ky)^{-1} [\delta_{LL'} \delta_{SS'} F_L(y_i) + \mathcal{T}^{LS}_{L'S'} \mathcal{O}_{L'}(y_i)]$$

where $\mathcal{B}_{[K]}(\Omega)$ are a set of antisymmetrized HH functions and $\mathcal{T}^{LS}_{L'S'}$ are the T-matrix elements.

The asymptotic behaviour of the wave functions Ψ_{LSJ} is chosen so that if we turn off the nuclear interaction they reduce to

$$\Psi_{LSJJ_z} \to \frac{1}{\sqrt{3}} \sum_{ij\ell} \Big\{ Y_L(\hat{y}_\ell) \Big[\phi(ij)\chi(\ell) \Big]_S \Big\}_{JJ_z} \frac{F_L(\eta, ky_\ell)}{ky_\ell} \ ,$$

in fact in such a case $u_{[K]} = \mathcal{T}^{LS}_{L'S'} = 0$ and Ψ_{m_2,m_1} reduces to Ψ^0_s.

In the calculation, we include the effect of the nuclear interaction up to a given $\bar{J}$. For $J > \bar{J}$, the free and full wave functions is equivalent.

It is convenient to resum all the terms proportional to $F_L(\eta, ky_\ell)$ in order to reproduce the free wave function. Let us define

$$\begin{aligned} \widetilde{\Psi}_{LSJJ_z} &= \sum_{[K]} u_{[K]}(\rho) \mathcal{B}_{[K]}(\Omega) \\ &+ \frac{1}{\sqrt{3}} \sum_{iL'S'} \mathcal{T}^{LS}_{L'S'} \Big\{ Y_{L'}(\hat{y}_i) \Big[\phi(i)\chi(i) \Big]_{S'} \Big\}_{JJ_z} \frac{\mathcal{O}_{L'}(\eta, ky_i)}{ky_i} \ , \end{aligned}$$

where we have subtracted from the wave function the “free” part. The full wave function can be cast in the form

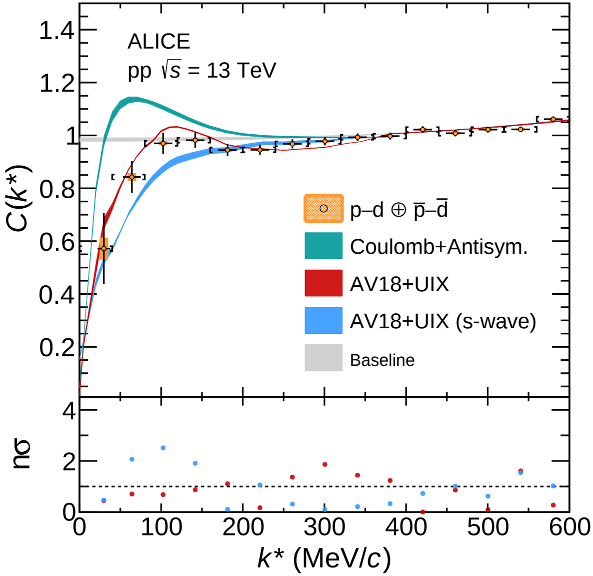
$$\Psi_{m_2,m_1}(\mathbf{x},\mathbf{y}) = \Psi_s^0 + \sum_{LSJ}^{J\leq\bar{J}} \sqrt{4\pi}\, i^L \sqrt{2L+1}\, e^{i\sigma_L} (1 m_2 \frac{1}{2} m_1 | S J_z)(L 0 S J_z | J J_z) \widetilde{\Psi}_{LSJJ_z}$$

The correlation function is calculated using two steps: the wave function is projected on the *dp* chanel

$$\Psi_{m_2' m_1', m_2 m_1}(k,\mathbf{y}) = \int d^3x \left[\phi_{m_2'}(1,2)\chi_{m_1'}(3)\right] \Psi_{m_2,m_1}(\mathbf{x},\mathbf{y})$$

Then the overlap with the source is computed

$$C_{pd}(k) = 3 \times \frac{1}{6} \sum_{m_2' m_1'} \sum_{m_2 m_1} \int d^3y\; S_R(y) |\Psi_{m_2' m_1', m_2 m_1}(k,\mathbf{y})|^2$$


ALICE
pp √s = 13 TeV
p–d ⊕ p̄–d̄
Coulomb+Antisym.
AV18+UIX
AV18+UIX (s-wave)
Baseline
C(k*)
nσ
k* (MeV/c)
1.4
1.2
1
0.8
0.6
0.4
0.2
4
2
0
0
100
200
300
400
500
600

The ppp Wave Function

The total wave function is

$$\Psi(\vec{x},\vec{y}) = \sum_i \psi(\vec{x}_i,\vec{y}_i) = \rho^{-5/2}\sum_{[K]} u_{[K]}(\rho)\mathcal{B}^{J\pi}_{[K]}(\Omega)$$

with $\mathcal{B}^{J\pi}_{[K]}$ antisymmetric HH-spin functions

The ppp wave is completely determined from the hyperradial functions $u_{[K]}(\rho)$. And they are determined from the boundary conditions as $\rho \to \infty$.

For a given energy, $E = \hbar^2 Q^2/m$, and in the nnn case

$$u_{[K]}(\rho \to \infty) \to \sqrt{Q\rho}\,[J_{K+2}(Q\rho) + \tan\delta_K\, Y_{K+2}(Q\rho)]$$

In the ppp case the asymptotic equations are coupled not allowing this simple picture

ppp Correlation Analysis

Using the property of the HH functions

$$\Psi_s^0 = e^{i\vec{Q}\cdot\vec{\rho}} = \frac{(2\pi)^3}{(Q\rho)^2} \sum_{[K]} i^K J_{K+2}(Q\rho)\mathcal{Y}_{[K]}(\Omega)\mathcal{Y}^*_{[K]}(\hat{Q})$$

where $\vec{Q}\cdot\vec{\rho} = \vec{k}_1\cdot\vec{x} + \vec{k}_2\cdot\vec{y}$ and J_{K+2} a Bessel function.

- For the case of three nucleons we have to include the correct symmetrization.
- For the case of three protons we have to include the correct asymptotics

The nnn (or ppp) case:

$$\Psi_s^0 = \frac{(2\pi)^3}{(Q\rho)^2} \sum_{[K]} i^K J_{K+2}(Q\rho)\mathcal{B}_{[K]}(\Omega)\mathcal{B}^*_{[K]}(\hat{Q})$$

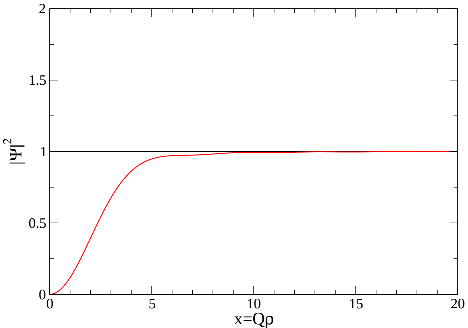
with $\mathcal{B}_{[K]}(\Omega)$ antisymmetric in the hyperangle-spin space.

ppp Correlation Analysis

Taken spin traces and performing the hyperangular integration, the norm results

$$|\Psi_s^0|^2 = \frac{(2\pi)^6}{(Q\rho)^6} \sum_{[K]} J_{K+2}^2(Q\rho) N_{ST}(K)$$

where $N_{ST}(K)$ is the number of states.



ppp Correlation Analysis

For three protons the asymptotic form changes (and it is not known in a close form)
The Coulomb interaction coupled the asymptotic equations through the term

$$\sum_{ij} \frac{e^2}{r_{ij}}$$

In this preliminary study we perform an average of the Coulomb interaction on the hyperangles

$$V_c(\rho) = \int d\Omega \sum_{ij} \frac{e^2}{r_{ij}} |\mathcal{Y}_0(\Omega)|^2 = \frac{16}{\pi}\frac{e^2}{\rho}$$

and the plane wave takes the form

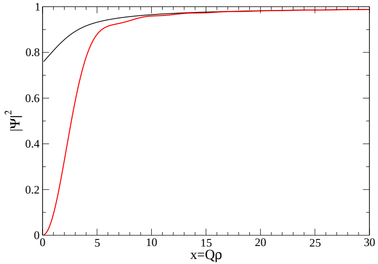
$$e^{i\vec{Q}\cdot\vec{\rho}} \rightarrow \Psi_s^0 = \frac{1}{C_{3/2}(0)} \frac{(\pi)^3}{(Q\rho)^{5/2}} \sum_{[K]} i^K F_{K+3/2}(\eta, Q\rho) \mathcal{B}_{[K]}(\Omega) \mathcal{B}^*_{[K]}(\hat{Q})$$

ppp Correlation Analysis

Taken spin traces and performing the hyperangular integration, the norm results

$$|\Psi_s^0|^2 = \frac{1}{C_{3/2}^2}\frac{1}{(Q\rho)^5}\sum_K F_{K+3/2}^2(\eta, Q\rho) N_{ST}(K)$$

where $N_{ST}(K)$ is the number of states and the Coulomb factor $C_\lambda = \frac{(\lambda^2+\eta^2)^{1/2}}{\lambda(2\lambda+1)} C_{\lambda-1}$



ppp Correlation Analysis

The ppp wave function is

$$\Psi_{ppp} = \sum_{[K]} u_{[K]}(\rho)\mathcal{B}_{[K]}(\Omega) = \Psi^0 + \sum_{J}^{\bar{J}} \Psi^J$$

with $\Psi^J = \sum_{[K]} u^J_{[K]}(\rho)\mathcal{B}_{[K]}(\Omega)$

To determine the hyperradial functions $u^J_{[K]}(\rho)$ we use the Adiabatic Hyperspherical Harmonic basis

$$\Psi^J = \rho^{-5/2} \sum_{\nu} w^J_\nu(\rho)\phi_\nu(\rho, \Omega)$$

with the adiabatic functions $\phi_\nu(\rho \to \infty, \Omega) \to \mathcal{B}_{[K]}(\Omega)$

Integrating on a Hyperradial source

The hyperradial source in the case of three particles is defined as

$$S_{123} = \frac{1}{\pi^3 \rho_0^6} e^{-(\rho/\rho_0)^2}$$

with $\rho^2 = \frac{2}{3}(r_{12}^2 + r_{23}^2 + r_{31}^2)$ and the condition

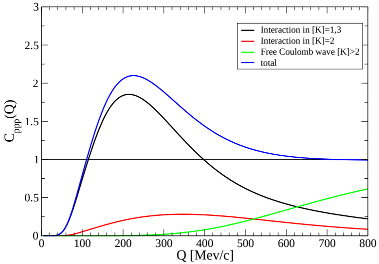
$$\int S_{123} \rho^5 d\rho \, d\Omega = 1$$

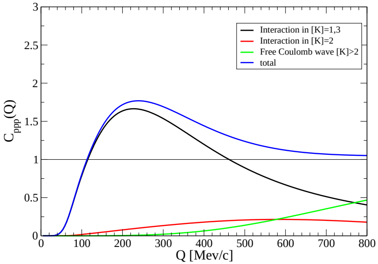
The correlation function is defined now as

$$C_{123}(Q) = \int \rho^5 d\rho \, d\Omega \, S_{123} |\Psi_s|^2$$

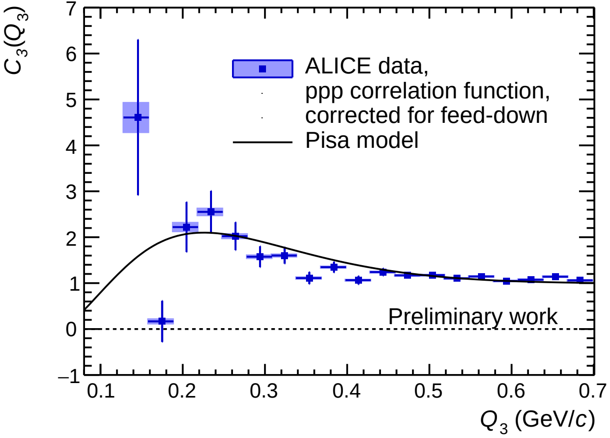
Integrating on a Hyperradial source

Preliminary results with size source of 2 fm and 1.5 fm





Comparison to data (preliminary)



Summary

- Although its apparent simplicity, the three-nucleon problem is of great complexity
- The antisymmetrization of the wave function is perfomed using the HH basis
- In the ppp case the Coulomb interaction couples the asymptotic dynamics increaing the difficulties of the numerical treatment.
- In this preliminary description the Coulomb interaction was averaged through the hyperangles
- Moreover only the $K = 1, 3$ and $K = 2$ hyperangular channels were included

- The next work is to inlcude more channels and to relax the average of the Coulomb force