Report on the INT-01-21 Workshop: Computing $\sigma(DD \to \alpha\pi^0)$ and Charge Symmetry Breaking

Gerald Miller and Bira van Kolck

The workshop began with reports from experimentalists regarding the extensive TRIUMF effort to study the forward-backward asymmetry in the reaction $pn \to D\pi^0$, and the IUCF effort to measure the cross section for $DD \to \alpha\pi^0$. The np experiment is expected to have results which will test existing theories in a month or two, and the DD experiment is planned to finish running in 13 months. The discussion of the experiments was followed by brief reviews of basic background information on effective field theory and charge-symmetry breaking (CSB). An important CSB pion-production mechanism stems from the quark-mass and electromagnetic components of the nucleon mass difference, which in these reactions appear in a combination other than the nucleon mass difference itself. Another important CSB pion-production mechanism is pi-eta mixing. The two mechanisms influence the two different reactions in different ways, so both experiments are needed. Several talks discussed the status of the theory of pion production in two-nucleon interactions, including a calculation of the $pn \to D\pi^0$ forward-backward asymmetry. Interest was expressed by some participants in further studying this observable, in order to reduce theoretical uncertainties. The important background process $DD \to \alpha\gamma\gamma$ was examined, and discussion in the audience led to the consideration of a new term involving the interference between the amplitudes for the direct production of the $\gamma\gamma$ pair and the pair production via π^0 decay. The formal talks concluded, at the mid-point of the second day, with a review of the relevant aspects of four-nucleon physics.

The remainder day and a half was devoted to work on the computation of the $DD \to \alpha\pi^0$ cross section. Every attendee was actively involved, and this led to much progress.

- Three working groups were formed: (1) power counting and effective operators; (2) coordinate-space approaches; and (3) momentum-space approaches.
- A reasonable power-counting scheme which enables a proper expansion, and allows a well-defined calculation of the scattering amplitude was established. Furthermore, CSB in the pion-production operator was shown to be more important than that occurring in the initial- and final-state wave functions. Similarly, CSB in three-nucleon terms was shown to be smaller than that in two-nucleon terms.
- The coordinate-space group developed two approaches, one using explicit four-body physics evaluated using Monte-Carlo integration, and the other a phenomenological two-body model.
- The momentum-space group has available a four-body calculation of both the initial-state and alpha-particle wave functions. As a check on the approximation, the initial-state wave function will be used to compute DD scattering observables.

- A homework problem was developed. This involves using the simplest possible DD and α wave functions to provide a semi-analytic calculation to test the use of more complicated methods.

- The collection of physicists at the meeting agreed to cooperate together as a single collaboration with several sub-groups. Invitations to join will be sent to interested theorists who could not attend the workshop due to time conflict.

- The collaboration agreed to establish a web page to enhance communication, and increase the probability that a reasonable calculation of the cross section for $DD \to \alpha\pi^0$ will be done by the time the experiment concludes its running. Tentative plans were made to have a meeting around March at Indiana University.

The stated goal of the workshop was to create a collaboration to compute the cross section. Three separate reasonable approaches were developed during the meeting, and considerable enthusiasm for finishing the calculations was expressed. The workshop was, therefore, extremely successful.