Δ contributions to pp → ppπ^0

G. Ramachandran\textsuperscript{1,}\textsuperscript{*} Venkatraya\textsuperscript{1,2,\dagger} and Sujith Thomas\textsuperscript{1,3,‡}
\textsuperscript{1}G. V. K. Academy, Jayanagar, Bangalore - 560082, India
\textsuperscript{2}Vijaya College, Bangalore-560011, India and
\textsuperscript{3}K. S. Institute of Technology, Bangalore - 560062, India

Introduction

Ever since the total crosssection measurements \cite{1} for pp \rightarrow pp\pi^0 were found to be more than factor of 5 larger than the then available theoretical prediction \cite{2}, experimental and theoretical study of the reaction excited considerable interest. Advances in storage ring technology led to detailed experimental studies including measurements of spin observables \cite{3} when both the colliding protons are polarised. The Julich meson exchange model \cite{4} was thoroughly confronted with this data. It was found that the model was comparatively more successful with the less complete data \cite{5} on pp \rightarrow d\pi^+ and pp \rightarrow pn\pi^+ but fail to provide an overall satisfactory reproduction of the data on pp \rightarrow pp\pi^0. In this context, a model independent approach to the reaction was developed \cite{6} using irreducible tensor techniques \cite{7}. This approach was employed \cite{8} to incisively analyse the findings of the Julich model, which revealed that (i) the Δ contributions are important (ii) the model deviated very strongly in the case of \textsuperscript{3}P_1 \rightarrow \textsuperscript{3}P_0p and to a lesser extent in \textsuperscript{3}F_3 \rightarrow \textsuperscript{3}F_2p. Because the final spin singlet and spin triplet states do not mix in any of the spin observables measured in \cite{3}, both these amplitudes were assumed to be real in \cite{9}. It was shown more recently \cite{9} how this drawback can be removed.

The purpose of the present paper is to discuss the Δ contributions to pp \rightarrow pp\pi^0 employing the model independent approach.

\textsuperscript{*}Electronic address: guvrm@yahoo.com
\textsuperscript{1}Electronic address: venkatraya@gmail.com
\textsuperscript{2}Electronic address: mailsujiththomas@gmail.com

Theoretical Formalism

If \textbf{p}_1, \textbf{p}_2, \textbf{q} denote respectively the c.m. momenta of the 2 nucleons and the pion in the final state and \textbf{p}_0 the c.m. momentum in the initial state, we may define invariant masses \(W_1\) and \(W_2\) for the two \(\pi^0 - p\) systems in the final state and choose events corresponding to \(W_1, W_2 = m_\Delta\) for the analysis, where \(m_\Delta\) denotes the mass of Δ resonance. The matrix \(M\) for pp \rightarrow p\Delta is given by

\[ M = \sum_{s_f=0}^{2} \sum_{s_l=1, -1} \sum_{|s_f + s_l|} (S^\lambda(s_f, s_l).M^\lambda(s_f, s_l)) \]

where the irreducible tensor amplitudes are

\[ M^\lambda_\mu(s_f, s_l) = \sum_{\alpha} G_\alpha f_\alpha(Y_{i\lambda}(\hat{p}_f) \otimes Y_{i\mu}(\hat{p}_l)) \]

in terms of the partial wave amplitudes \(f_\alpha = n_{s_f, l_i} (E)\) at any given c.m. energy \(E\) and the geometrical factors \(G_\alpha = (-1)^{l_f + s_f + l_i - j}[2s_f]^{-1} W(s_f, k_f, j, \lambda)\). The final c.m. momentum \(p_f = p_1 + q - p_2\), if \(W_1 = m_\Delta\) and \(p_r = p_2 + q - p_1\), if \(W_2 = m_\Delta\). Conservation of iso-spin \(I\) implies that \(I\) can take only one value \(I = 1\) and \(l_f + s_l\) must be even because of Pauli exclusion principle. Parity conservation implies that \((-1)^{l_i} = \text{(-1)}^{l_f}\). Limiting ourselves to \(I_f = 0, 1\) at threshold energies, we have a set of 9 partial

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where the Fano-statistical tensors $I^k_\alpha(s_i,s'_i)$ characterize the initial $\vec{p} - \vec{p}$ system and $A^k_\alpha$ are the analysing powers.

It should therefore be feasible to measure experimentally the Fano-statistical tensors $I^k_\alpha$ and the analysing powers $A^k_\alpha$ to determine empirically the threshold partial wave amplitudes $f_1, f_2 \cdots f_9$ and hence assess the importance of the $\Delta$ contributions.

References


