Introduction to Final State Interactions

Aidan M. Kelleher
The College of William & Mary

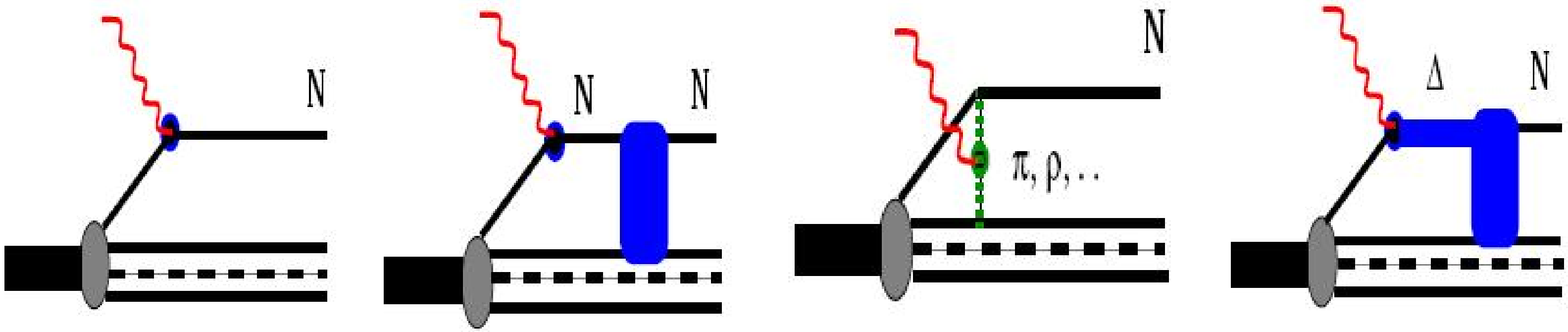
February 25, 2009

Introduction to Final State Interactions

- Scattering Interactions
- Final State Interaction Expansion
- Glauber Approximation
- Generalized Eikonal Approximation
- Rocco's Concerns
  - Spin Dependence
  - Charge Exchange

Scattering Interactions

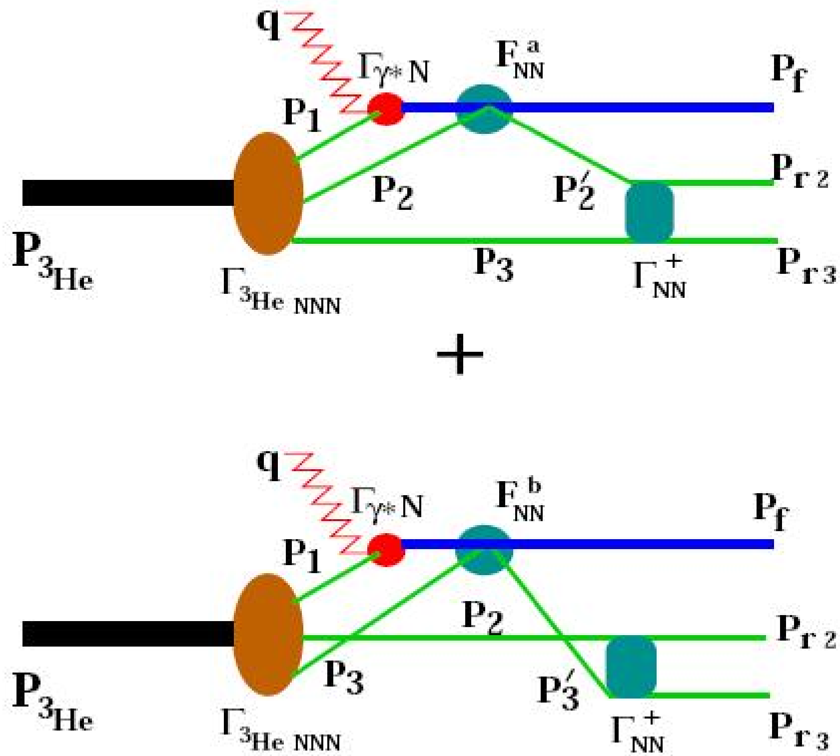
There are 4 main classes of interactions: Impulse Approximation, Final State Interactions, Meson Exchange Current, Isobar Current



MEC and IC small for high momentum transfer ($Q^2 \geq 1GeV^2$)

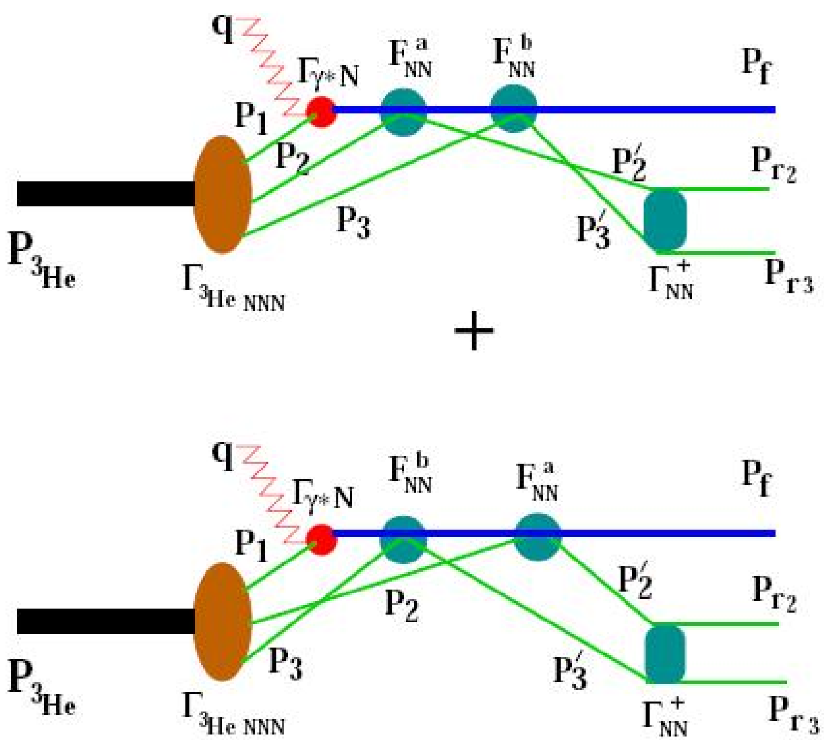
Final State Interaction Expansion

Single Rescattering Amplitudes



Final State Interaction Expansion

Double Rescattering Amplitudes



Glauber Approximation

Approximation applied to scattering by a bound particle: "In most applications the high-energy approximation is valid only for energies which are considerably larger than those characteristic of bound states of nuclei or atoms, so that the later energies may be justifiably neglected"

Actual approximation: "We shall assume that then energy of the incident particle greatly exceeds the magnitude of the potential, and is also large enough that the particle wavelength is much smaller than the potential width": $\frac{V}{E} \ll 1$

In practice, for our experiment, Glauber approximation truncates scattering sum after double scattering by assuming that the spectator particles are at rest.

Generalized Eikonal Approximation

- New (Approximate) Conservation Rule At high energy, the momentum distribution of the bound state is conserved.

- Reduction Theorem "High energy particles propagating in the nuclear medium can not interact with the same bound nucleon a second time after interacting with another bound nucleon"

Generalized Eikonal Approximation – Relation to Glauber

Rescattering amplitude for deuteron:

$$A_1^\mu = -j^\mu(p_s + q, p_s)\frac{\sqrt{2E_s}}{2i}\int d^3r\phi(r)\theta(-z)\Gamma^{pn}(\Delta, -z, -b)e^{ip_sr}$$

where $\vec{r} = \vec{r_p} - \vec{r_n}$, and a generalized profile function Γ is defined:

$$\Gamma^{pn}(\Delta, z, b) = \frac{1}{2_i}e^{-i\Delta z}\int f_{pn}(k_\perp)e^{-ik_\perp b}\frac{d^2k_\perp}{(2\pi)^2}.$$

And, $\Delta = \frac{q_0}{|\mathbf{q}|}(E_s - m)$.

Amplitude reduces to the Glauber appromiation in the limit $\Delta \rightarrow 0$

Generalized Eikonal Approximation – Differences from Glauber

- GEA allows calculations of short range correlations
- GEA and Glauber agree when recoil momentum is small (see next page)

$$T = \frac{\sigma^{IA+FSI}}{\sigma^{IA}}$$

- "The Q^2 dependence of T within GEA can be used as a baseline reference point to study the onset of the color coherence regime in high Q^2 exclusive reactions" (beyond the scope of this presentation)

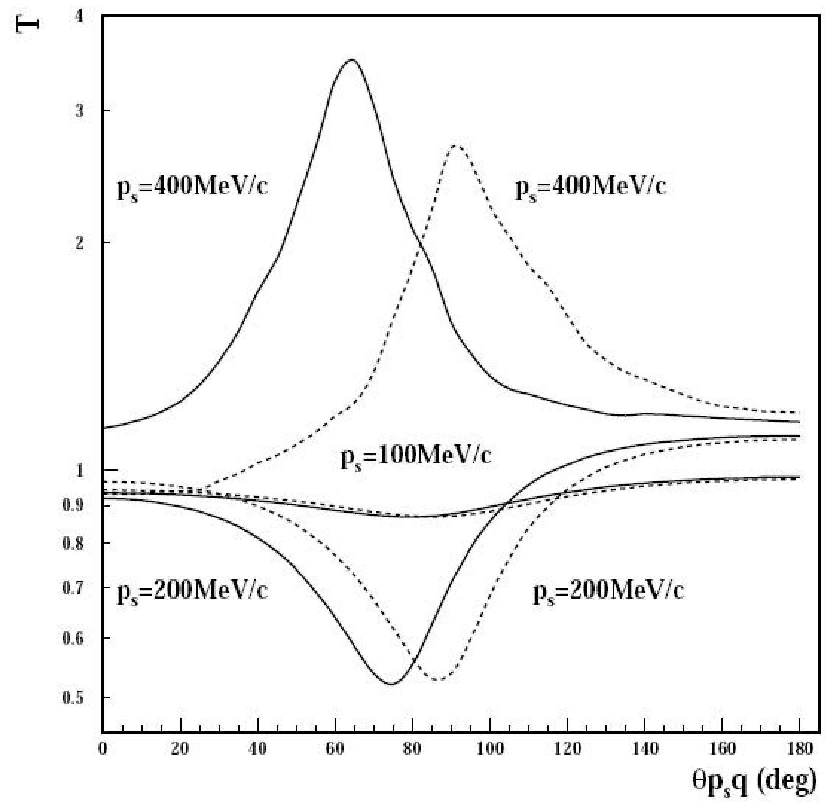
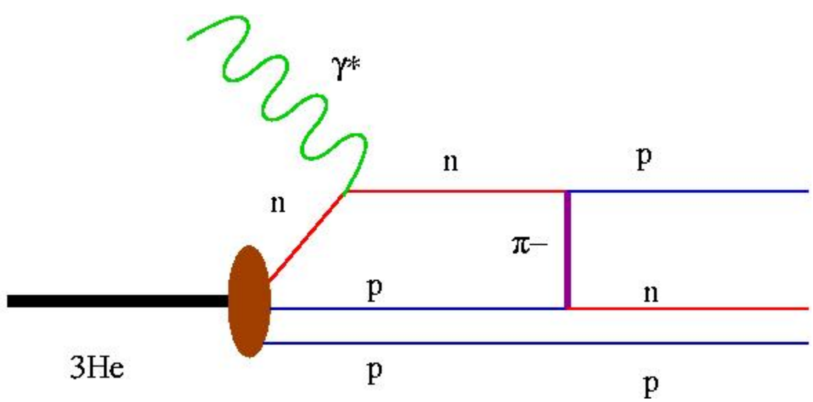


FIG. 15. The $\theta_{p_s q}$ dependence of T at different values of p_s. Solid lines- GEA, dashed lines - Glauber approximation.

Rocco's Concerns

- Does Misak assume no spin dependence in the scattering amplitude? In papers, he averages over spins. This may be to simplify papers.
- Is charge exchange handled?



References

C. Coifi deli Atti and L.P.Kaptari arXiv:nucl-th/0407024

R.J. Glauber, in *Lectures in Theoretical Physics*, Vol 1 p.315, edited by W.E.Brittin and L.G. Dunham. Wiley Interscience, New York (1959).

M.M. Sargasian, *et al* arXiv:nucl-th/040602.

M.M. Sargasian *Int. J of Modern Physics E* v10, 6 405-457 (2001) updated: arXiv:nucl-th/0110053.

R. Schiavilla, *et al*, PRC 72, 064003 (2005)